ATOLL RESEARCH BULLETIN NOS. 390-396

ATOLL RESEARCH BULLETIN

F. RAYMOND FOSBERG (1908-1993)

COMMEMORATIVE ISSUE

Issued by

NATIONAL MUSEUM OF NATURAL HISTORY

SMITHSONIAN INSTITUTION

WASHINGTON, D.C. U.S.A.

FEBRUARY 1994

ATOLL RESEARCH BULLETIN

NOS. 390-396

F. RAYMOND FOSBERG (1908-1993) COMMEMORATIVE ISSUE

ISSUED BY
NATIONAL MUSEUM OF NATURAL HISTORY
SMITHSONIAN INSTITUTION
WASHINGTON, D.C., U.S.A.
FEBRUARY 1994

ACKNOWLEDGMENT

The Atoll Research Bulletin is issued by the Smithsonian Institution to provide an outlet for information on the biota of tropical islands and reefs and on the environment that supports the biota. The Bulletin is supported by the National Museum of Natural History and is produced by the Smithsonian Press. This issue is partly financed and distributed with funds from readers.

The Bulletin was founded in 1951 and the first 117 numbers were issued by the Pacific Science Board, National Academy of Sciences, with financial support from the Office of Naval Research. Its pages were devoted largely to reports resulting from the Pacific Science Board's Coral Atoll Program.

Articles submitted for publication in the Atoll Research Bulletin should be original papers in a format similar to that found in recent issues of the Bulletin. First drafts of manuscripts should be typewritten double spaced and can be sent to any of the editors. After the manuscript has been reviewed and accepted, the author will be provided with a page format with which to prepare a single-spaced camera-ready copy of the manuscript.

F. Raymond Fosberg Ohio 1968
Photograph by H. Gray Multer

F. RAYMOND FOSBERG, 1908-1993

It is with deep sadness and regret that we record the passing of our Founding Editor Dr F. Raymond Fosberg, at his home in Falls Church, Virginia, on 25 September 1993. He was 85 years old, and had been seriously ill with cancer for several months.

Ray occupied a very special place in the development of coral reef and island studies in the twentieth century. Through the *Atoll Research Bulletin* he helped create an autonomous branch of science, known now for its national and international meetings, its public importance, and its diverse and dynamic research programs. The *Bulletin* was and remains central in these endeavors.

His career in the Pacific effectively began when he took an assistantship in the Department of Botany at the University of Hawaii with Professor Harold St John in 1932. He had gained his B.A. at Pomona College in 1930, and during 1930-1932 served as Botanist at the Los Angeles County Museum, working on the floras of the southwestern United States and northern Mexico. In 1934 he joined St John on the Bishop Museum's Mangarevan Expedition, led by the malacologist C. Montague Cooke, Jr. This took him from Hawaii to Fanning in the Lines, Tahiti and Mehetia in the Societies, to the atolls of Anaa, Tepoto, Napuka, Fangatau, Hao and Vahitahi in the Tuamotus, Mangareva in the Gambiers, Pitcairn and nearby Henderson and Oeno in southeastern Polynesia, to the islands of the Australs from Marotiri to Maria, and back to Hawaii by way of Raiatea, Borabora, Vostok, Flint, Christmas and Fanning. In total the expedition visited 25 high islands and 31 coral islands; St John and Fosberg brought back 15,000 plant specimens. It was an extraordinary introduction to the island world of the tropical Pacific, and it determined Ray's interests for the rest of his life.

Following the expedition Ray gained his M.S. in 1935 at the University of Hawaii with a monograph on the Hawaiian genus *Gouldia* (Rubiaceae), and then moved to the University of Pennsylvania, taking his Ph.D. in 1939 with a thesis on the Polynesian species of *Hedyotis* in the same family. Then for several years during and after World War II he worked in South America on the medically important genus *Cinchona*, also in the Rubiaceae. But he returned to Pacific island studies in 1946 when he spent six months working on an Economic Survey of Micronesia for the U.S. Commercial Company. By the end of the 1940s he was deeply immersed in the study of the vegetation and floristics of Pacific islands.

This coincided with the development of the Coral Atoll Program of the Pacific Science Board, beginning with an expedition to Arno Atoll in the Marshalls in 1950 and 1951. Ray was responsible for founding the *Atoll Research Bulletin* in 1951 as an outlet for the results of the Pacific Science Board expeditions. It became the major repository for information on coral reefs and islands, especially their terrestrial aspects, and Ray's first paper in the original issue was reprinted in the *Bulletin* in 1992. Ray was always deeply respectful of the director of the Pacific Science Board, Dr Harold Jefferson Coolidge—at least to me he always called him 'Mr Coolidge'—who in addition to the Coral Atoll Program was also responsible for the programs Coordinated Investigations in Micronesian Anthropology and Scientific Investigations in Micronesia, as well as being a leading figure in the Pacific Science Association and the International Union for the Conservation of Nature and Natural Resources. Ray wrote an appreciation of him in the *Bulletin* in 1985.

Virtually from the start of the Coral Atoll Program Ray was assisted by Dr Marie-Hélène Sachet. Together they built up a formidable data base on island biogeography, as well as an unprecedented collection of publications, photographs and reports, now in the Smithsonian Institution. Resulting from this work they published the massive *Island Bibliographies* and its *Supplement* in 1955 and 1971. Marie-Hélène was largely responsible for the practical editing and production of the *Bulletin*, especially in the early days when it was a much more time-intensive operation than it is now. Her own thesis had been on the natural history of Clipperton Atoll, but in 1963 she worked in the Societies and on Rangiroa, in 1963 and 1974 in the Marquesas, and in 1982 and 1983 especially in the high Society Islands, on Tetiaroa, and in the Tuamotu. Many of her papers on this work appeared in the *Bulletin* (nos. 274, 275, 276, 277, 294). Her sudden death in 1986 was a severe blow to Ray, since there were still so many major projects to be completed. Ray wrote a detailed appreciation of their collaboration in a Commemorative Issue of the *Bulletin* in 1987, and there is also a very perceptive notice of her by R. Koenig in the *Bulletin* of the Société des Etudes Océaniennes [Tahiti] in the same year.

Their work, together with that of Royce Oliver in the Department of Botany at the National Museum of Natural History, led to the codification of an enormous body of knowledge, especially in their geographical checklists of the plants of Micronesia published in 1976, 1982 and 1987, and in a continuing project on the *Flora of Micronesia* (1975–1993). In collaboration with Steve Renvoize of the Royal Botanic Gardens, Kew, Ray also published the *Flora of*

Aldabra and nearby islands in 1980, and co-edited with M. D. Dassanayake the *Revised Handbook of the Flora of Ceylon*, of which seven volumes have been published since 1980. The *Vascular flora of the northern Mariana Islands* appeared in 1975. Ray also put in order the *Partial flora of the Society Islands* (1974) based on the large collections and voluminous notes assembled by his friend Martin Grant in 1930-31: Ray had been deeply affected by Grant's death in 1968 before any of his wealth of knowledge had been published, and I think this spurred him on over the last quarter of a century to ensure that it would not happen to himself.

The complete bibliography of Ray's publications in this issue includes many floristic papers on reef islands over an immense biogeographic range. In the *Bulletin* these include plant lists for the Marshall Islands (1955, 1990), the Gilbert Islands (1987), Henderson Island (1983), Wake Island (1959, 1969), and Nauru and the Phoenix Islands (this issue), as well as many other Pacific localities; of the northern Great Barrier Reef (1991); of the Maldive Islands (1957, 1966), Agalega (1983), Cousin (1983), and many other western Indian Ocean islands (1970, 1983); and of Alacran (1962), the Dry Tortugas (1981), the Belize cays (1982), and the Jamaican cays (1991) in the western Atlantic. As his bibliography shows, this list is very far from complete. Over his lifetime Ray collected more than 66,000 plant numbers in multiple sets, and probably carried out and published more scientific work on more tropical islands, both high and low, around the world than anyone else. Sadly he did not live to see the publication of a final synthesis with Dieter Mueller-Dombois, *Vegetation of the tropical Pacific islands*, though a precursor summary on the Society Islands did appear in 1992.

While the major thrust of his work was floristic and taxonomic, Ray had an enormously wide range of interests in natural history broadly conceived—in geomorphology, diagenesis, soils, birds, biogeography, ecology, conservation, geography. He wrote originally and trenchantly on all of these topics, and it is clear that these more general writings derived from deep conviction as well as scientific expertise. Though he spent his life on the tropical oceans and their islands, Ray came from the land: his youth was spent on the family melon-growing enterprise in California. I think he learned the lessons then of environmental uncertainty, accountability, and practical conservation.

He was not deeply interested in theory, and in fact distrustful of it. He was a pragmatic and realistic recorder of empirical nature in all its unpredictable variety. He tried to bring order into this complexity by classifying and naming and by studying distributions. He belonged as an interpreter of the island world with the founders of the discipline—Darwin, Hooker, Wallace—and used much the same methods.

In addition to the taxonomic and floristic papers—the building blocks of his life work—Ray wrote a number of influential interpretative papers. One of the earliest and still most widely cited was his 'Derivation of the flora of the Hawaiian Islands' in volume 1 of Zimmerman's *Insects of Hawaii* (1948), which took an uncompromisingly dispersalist position. Based on an analysis of nearly two thousand species of seed plants and ferns in over 250 genera, he concluded that "the flora has always been insular. It is exactly the type that might be expected to be descended from a random aggregation of chance waifs carried overseas by a combination of factors such as storms, currents and birds. Of seed plants, an average of but one successful arrival and establishment every 20,000 to 30,000 years would account for the flora" (1948, p. 119). This was robust material, especially in an age and a subject dominated by Skottsberg and Corner, Darlington and Simpson. Another landmark paper was his 'Qualitative description of the coral atoll ecosystem' (1961), which sought to provide a framework for the diversity of data accumulating at a rapidly accelerating rate. A third (which appealed to me) was his address on 'Geography, ecology, and biogeography' to the Association of American Geographers in 1976, in which he forcefully informed geographers what they really ought to be about .

There was one major project that he did not get completed in his lifetime, and in many respects it was one of the more intriguing ones. From the outset in his Pacific studies Ray had been concerned by the problem of the botany of Cook's voyages. He had toiled to make Merrill's somewhat eccentric volume on that subject publishable. He wrote on Parkinson and Banks long before the *Florilegium* was finally published. But from the time of the Mangarevan Expedition he became especially concerned with the collections made by Johann Reinhold and Georg Forster on Cook's second voyage. For decades our home in Cambridge was a way station for Ray en route to herbaria in Leningrad, Paris, Berlin, and up to two dozen other places, where he indefatigably tracked down the widely dispersed Forster collections from the Pacific; his intention was to lectotypify species which had been inadequately established. The work is virtually complete, and indeed Ray saw the proof of a precursor paper to *Allertonia* only a day before he died. He was also interested in Robert Brown's collections on the Flinders Expedition, and re-collected at Brown's sites in the Gulf of Carpentaria, but I do not think he published on Brown's material.

Ray was a large, powerfully built, imposing man—tall and handsome, as Clifford Gessler described him at the time of the Mangarevan Expedition, hough sadly increasingly stooped in later years. He had fairly craggy features, a rather shy and disarmingly boyish smile, often a twinkle in clear blue eyes which never needed glasses; indeed the only aid he needed was the trademark hand lens he always wore around his neck. His speech was slow and deliberate, his convictions clear, his distaste for some more recent ideas not disguised. Both he and Marie-Hélène could be severe critics of work that did not reach their own exacting standards, as I have reason to recall. He was a man of some stubbornness and considerable physical determination (he took up SCUBA, for example, when well into his sixties).

I first met him more than thirty years ago when I was just starting work on the sand cays of Belize. E. J. H. Corner of Cambridge, one of tropical botany's memorable figures, told me to seek Ray out. I went to Washington, and Ray and Marie-Hélène came to see me in the lobby of the old Raleigh Hotel. Somehow I had the premonition that it was to be a very important meeting for me. Something worked that day, in spite of the fact that I had very little idea of what I was about. Indeed I recall with embarrassment the state of the earliest collections I sent him. But he persevered. I have seen that pattern of support repeated so many times since: Ray never grudging his time or his advice to those he thought he could help. He did this to educate people, especially students; to advance science in the tropical seas; and to build the Smithsonian's plant collections. He helped unknown and beginning students and members of the general public as well as his scientific peers and friends. Indeed he sometimes exasperated me by the way he allowed himself to be deflected from the task in hand during long-planned visits to overseas herbaria when people learned he was in town and descended on him.

This is not the place to record Ray's unremitting work for conservation, but some instances of his powerful initiatives in the atoll realm must be mentioned. From the middle 1950s he urged the preservation of Aldabra, the western Indian Ocean elevated atoll renowned for its huge population of giant tortoises, and he played a central rôle in the United States in orchestrating the opposition to plans to turn it into a military base in 1965-1967. Less well known were his successful efforts to limit the impact of U.S. missile testing programs in the Phoenix Islands in the early 1970s. And he was central—with his unique knowledge—in the campaign to preserve Henderson Island in southeastern Polynesia from bizarre plans in the late 1970s and early 1980s to turn it into a private refuge from nuclear attack. The issue of the *Bulletin* (321-329, 1989) recording the first results of the new wave of Henderson studies carries an appreciation by Ray of the work of the former Secretary of the Smithsonian, S. Dillon Ripley—again, always 'Mr Ripley' to Ray—who had appointed him to the Institution and who had a particular interest in the Henderson and Aldabra Rails. Ray pursued these causes to the highest political levels with tenacity and immense authority, and in each case the cause was won. Ray also advised Mr Marlon Brando over many years on his management of Tetiaroa Atoll in the Societies.

Ray was both facilitator and communicator in international science. He attended the Pacific Science Congresses between 1949 and 1991, and was active in Pacific Science Association committees and in organizing symposia and fieldtrips. The book he edited following the symposium he organized at the Honolulu Congress in 1961 on *Man's Place in the Island Ecosystem* became a classic. The theme was re-examined at the Vancouver Congress in 1975 but the results were unfortunately never published. At his last Congress in Honolulu he gave a plenary lecture, published in the *Bulletin* in 1992, as well as a contributed paper, and met many friends and colleagues for what was to be the last time. He was one of that small group which founded the International Coral Reef Symposia at Mandapam in India a quarter of a century ago. He was at the Second Symposium for the memorable cruise along the Great Barrier Reef in 1973. Both he and Marie-Hélène were on home ground for the spectacular 5th meeting in Tahiti in 1985. Ray went off on the slightly alarming Makatea fieldtrip with Josh Tracey and others afterwards, and Marie-Hélène went to Takapoto. Both were in their element at that meeting, and no-one could have foreseen that we should lose both of them so soon. Ray naturally became an honorary member of the International Society for Reef Studies when that was founded. He was an active member of the International Botanical Congresses from Stockholm (1950) to Berlin (1988). He was a major figure in the UNESCO Humid Tropics Program, in the International Society for Tropical Ecology, the U.S. Nature Conservancy, and the International Biological Program. He attended all of Nicholas Polunin's International Conferences on Environmental Futures.

Many honors came to him: he was truly touched by such recognition but did not need it. He received the George Davidson Medal and the Edward W. Browning Achievement Award. He particularly appreciated the Robert Allerton Medal from the Pacific Tropical Botanical Garden on Kauai and the Herbert E. Gregory Medal from the Pacific Science Association. He was glad that his wider messages were recognised by the award of the Daly Medal by the American Geographical Society. Pomona College, where he did his undergraduate work and to which he left his personal plant collection, awarded him an honorary degree in 1980, as did the University of Guam in 1986, the University of Peradeniya, Sri Lanka, in 1986, and the University of the South Pacific in Fiji in 1989. He much appreciated this academic recognition.

Toward the end of his life there were three public celebrations in which he delighted. The first was a meeting at Bishop Museum in Honolulu on March 23, 1984, for the 50th anniversary of the Mangarevan Expedition. It was attended by Harold St John, Kenneth P. Emory, Yoshio Kondo and Donald Anderson. C. Montague Cooke, Jr., Peter H. Buck and J. Frank Stimson had already passed away, and Ray was in fact the last survivor of those who met again in 1984. Only E. C. Zimmerman can now tell us about that historic expedition. Ray was also honored by a special symposium at the INTECOL meeting in Yokohama in 1990. This was published as a special issue of *Pacific Science*, to which Ray himself contributed, in 1992.

Finally the editors of the *Bulletin* assembled a special 40th anniversary issue, without Ray's knowledge, and this appeared in 1992. In November that year the Director of the National Museum of Natural History, Frank Talbot, himself a coral reef specialist who had also been at Mandapam, hosted a reception in his office at which the issue was presented to Ray. There is a note with photographs in the News and Comment section of issue 379-389 in 1993. Among those present were long-time associates Josh Tracey and Frank Whitmore; his colleague Royce Oliver; and Myron M. Weinstein, the Hebraic scholar from the Library of Congress, a friend over very many years to both Ray and Marie-Hélène. Ray was already very frail, but he gave a powerful and moving address. It was his last public appearance, though he continued to go to his office in the Department of Botany until August of 1993.

It is sad indeed that so soon after the 40th Anniversary Issue we collectively recall the life, work, personality and achievements of F. Raymond Fosberg. We do so through a Commemorative Issue of the journal he founded and nurtured. This issue records his remarkable contribution to knowledge of the natural world, through his publications and through the taxa which he named and which are named for him. We publish also a number of papers which Ray left in final form, including the *Flora of Nauru* and his Sauer Memorial Lecture, the first papers from his Phoenix Islands investigations, and a final commentary on his phosphate rock hypothesis. His lifetime's collection of plants will form an enduring monument in herbaria around the world, and especially in the U.S. National Herbarium in Washington, D.C.

These will not be the last of Ray's publications in the *Bulletin*. There are other substantial works near completion, as well as the monograph on the Forsters. The encyclopaedic dictionary of reef terminology which he completed years ago with Rhodes Fairbridge and many others is now again accessible. There is a checklist of Indian Ocean reef island plants similar to those he prepared on Micronesia.

The *Atoll Research Bulletin* will stand as one of Ray's chief memorials, not only for the information it records but for the way it has served to codify and institutionalize the emergent discipline of coral reef and island studies during Ray's professional life. Mary McCutcheon's exemplary and comprehensive Index to the *Bulletin* in 1991 gives a measure of that achievement. In thinking of Ray and the difference he has made to all of us, it is worth reflecting not only on the status and scope of reef and island science when the *Bulletin* was founded in 1951, but also on what it was like when Ray embarked on the Mangarevan Expedition exactly sixty years ago.

This introductory note is very far from being a comprehensive treatment of Ray's life and work. Others will speak with more authority than I can on many interests that he had. It has not been an easy notice to write, largely because I knew him for too long and too well for that to be possible. Both Ray and Marie-Hélène entered into the folklore of our family, as we doubtless did into theirs. Both were true friends.

There is a fine appreciation of Ray by Dieter Mueller-Dombois in the INTECOL Symposium issue of *Pacific Science* in 1992. There is also a substantial notice of him by Steve Renvoize, his co-author on the Aldabra flora, in the London *Independent* for 14 October 1993.

David R. Stoddart

A 50th Anniversary Reunion of Members of the Bishop Museum's 1934 Mangarevan Expedition (From left to right): D. Anderson, K.P. Emory, F.R. Fosberg, Y. Kondo, and H. St. John

Bishop Museum Photo

The F. Raymond Fosberg Fund

Friends and colleagues of Ray Fosberg (1908–1993) are establishing The F. Raymond Fosberg Fund in memory of the man who was the foremost student of Pacific botany and vegetation of his time and a leading conservationist. Extensive travel provided him with the broadest concepts of world patterns of geography, vegetation, coral reefs, and islands and their life, a view surpassing that of most scientists. He wrote works (more than 800) on the plants of Hawaii, Micronesia, Aldabra, and many other places, that are the basis of our present knowledge. He advised and helped innumerable younger colleagues in developing their careers and pioneered the ethic to conserve the plants and animals of the world. This fund is established in his memory, and with the hope that through it his efforts for Pacific island botany and conservation can be furthered. The fund will be administered by The Nature Conservancy of Hawaii, a non-profit conservation organization, to support the protection of native Hawaiian forests and the plants and animals which depend on them for their survival.

Of all the places on Earth, Hawaii has the most alarming concentration of species teetering on the brink of extinction. Hawaii amounts to only 0.2% of the land area of the United States. Yet nearly 75% of the nation's historically documented plant and bird extinctions are from Hawaii. And of all the bird species currently endangered in the 50 United States, 40% are from Hawaii. Hawaiian plant species account for 34% of the list of endangered plants in the nation. The Nature Conservancy of Hawaii is working to protect the forests that these remaining native plants and animals need to survive.

If you wish to give to The F. Raymond Fosberg Fund, write your check to The Nature Conservancy of Hawaii and send it to:

The Nature Conservancy of Hawaii
Att: The F. Raymond Fosberg Fund
1116 Smith Street, #201
Honolulu, Hawaii 96817

ATOLL RESEARCH BULLETIN

NO. 390

LISTS OF TAXA NAMED FOR F. RAYMOND FOSBERG AND BY HIM

BY

DAN H. NICOLSON

ISSUED BY
NATIONAL MUSEUM OF NATURAL HISTORY
SMITHSONIAN INSTITUTION
WASHINGTON, D.C., U.S.A.
FEBRUARY 1994

LISTS OF TAXA NAMED FOR F. RAYMOND FOSBERG AND BY HIM

BY

DAN H. NICOLSON

SUMMARY

Fifty-one plant names, using epithets such as *fosbergii* or *fosbergiana*, honor Dr. Fosberg. Almost 1000 taxa were named by him or with him as co-author, over half being infraspecific taxa (subspecies, varieties, formae) in *Gouldia* and *Hedyotis* of the Rubiaceae.

The basic tool used for these lists was *Index Kewensis* (mostly includes only seed plants and only to species level) on a compact disk, read-only-memory (CD-ROM) in the beta-test version. There are some difficulties with data misread by the optical character reader, such as *Piper "foshergii"* and *Diplostephium "fcsbergii"*. Thus, there may be some overlooked species names masked by a misspelling. Also, *Index Kewensis* did not incorporate trinomials (infraspecific names) or names of subdivisions of families and genera until relatively recently. This may result in some overlooked names at these ranks.

More names were found in databases maintained at Missouri Botanical Garden (TROPICOS is excellent for mosses). Marshall Crosby and Robert Magill, bryologists, found two more moss names and four more vascular plant names, all older trinomials. A trinomial and an unexpected binomial (*Gouldia fosbergii*, apparently overlooked by *Index Kewensis)* was found by my colleague, Warren L. Wagner, in a database of Hawiian plant names. The "Gray Cards" database of Harvard University (names of New World vascular plants after 1890), now on-line, was checked.

I don't know of tools comparable to *Index Kewensis* and these databases for other biological groups. Dr. Paul C. Silva (University of California at Berkeley), who maintains a card index to algae, was asked if he could locate phycological names. Dr. F. Christian Thompson, member of the Zoological Commission, was asked if he could locate zoological names. Dr. David Lellinger, pteridologist here at the Smithsonian, was asked about finding fern names. All reported that they knew of no taxa named for Dr. Fosberg but that the tools do not exist to check, let alone to be certain.

Author names are abbreviated in accordance with *APN* (R. K. Brummitt & C. E. Powell's 1992 *Authors of plant names*). Periodical titles are abbreviated in accordance with *B-P-H* (G. H. M. Lawrence et al.'s 1968 *Botanico-Periodicum-Huntianum*) and its *Supplement* (Bridson & Smith, 1991).

Unless some problem or inconsistency was noted, the original publication was not checked. If errors of commission or omission are noted, the author would be grateul for the information.

Botany Department, MRC-166, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560, U.S.A.

TAXA NAMED FOR F. RAYMOND FOSBERG

Shortly before Dr. Fosberg died, I reported to him that his moss, *Pottia fosbergii* (see below), had been demoted to a variety, *Pottia sterkeana* var. *fosbergii*. He commented that it was the first species named for him, based on material that he collected shortly before his twentieth birthday in 1928 as a student of Philip Munz at Pomona College.

On a more personal note, some of Dr. Fosberg's colleagues have told me that he was pleased that *Emilia fosbergii* was named for him. Dr. Fosberg showed me how to tell the three confused neotropical species apart, almost at arm's length. This species, going under a misapplied name, was new so I named it for him. In any case, wherever he went in the tropics, he could point out this widespread weed and tell listeners that it was named for him.

The *Manual of Flowering Plants of Hawai'i* says that Fosberg's lovegrass (*Eragrostis fosbergii*) is extinct. Throughout his career Dr. Fosberg supported conservation and warned of the dangers of man's destruction of habitats. Are others extinct?

Fifty-one names in his honor have been located, although some are transfers of the same taxon, such as Bernardi's transferring *Cussonia fosbergiana* to *Schefflera*. One invalidly published name, a nomen nudum, has been omitted: *Serianthes minhassae* subsp. *fosbergii* Kanis in Brunonia 2: 302. 1980 (= *Albizia melanesica* Fosberg).

There is a distinction between adjectival and substantive epithets. Adjectival epithets, agreeing in gender, number and case with the generic name (*fosbergianus, -a, -um*), are appropriate to honor someone who has not had a direct part in the taxon itself, such as a professor, supporter, etc., and is literally translated from Latin as "the Fosbergian *Cussonia*." Substantive epithets, nouns with independent gender, number and case, are in genitive case (*fosbergii*) and are appropriate to honor one who has had a direct and substantive part in the taxon, such as having collected it, recognized it as new, etc., literally "Fosberg's *Emilia*." Recent workers may be unaware of the distinction and use the substantive form because it is shorter. Nevertheless, of the species named in Fosberg's honor, he appears to have a substantive, direct part in 90% (*fosbergii*) and an indirect part in 10% (*fosbergianus, -a, -um*), the mark of an active field worker.

Musci

Ectropothecium fosbergii E. B. Bartram in Occas. Pap. Bernice P. Bishop Mus. 15(27): 346 (1940).

Phascum fosbergii (E. B. Bartram) J. Guerra in J. Bryol. 16: 59 (1990) (*Pottia fosbergii*).

Pottia fosbergii E. B. Bartram in Bryologist 33: 18 (1930).

Pottia sterkeana var. *fosbergii* (E. B. Bartram) R. H. Zander in Novon 3: 92 (1993) (*Pottia fosbergii*).

Acanthaceae

Aphelandra fosbergii Leonard in Contrib. U. S. Natl. Herb. 31: 711 (1958).

Aquifoliaceae

Ilex fosbergiana S. Y. Hu in J. Jap. Bot. 46: 68 (1971).

Araliaceae

Cheirodendron trigynum var. *fosbergii* Sherff in Bot. Leafl. 5: 7 (1951).
Cussonia fosbergiana Bernardi in Ber. Schweiz. Bot. Ges. 76: 363 (1966).
Schefflera fosbergiana (Bernardi) Bernardi in Candollea 24: 117 (1969) (*Cussonia fosbergiana*).

Asteraceae (Compositae)

Adenostemma fosbergii R. M. King & H. Rob. in Phytologia 29: 6 (1974).
Ageratina fosbergii R. M. King & H. Rob. in Phytologia 28: 495 (1974).
Emilia fosbergii Nicolson in Phytologia 32: 34 (1975).
Diplostephium fosbergii Cuatrec. in Bull. Torrey Bot. Club 80: 403 (1953).
Hesperomannia bushiana var. *fosbergii* Degener, Fl. Haw. Fam. 344 *Hesperomannia bushiana* [unpaged] (1937).
Munnozia fosbergii H. Rob. in Phytologia 34: 382 (1976).
Perezia fosbergii Tovar in Publ. Mus. Hist. Nat. "Javier Prado", ser. B, Bot. 1(8):22 (1955).
Pluchea fosbergii Cooperr. & Galang in Amer. J. Bot. 52: 1025 (1965).
Senecio fosbergii Cuatrec. in Feddes Repert. Spec. Nov. Regni Veg. 55: 138 (1953).

Cactaceae

Opuntia fosbergii C. B. Wolf in Occas. Papers Rancho Santa Ana Bot. Gard. 2: 79 (1938).

Cyclanthaceae

Sphaeradenia fosbergii Harling in Acta Hort. Berg. 18: 353 (1958).

Cyperaceae

Fimbristylis fosbergiana T. Koyama in Bull. Arts & Sci. Div. Ryukyu Univ. 3 : 66 1959).

Ericaceae

Themistoclesia fosbergii A. C. Sm. in Amer. J. Bot. 40: 470 (1953).

Fabaceae (Leguminosae)

Schleinitzia fosbergii Nevling & Niezgoda in Adansonia, n. s. 18: 362 (1978).

Gesneriaceae

Cyrtandra fosbergii St. John & Storey in Occas. Pap. Bernice P. Bishop Mus. 20(16): 84 (1950).
Cyrtandra grayana var. *fosbergii* St. John in Phytologia 63: 479 (1987).

Lauraceae

Litsea fosbergii Kosterm. in Ceylon J. Sci., Biol. Sci. 9: 51 (1971).

Loganiaceae

Labordia kaalae var. *fosbergii* Sherff in Amer. J. Bot. 5: 588 (1938).

Marcgraviaceae

Gravia fosbergiana Ewan in Nat. Hist. Misc. 88: 2 (1951).

Melastomataceae

Miconia fosbergii Wurdack in Phytologia 11: 390 (1965).

Menispermaceae

Tinospora fosbergii Kundu in Ceylon J. Sci., Biol. Sci. 12: 49 (1976).

Monimiaceae

Siparuna fosbergii A. C. Sm. in Amer. J. Bot. 40: 469 (1953).

Myrsinaceae

Myrsine fosbergii Hosaka in Occas. Papers Bernice P. Bishop Mus. 16(2): 46 (1940).
Myrsine meziana var. *fosbergii* (Hosaka) Wilbur in Pac. Sci. 19: 522 (1965) (*Myrsine fosbergii*).
Rapanea fosbergii (Hosaka) Degener & I. Degener in Phytologia 22: 212 (1971) (*Myrsine fosbergii).*

Onagraceae

Fuchsia fosbergii Munz in Aliso 7: 409 (1972).

Pandanaceae

Pandanus fosbergii St. John in Pacific Sci. 15: 331 (1961).

Piperaceae

Peperomia fosbergii Yunck. in Bernice P. Bishop Mus. Bull. 143: 46 (1937).
Piper fosbergii Trel. in Lloydia 3: 111 (1940).

Pittosporaceae

Pittosporum insigne var. *fosbergii* Sherff in Field Mus. Nat. Hist., Bot. Ser. 22: 413 (1941).

Poaceae (Gramineae)

Eragrostis fosbergii Whitney in Occas. Pap. Bernice P. Bishop Mus. 13(8): 75 (1937).

Polygalaceae

Monnina fosbergii Ferreyra in Phytologia 69: 356 (1990).

Portulacaceae

Portulaca fosbergii Poelln. in Occas. Pap. Bernice P. Bishop Mus. 12(9): 3 (1936).

Rubiaceae

Arachnothrix fosbergii Steyerm. in Mem. New York Bot. Gard. 17: 255 (1967).
Galium fosbergii Dempster in Madroño 35: 3 (1988).
Gardenia fosbergii Tirveng. in Nordic J. Bot. 3: 460 (1983).
Gouldia fosbergii Degener & I. Degener in Phytologia 15: 49 (1967).
Hedyotis fosbergii W. L. Wagner & D. R. Herbst in Bishop Mus. Occas. Pap. 29: 111 (1989).
Psychotria fosbergii Steyerm. in Mem. New York Bot. Gard. 23: 630 (1972).
Psychotria fosbergii Sohmer in Bot. Notiser 129: 381 (1977) (= *Psychotria sohmeri* Kiehn 1986).

Solanaceae

Solanum fosbergianum D'Arcy in Ann. Missouri Bot. Gard. 60: 700 (1974).

Tiliaceae

Trichospermum fosbergii Kosterm. in Trans. Bot. Soc. Edinburgh 41: 416 (1972).

TAXA NAMED BY F. RAYMOND FOSBERG

The basic input was again taken from *Index Kewensis* on CD-ROM, this time by Dr. Joseph Kirkbride (US Department of Agriculture). Ellen Farr (Smithsonian Botany Department) brought Dr. Kirkbride's data through a database (DBase IV) into text. I am very grateful to them for their time and trouble. I then removed all entries with Fosberg as an author in parentheses (transfer of a Fosberg taxon), such as *Chamaesyce stoddartii* (Fosberg) J. Sojak, unless it was made by Fosberg, such as *Casuarina litorea* var. *souderi* (Fosberg) Fosberg & Sachet. I also removed "Fosberg ex" citations, such as *Hedyotis angulata* Fosberg ex Shinners since Dr. Fosberg was not actually an author. At that point there were 466 entries.

A card file of taxa named by Dr. Fosberg was the basis for additions. Finally, his recent papers were scanned for new taxa. When this was completed there were 993 entries.

The bulk of the new entries concern infraspecific names. No effort was made to include autonyms (a trinomial combination in which the final epithet is the same as the species epithet). Infraspecific uses of "*eu*-" epithets were also omitted. An example is *Gouldia terminalis* var. *ovata* f. *euovata* (a classification, not a combination) which becomes *Gouldia terminalis* f. "*euovata*" (a combination, not a classification). Names with such epithets are invalidly published under Art. 24.3. A similar problem involves *Gouldia terminalis* var. *ovata* f. *russii* (Brittonia 8: 176. 1956). This, reduced from a classification to the combination *G. terminalis* f. *russii,* is an isonym of *G. terminalis*

f. *russii* Fosberg (Bernice P. Bishop Mus. Bull. 147: 49. 1937), not a new combination based on it, there classified as a form of *G. terminalis* var. *kaala*. In short, moving a forma from one variety to another in the same species, does not create a new name.

Fungi

Diaporthopsis metrosideri Roane & Fosberg in Mycologia 75: 165 (1983). [Pyrenomycetes]

Pteridophyta

Gleicheniaceae

Gleichenia linearis var. *latiloba* (Holttum) Fosberg in Smithsonian Contr. Bot. 45: 4 (1980).

Gleichenia linearis var. *tomentosa* (Luerss.) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 24(2): 10 (1969).

Gleichenia weatherbyi Fosberg in Amer. Fern J. 40: 140 (1950).

Hymenophyllaceae

Hymenophyllum alternatum Fosberg in Amer. Fern J. 40: 135 (1950).

Hymenophyllum digitaria (Sw.) Fosberg in Smithsonian Contr. Bot. 45: 1 (1980).

Trichomanes javanicum var. *boryanum* (Kunze) Fosberg in Amer. Fern J. 40: 136 (1950).

Lycopodiaceae

Lycopodium phlegmaria var. *mirabile* (Willd.) Fosberg in Lloydia 3: 110. (1940).

Ophioglossaceae

Ophioglossum pendulum var. *falcatum* (Presl) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 23(2): 29 (1962).

Polypodiaceae

Dryopteris goggilodus (Schkuhr) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 16(15): 337 (1942).

Polypodium katuii (Brownlie) Fosberg in Micronesica 23: 1 (1990).

Sphenomeris chinensis var. *hawaiiensis* Fosberg & Sachet in Micronesica 18(1): 131 (1983 "1982").

Sphenomeris chinensis var. *tenuisecta* Fosberg & Sachet in Micronesica 18(1): 132 (1983 "1982").

Thelypteris carolinensis (Hosok.) Fosberg in Smithsonian Contr. Bot. 45: 4 (1980).

Thelypteris cyatheoides (Kaulf.) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 23(2): 30 (1962).

Thelypteris fadenii Fosberg & Sachet in Smithsonian Contr. Bot. 8: 9 (1972).

Thelypteris guamensis (Holttum) Fosberg & Sachet in Amer. Fern. J. 71: 82 (1981).

Thelypteris opulenta (Kaulf.) Fosberg in Smithsonian Contr. Bot. 8: 3 (1972).

Thelypteris opulenta var. *hirsuta* (Ching) Fosberg in Smithsonian Contr. Bot. 8: 6 (1972).

Thelypteris parasitica (L.) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 23(2): 30 (1962).

Thelypteris peliliuensis Fosberg in Smithsonian Contr. Bot. 45: 4 (1980).

Thelypteris rupi-insularis Fosberg in Smithsonian Contr. Bot. 45: 5 (1980).

Thelypteris sandwicensis (Hook. & Arn.) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 23(2): 30 (1962).

Thelypteris stenogrammoides (Baker) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 23(2): 30 (1962).

Thelypteris wagneri Fosberg & Sachet in Smithsonian Contr. Bot. 8: 6 (1972).

Schizaeaceae

Lygodium circinnatum var. *semihastatum* (Cav.) Fosberg in Amer. Fern J. 40: 142 (1950).

Schizaea dichotoma var. *sellingii* Fosberg in Amer. Fern J. 40: 144 (1950).

Spermatophyta

Acanthaceae

Hygrophila triflora (Roxb.) Fosberg & Sachet in Baileya 21: 147 (1981).

Pseuderanthemum bibracteatum Fosberg in Lloydia 3: 119 (1940).

Pseuderanthemum bibracteatum f. *ochraceum* Fosberg in Lloydia 3: 121 (1940).

Pseuderanthemum carruthersii var. *atropurpureum* (Bull) Fosberg in Phytologia 5: 290 (1955).

Pseuderanthemum carruthersii var. *reticulatum* (Bull) Fosberg in Smithsonian Contr. Bot. 45: 26 (1980).

Pseuderanthemum palauense Fosberg & Sachet in Smithsonian Contr. Bot. 45: 27 (1980).

Aceraceae

Acer nigrum var. *floridanum* (Chapm.) Fosberg in Castanea 19: 27 (1954).

Acer nigrum var. *glaucum* (Schmidt) Fosberg in Castanea 19: 27 (1954).

Acer nigrum var. *grandidentatum* (Torr. & A. Gray) Fosberg in Castanea 19: 27 (1954).

Acer nigrum var. *leucoderme* (Small) Fosberg in Castanea 19: 27 (1954).

Acer nigrum var. *pseudoplatanoides* (Pax) Fosberg in Amer. Midl. Naturalist 26: 695 (1941).

Acer nigrum var. *schneckii* (Rehder) Fosberg in Castanea 19: 27 (1954).

Acer nigrum var. *sinuosum* (Sarg.) Fosberg in Castanea 19: 27 (1954).

Aizoaceae

Sesuvium portulacastrum var. *griseum* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 21(14): 47 (1952).

Amaranthaceae

Alternanthera paronychioides var. *bettzickiana* (Regel) Fosberg in Willdenowia 20: 259 (1991).

Lagrezia oligomeroides (C. H. Wright) Fosberg in Kew Bull. 29: 262 (1974).

Amaryllidaceae

Crinum asiaticum var. *pedunculatum* (R. Br.) Fosberg & Sachet in Micronesica 20: 131 (1988 "1987").

Apocynaceae

Alstonia marquisensis M. L. Grant ex Fosberg & Sachet in Micronesica 8: 46 (1972).
Alyxia stellata var. *deckeri* Fosberg & Sachet in Micronesica 10: 254 (1974).
Alyxia stellata var. *fatuhivensis* Fosberg & Sachet in Micronesica 10: 254 (1974).
Alyxia stellata var. *marquesensis* (F. Br.) Fosberg & Sachet in Micronesica 10: 253 (1974).
Melodinus insularis (Markgr.) Fosberg in Micronesica 23: 150 (1990).
Neisosperma acuminata (Valeton) Fosberg & Sachet in Adansonia, n. s. 17: 28 (1977) without basionym page.
Neisosperma apoensis (Elmer) Fosberg & Sachet in Adansonia, n. s. 17: 28 (1977).
Neisosperma brownii Fosberg & Sachet in Micronesica 8: 49 (1972).
Neisosperma citrodora (Lauterb. & K. Schum.) Fosberg & Sachet in Adansonia, n. s. 17: 29 (1977).
Neisosperma ficifolia (S. Moore) Fosberg & Sachet in Adansonia, n. s. 17: 29 (1977).
Neisosperma glomerata (Blume) Fosberg & Sachet in Adansonia, n. s. 17: 29 (1977).
Neisosperma iwasakiana (Koidz.) Fosberg & Sachet in Adansonia, n. s. 17: 29 (1977).
Neisosperma kilneri (F. Muell.) Fosberg & Sachet in Adansonia, n. s. 17: 29 (1977).
Neisosperma nakaiana (Koidz.) Fosberg & Sachet in Adansonia, n. s. 17: 30 (1977).
Neisosperma oppositifolia (Lam.) Fosberg & Sachet in Micronesica 8: 48 (1972).
Neisosperma poweri (F. M. Bailey) Fosberg & Sachet in Adansonia, n. s. 17: 31 (1977).
Neisosperma rudis (Markgr.) Fosberg & Sachet in Adansonia, n. s. 17: 31 (1977).
Neisosperma sciadophylla (Markgr.) Fosberg & Sachet in Adansonia, n. s. 17: 31 (1977).
Ochrosia coccinea var. *peekelii* (Markgr.) Fosberg & Sachet in Adansonia, n. s. 17: 25 (1977).
Ochrosia fatuhivensis Fosberg & Sachet in Micronesica 8: 48 (1972).
Ochrosia mariannensis var. *crassicarpa* Fosberg & Falanruw in Micronesica 11: 80 (1975).
Ochrosia minima (Markgr.) Fosberg & Boiteau in Adansonia, n. s. 17: 27 (1977).
Ochrosia nukuhivensis Fosberg & Sachet in Micronesica 8: 48 (1972).
Ochrosia solomonensis (Merr. & Perry) Fosberg & Boiteau in Adansonia, n. s. 17: 28 (1977).
Rauvolfia sachetiae Fosberg in Smithsonian Contr. Bot. 47: 21 (1981).

Araceae

Rhaphidophora carolinensis (Volkens) Fosberg in Smithsonian Contr. Bot. 45: 5 (1980).

Araliaceae

Osmoxylon mariannense (Kaneh.) Fosberg & Sachet in Smithsonian Contr. Bot. 45: 16 (1980).

Osmoxylon oliveri Fosberg & Sachet in Smithsonian Contr. Bot. 45: 16 (1980).

Osmoxylon pachyphyllum (Kaneh.) Fosberg & Sachet in Smithsonian Contr. Bot. 45: 16 (1980).

Osmoxylon truncatum (Kaneh.) Fosberg & Sachet in Smithsonian Contr. Bot. 45: 16 (1980).

Polyscias scutellaria (Burm. f.) Fosberg in Occas. Pap. Univ. Hawaii 46: 9 (1948).

Polyscias tricochleata (Miq.) Fosberg in Phytologia 5: 290 (1955).

Arecaceae (Palmae)

Clinostigma carolinense (Becc.) H. E. Moore & Fosberg in Gentes Herb. 8: 462 (1956).

Clinostigma ponapense (Becc.) H. E. Moore & Fosberg in Gentes Herb. 8: 463 (1956).

Clinostigma savoryanum (Rehder & E. H. Wilson) H. E. Moore & Fosberg in Gentes Herb. 8: 465 (1956).

Clinostigma smithii (Burret) H. E. Moore & Fosberg in Gentes Herb. 8: 462 (1956)

Gulubia palauensis (Becc.) H. E. Moore & Fosberg in Gentes Herb. 8: 455 (1956).

Ptychosperma hosinoi (Kaneh.) H. E. Moore & Fosberg in Gentes Herb. 8: 468 (1956).

Ptychosperma ledermannianum (Becc.) H. E. Moore & Fosberg in Gentes Herb. 8: 469 (1956).

Ptychosperma palauense (Kaneh.) H. E. Moore & Fosberg in Gentes Herb. 8: 470 (1956).

Asclepiadaceae

Dischidia melanesica Fosberg in Lloydia 3: 116 (1940).

Hoya dodecatheiflora Fosberg in Lloydia 3: 118 (1940).

Asteraceae (Compositae)

Dubautia sherffiana Fosberg in Bull. Torrey Bot. Club 70: 395 (1943).

Emilia alstonii Fosberg in Ceylon J. Sci., Biol. Sci. 10: 66 (1972).

Emilia baldwinii Fosberg in Ceylon J. Sci., Biol. Sci. 10: 68 (1972).

Emilia exserta Fosberg in Ceylon J. Sci., Biol. Sci. 10: 65 (1972).

Emilia speeseae Fosberg in Ceylon J. Sci., Biol. Sci. 10: 67 (1972).

Wedelia biflora var. *canescens* (Gaudich.) Fosberg in Phytologia 5: 291 (1955).

Wollastonia biflora var. *canescens* (Gaudich.) Fosberg in Smithsonian Contr. Bot. 45: 33 (1980).

Wollastonia lifuana (Hochr.) Fosberg in Allertonia 7: 80 (1993).

Bignoniaceae

Chilopsis linearis var. *arcuata* Fosberg in Madroño 3: 366 (1936).

Chilopsis linearis var. *glutinosa* (Engelm.) Fosberg in Madroño 3: 365 (1936).

Boraginaceae

Heliotropium procumbens var. *depressum* (Cham.) Fosberg & Sachet in Smithsonian Contr. Bot. 45: 24 (1980).

Brassicaceae (Cruciferae)

Lepidium bidentatum var. *o-waihense* (Cham. & Schtdl.) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 24(2): 17 (1969).

Lepidium bidentatum var. *remyi* (Drake) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 24(2): 18 (1969).

Cactaceae

Coryphantha bella (Britton & Rose) Fosberg in Bull. S. Calif. Acad. Sci. 30: 58 (1931).

Coryphantha chaffeyi (Britton & Rose) Fosberg in Bull. S. Calif. Acad. Sci. 30: 58 (1931).

Coryphantha chihuahensis (Britton & Rose) Fosberg in Bull. S. Calif. Acad. Sci. 30: 58 (1931).

Coryphantha dasycantha (Engelm.) Fosberg in Bull. S. Calif. Acad. Sci. 30: (1931).

Coryphantha lloydii (Britton & Rose) Fosberg in Bull. S. Calif. Acad. Sci. 30: 58 (1931).

Coryphantha piercei Fosberg in Bull. S. Calif. Acad. Sci. 30: 58 (1931).

Coryphantha sneedii (Britton & Rose) Fosberg in Bull. S. Calif. Acad. Sci. 30: 58 (1931).

Coryphantha tuberulosa (Engelm.) Fosberg in Bull. S. Calif. Acad. Sci. 30: 58 (1931).

Echinocactus johnstonianus (Britton & Rose) Fosberg in Amer. Midl. Naturalist 27: 257 (1942).

Echinocereus englemannii var. *munzii* (Parish) Fosberg in Bull. S. Calif. Acad. Sci. 32: 123 (1933).

Neomammillaria subg. *Dolichothele* (Schum.) Fosberg in Bull. S. Calif. Acad. Sci. 30: 57 (1931).

Neomammillaria subg. *Galactochylus* (Schum.) Fosberg in Bull. S. Calif. Acad. Sci. 30: 58 (1931), based on generic type.

Neomammillaria subg. *Hydrochylus* (Schum.) Fosberg in Bull. S. Calif. Acad. Sci. 30: 56 (1931).

Neomammillaria subg. *Phyllospermum* (Britton & Rose) Fosberg in Bull. S. Calif. Acad. Sci. 30: 57 (1931).

Neomammillaria subg. *Solisia* (Britton & Rose) Fosberg in Bull. S. Calif. Acad. Sci. 30: 57 (1931).

Neomammillaria echinops (Scheidw.) Fosberg in Bull. S. Calif. Acad. Sci. 30: 56 (1931).

Neomammillaria longimamma (DC.) Fosberg in Bull. S. Calif. Acad. Sci. 30: 58 (1931).

Neomammillaria pectinata (B. Stein) Fosberg in Bull. S. Calif. Acad. Sci. 30: 58 (1931).

Neomammillaria sphaerica (Dietr.) Fosberg in Bull. S. Calif. Acad. Sci. 30: 58 (1931).

Neomammillaria tetrancistra (Engelm.) Fosberg in Bull. S. Calif. Acad. Sci. 30: 57 (1931).

Neomammillaria uberiformis (Zucc.) Fosberg in Bull. S. Calif. Acad. Sci. 30: 58 (1931).

Neomammillaria zeyeriana (F. Haage) Fosberg in Bull. S. Calif. Acad. Sci. 30: 56 (1931).

Opuntia bigelovii var. *hoffmannii* Fosberg in Bull. S. Calif. Acad. Sci. 32: 121 (1933).

Opuntia engelmannii var. *megacarpa* (Griffiths) Fosberg in Bull. S. Calif. Acad. Sci. 33: 100 (1934).

Opuntia engelmannii var. *wootonii* (Griffiths) Fosberg in Bull. S. Calif. Acad. Sci. 30: 59 (1931).

Opuntia phaeacantha var. *covillei* (Britton & Rose) Fosberg in Bull. S. Calif. Acad. Sci. 33: 102 (1934).

Opuntia phaeacantha var. *mojavensis* (Engelm. & Bigel.) Fosberg in Bull. S. Calif. Acad. Sci. 33: 103 (1934).

Opuntia phaeacantha var. *piercei* Fosberg in Bull. S. Calif. Acad. Sci. 33: 102 (1934).

Campanulaceae

Campanula divaricata f. *alba* Fosberg in Castanea 20: 60 (1955).

Lobelia gaudichaudii var. *koolauensis* Hosaka & Fosberg in Occas. Pap. Bernice P. Bishop Mus. 14(1): 4. (1938).

Rollandia lanceolata var. *kipapensis* Hosaka ex Fosberg in Occas. Pap. Bernice P. Bishop Mus. 12(15): 10 (1936).

Caprifoliaceae

Sambucus racemosa var. *arborescens* (Torr. & A. Gray) Fosberg in Amer. Midl. Naturalist 37: 765 (1942).

Caryophyllaceae

Drymaria gentryi Fosberg in Proc. Biol. Soc. Wash. 62: 147 (1949).

Drymaria stipitata Fosberg in Lloydia 4: 281 (1941).

Casuarinaceae

Casuarina equisetifolia var. *souderi* Fosberg in Micronesica 2: 143 (1966).

Casuarina litorea var. *souderi* (Fosberg) Fosberg & Sachet in Smithsonian Contr. Bot. 24: 6 (1975).

Celastraceae

Loeseneriella macrantha var. *palauica* (Loes.) Fosberg in Smithsonian Contr. Bot. 45: 12 (1980).

Maytenus palauica (Loes.) Fosberg in Phytologia 5: 290 (1955).

Maytenus thompsonii (Merr.) Fosberg in Phytologia 5: 290 (1955).

Chenopodiaceae

Atriplex argentea var. *caput-medusae* (Eastw.) Fosberg in Amer. Midl. Naturalist 26: 693 (1941).

Atriplex phyllostegia var. *draconis* (Jones) Fosberg in Amer. Midl. Naturalist 26: 694 (1941).

Atriplex tenuissima var. *greenei* (Nelson) Fosberg in Amer. Midl. Naturalist 27: 253 (1942).

Chenopodium fremontii var. *atrovirens* (Rydb.) Fosberg in Amer. Midl. Naturalist 26: 691 (1941).

Chenopodium oahuense var. *discosperma* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 23(2): 35 (1962).

Clusiaceae (Guttiferae)

Calophyllum inophyllum var. *takamaka* Fosberg in Kew Bull. 29: 255 (1974).

Calophyllum inophyllum var. *wakamatsui* (Kaneh.) Fosberg & Sachet in Smithsonian Contr. Bot. 45: 12 (1980).

Garcinia ponapensis var. *trukensis* (Kaneh.) Fosberg in Smithsonian Contr. Bot. 45: 13 (1980).

Garcinia rumiya var. *calcicola* Fosberg in Smithsonian Contr. Bot. 45: 14 (1980).

Garcinia laddii Fosberg in Pac. Sci. 31: 297 (1977). [fossil]

Combretaceae

Terminalia glabrata var. *brownii* Fosberg & Sachet in Smithsonian Contr. Bot. 47: 15 (1981).

Terminalia glabrata var. *haroldii* (Exell) Fosberg & Sachet in Smithsonian Contr. Bot. 47: 16 (1981).

Terminalia glabrata var. *intonsa* Fosberg in Micronesica 23: 2 (1990).

Terminalia glabrata var. *koariki* (Exell) Fosberg & Sachet in Smithsonian Contr. Bot. 47: 16 (1981).

Terminalia glabrata var. *rarotongensis* Fosberg & Sachet in Smithsonian Contr. Bot. 47: 16 (1981).

Terminalia rostrata Fosberg & Falanruw in Phytologia 28: 469 (1974).

Connaraceae

Connarus semidecandrus var. *gaudichaudii* (DC.) Fosberg in Micronesica 11: 82 (1975).

Convolvulaceae

Ipomoea indica var. *acuminata* (Vahl) Fosberg in Bot. Not. 129: 38 (1976).

Ipomoea indica var. *hosakae* Fosberg in Micronesica 2: 151 (1966).

Ipomoea setifera var. *fimbriosepala* (Choisy) Fosberg in Smithsonian Contr. Bot. 36: 24 (1977).

Ipomoea tiliacea var. *merremioides* Fosberg in Smithsonian Contr. Bot. 21: 14 (1975).

Ipomoea tiliacea var. *smithii* Fosberg in Smithsonian Contr. Bot. 21: 15 (1975).

Cornaceae

Cornus sericea f. *baileyi* (Coult. & Evans) Fosberg in Bull. Torrey Bot. Club 69: 588 (1942).

Cornus sericea f. *californica* (Meyen) Fosberg in Bull. Torrey Bot. Club 69: 589 (1942).
Cornus sericea f. *interior* (Rydb.) Fosberg in Bull. Torrey Bot. Club 69: 588 (1942).
Cornus sericea f. *occidentalis* (Torr. & A. Gray) Fosberg in Bull. Torrey Bot. Club 69: 589 (1942).
Cornus sericea subsp. *occidentalis* (Torr. & A. Gray) Fosberg in Bull. Torrey Bot. Club 69: 589 (1942).
Cornus sericea subsp. *stolonifera* (Michx.) Fosberg in Bull. Torrey Bot. Club 69: 587 (1942).
Cornus sericea subsp. *stolonifera* (Michx.) Fosberg in Bull. Torrey Bot. Club 69: 587 (1942).

Cucurbitaceae

Citrullus lanatus var. *caffrorum* (Alef.) Fosberg in Smithsonian Contr. Bot. 45: 15 (1980).
Trichosanthes hosokawae Fosberg in Occas. Pap. Bernice P. Bishop Mus. 22(1): 67 (1958).
Zehneria grayana (Cogn.) Fosberg & Sachet in Smithsonian Contr. Bot. 47: 12 (1981).
Zehneria grayana var. *vitiensis* (A. Gray) Fosberg & Sachet in Smithsonian Contr. Bot. 47: 13 (1981).
Zehneria guamensis (Merr.) Fosberg in Smithsonian Contr. Bot. 45: 15 (1980).
Zehneria samoensis (A. Gray) Fosberg & Sachet in Smithsonian Contr. Bot. 47: 12 (1981).

Cunoniaceae

Cunonia parviflora var. *glabrata* (F. Br.) Fosberg in Micronesica 8: 45 (1972).
Cunonia parviflora var. *marquesana* (F. Br.) Fosberg in Micronesica 8: 44 (1972).
Weinmannia parviflora var. *glabrata* (F. Br.) Fosberg in Micronesica 8: 45 (1972).
Weinmannia parviflora var. *marquesana* (F. Br.) Fosberg in Micronesica 8: 44 (1972).
Weinmannia parviflora var. *myrsinites* Fosberg & Sachet in Micronesica 8: 45 (1972).

Cyperaceae

Bulbostylis basalis Fosberg in Kew Bull. 31: 829 (1977).
Cyperus bigibbosa Fosberg in Kew Bull. 31: 832 (1977).
Cyperus niveus var. *leucocephalus* (Kunth) Fosberg in Kew Bull. 31: 835 (1977).
Cyperus odoratus var. *attenuatus* Fosberg & Sachet in Micronesica 20: 167 (1988 "1987").
Cyperus odoratus var. *curtispiculus* Fosberg & Sachet in Micronesica 20: 167 (1988 "1987").
Cyperus odoratus var. *novae-hannoverae* (Boeck.) Fosberg & Sachet in Micronesica 20: 168 (1988 "1987").
Fimbristylis juncea var. *marquesana* (Steud.) Fosberg in J. Jap. Bot. 63: 83 (1988).
Fimbristylis juncea var. *nukahivensis* (Steud.) Fosberg in J. Jap. Bot. 63: 82 (1988).
Fimbristylis juncea var. *separanda* (Jardin) Fosberg in J. Jap. Bot. 63: 81 (1988).
Fimbristylis juncea var. *tertia* (Jardin) Fosberg in J. Jap. Bot. 63: 81 (1988).

Fimbristylis sachetiana Fosberg in J. Jap. Bot. 63: 83 (1988).

Dioscoreaceae

Dioscorea esculenta var. *tiliifolia* (Kunth) Fosberg & Sachet in Micronesica 20: 135 (1988 "1987").

Ebenaceae

Diospyros sect. *Cupulifera* Fosberg in Bull. Torrey Bot. Club 65: 613 (1938).

Diospyros sect. *Ferreola* (Roxb.) Fosberg in Bull. Torrey Bot. Club 65: 609 (1938).

Diospyros christophersenii Fosberg in Bull. Torrey Bot. Club 65: 613 (1939).

Diospyros ellipticifolia var. *elliptica* (G. Forst.) Fosberg in Bull. Torrey Bot. Club 65: 611 (1939).

Diospyros ellipticifolia var. *iridea* Fosberg in Bull. Torrey Bot. Club 65: 612 (1939).

Diospyros ferrea f. *degeneri* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(10): 130 (1939).

Diospyros ferrea f. *kauaiensis* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(10): 131 (1939).

Diospyros ferrea f. *lanaiensis* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(10): 130 (1939).

Diospyros ferrea f. *obtusa* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(10): 127 (1939).

Diospyros ferrea f. *ovata* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(10): 127 (1939).

Diospyros ferrea f. *pubescens* (Skottsb.) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(10): 129 (1939).

Diospyros ferrea f. *sandwicensis* (A. DC.) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(10): 125 (1939).

Diospyros ferrea f. *subcoriacea* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(10): 127 (1939).

Diospyros ferrea f. *waiauensis* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(10): 128 (1939).

Diospyros ferrea f. *wiebkei* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(10): 131 (1939).

Diospyros ferrea subsp. *sandwicensis* (A. DC.) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(10): 122 (1939).

Diospyros ferrea var. *compacta* (R. Br.) Fosberg in Brittonia 40: 61 (1988).

Diospyros ferrea var. *degeneri* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(10): 129 (1939).

Diospyros ferrea var. *gillespiei* Fosberg in Bull. Torrey Bot. Club 65: 610 (1938).

Diospyros ferrea var. *kauaiensis* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(10): 130 (1939).

Diospyros ferrea var. *nandarivatensis* (Gillespie) Fosberg in Bull. Torrey Bot. Club 65: 610 (1938).

Diospyros ferrea var. *palauensis* (Kaneh.) Fosberg in Bull. Torrey Bot. Club 67: 417 (1940).

Diospyros ferrea var. *pubescens* (Skottsb.) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(10): 128 (1939).

Diospyros ferrea var. *savaiiensis* (Christ.) Fosberg in Bull. Torrey Bot. Club 65: 611 (1938).

Diospyros ferrea var. *sclerophylla* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(10): 129 (1939).

Diospyros ferrea var. *subimpressa* Fosberg in Bull. Torrey Bot. Club 65: 611 (1938).

Diospyros ferrea var. *toppingii* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(10): 129 (1939).

Diospyros globosa (A. C. Smith) Fosberg in Bull. Torrey Bot. Club 65: 612 (1939).

Diospyros hillebrandii (Seem.) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 12(15): 9 (1936).

Diospyros rufa (Labill.) Fosberg in Bull. Torrey Bot. Club 65: 613 (1939).

Diospyros samoensis var. *longisepala* (Gillespie) Fosberg in Bull. Torrey Bot. Club 67: 418 (1940).

Diospyros sandwicensis (A. DC.) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 12(15): 8 (1936).

Epacridaceae

Styphelia tameiameiae var. *hexamera* Fosberg & Hosaka in Occas. Pap. Bernice P. Bishop Mus. 14(1): 4 (1938).

Ericaceae

Vaccinium calycinum f. *grandifolium* (Wawra) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 16(15): 342 (1942).

Vaccinium calycinum f. *hamatidens* (H. Lév.) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 16(15): 343 (1942).

Vaccinium calycinum var. *grandifolium* (Wawra) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 16(15): 343 (1942).

Euphorbiaceae

Acalypha amentacea f. *circinata* (Müll. Arg.) Fosberg in Smithsonian Contr. Bot. 45: 11 (1980).

Acalypha amentacea subsp. *wilkesiana* (Müll. Arg.) Fosberg in Smithsonian Contr. Bot. 45: 10 (1980).

Acalypha amentacea var. *grandis* (Benth.) Fosberg in Smithsonian Contr. Bot. 45: 8 (1980).

Acalypha amentacea var. *heterotricha* Fosberg in Smithsonian Contr. Bot. 45: 9 (1980).

Acalypha amentacea var. *palauensis* Fosberg in Smithsonian Contr. Bot. 45: 9 (1980).

Acalypha amentacea var. *trukensis* (Pax & Hoffm.) Fosberg in Smithsonian Contr. Bot. 45: 10 (1980).

Acalypha amentacea var. *velutina* (Müll. Arg.) Fosberg in Smithsonian Contr. Bot. 45: 10 (1980).
Acalypha cardiophylla var. *ponapensis* (Kaneh. & Hatus.) Fosberg in Smithsonian Contr. Bot. 45: 11 (1980).
Acalypha crockeri Fosberg in Lloydia 3: 114 (1940).
Acalypha swallowensis Fosberg in Lloydia 3: 114 (1940).
Antidesma platyphylla var. *hamakuaense* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 12(15): 8 (1936).
Claoxylon ooumuense Fosberg & Sachet in Smithsonian Contr. Bot. 47: 6 (1981).
Euphorbia mertonii Fosberg in Kew Bull. 33: 181 (1978).
Euphorbia prostrata var. *candirhiza* Fosberg in Micronesica 25: 189 (1992).
Euphorbia stoddartii Fosberg in Kew Bull. 33: 182 (1978).
Glochidion cleistanthoides Fosberg in Willdenowia 20: 263 (1991).
Glochidion excorticans Fosberg in Willdenowia 20: 260 (1991).
Glochidion excorticans var. *calvum* Fosberg in Willdenowia 20: 261 (1991).
Glochidion hosokawae Fosberg in Willdenowia 20: 261 (1991).
Glochidion websteri Fosberg in Willdenowia 20: 262 (1991).
Jatropha integerrima var. *hastata* (Jacq.) Fosberg in Rhodora 78: 102 (1976).
Margaritaria anomala (Baillon) Fosberg in Kew Bull. 33: 185 (1978).
Margaritaria anomala var. *cheloniphorbe* (Hutch.) Fosberg in Kew Bull. 33: 185 (1978).
Melanolepis multiglandulosa var. *glabrata* (Müll. Arg.) Fosberg in Phytologia 5: 289 (1955).
Phyllanthus maderaspatensis var. *frazieri* Fosberg in Kew Bull. 33: 188 (1978).
Phyllanthus mckenziei Fosberg in Kew Bull. 33: 189 (1978).
Phyllanthus sandwicensis f. *rufidus* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 12(15): 6 (1936).

Fabaceae (Leguminosae)

Albizia sect. *Pachyspermae* (Benth.) Fosberg in Reinwardtia 7: 74 (1965).
Albizia eymae Fosberg in Reinwardtia 7: 87 (1965).
Albizia falcataria (L.) Fosberg in Reinwardtia 7: 88 (1965).
Albizia melanesica Fosberg in Reinwardtia 7: 85 (1965).
Albizia minhassae var. *ledermannii* (Harms) Fosberg in Reinwartdia 7: 85 (1965).
Albizia minhassae var. *proliferata* Fosberg in Reinwartdia 7: 83 (1965).
Albizia minhassae var. *umbellata* Fosberg in Reinwartdia 7: 84 (1965).
Albizia montana var. *kostermansii* Fosberg in Reinwartdia 7: 79 (1965).
Canavalia galatea var. *hawaiiensis* (Degener, I. Degener & Sauer) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 23(8): 132 (1966).
Canavalia galatea var. *kauaiensis* (Sauer) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 23(8): 132 (1966).
Canavalia galatea var. *molokaiensis* (Degener, I. Degener & Sauer) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 23(8): 132 (1966).
Canavalia megalantha var. *falanruwiae* Fosberg in Micronesica 11: 78 (1975).
Desmodium heterocarpon f. *substrigosum* Fosberg in Micronesica 2: 146 (1966).
Desmodium intortum var. *pilosiusculum* (DC.) Fosberg in Micronesica 4: 257 (1968).

Inocarpus fagifer (Parkinson) Fosberg in J. Wash. Acad. Sci. 31: 95 (1941).
Leucaena insularum var. *guamensis* Fosberg & B. C. Stone in Micronesica 2: 67 (1965).
Prosopis pallida f. *armata* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 23(8): 134 (1966).
Serianthes dilmyi Fosberg in Taxon 8: 65 (1959).
Serianthes ebudarum Fosberg in Reinwardtia 5: 307 (1960).
Serianthes kanehirae Fosberg in Reinwardtia 5: 302 (1960).
Serianthes kanehirae var. *hooglandii* Fosberg in Reinwardtia 5: 303 (1960).
Serianthes kanehirae var. *yapensis* Fosberg in Reinwardtia 5: 303 (1960).
Serianthes melanesica Fosberg in Reinwardtia 5: 312 (1960).
Serianthes melanesica var. *lifouensis* Fosberg in Reinwardtia 5: 314 (1960).
Serianthes melanesica var. *macdanielsii* Fosberg in Reinwardtia 5: 313 (1960).
Serianthes melanesica var. *meeboldii* Fosberg in Reinwardtia 5: 314 (1960).
Serianthes melanesica var. *yunkeri* Fosberg in Reinwardtia 5: 313 (1960).
Serianthes robinsonii Fosberg in Reinwardtia 5: 301 (1960).
Serianthes sachetiae Fosberg in Reinwardtia 5: 310 (1960).
Tephrosia purpurea var. *piscatoria* (Aiton) Fosberg in Micronesica 25: 187 (1992).

Flacourtiaceae

Flacourtia ramontchii var. *renvoizei* Fosberg in Kew Bull. 29: 254 (1974).
Flacourtia rukam var. *micronesica* Fosberg & Sachet in Smithsonian Contr. Bot. 45: 14 (1980).
Xylosma smithiana Fosberg in Allertonia 7: 66 (1993).

Gentianaceae

Fagraea berterana var. *galilai* (Gilg & Benedict) Fosberg in Smithsonian Contr. Bot. 45: 20 (1980).
Fagraea berterana var. *kusaiana* (Hosok.) Fosberg in Smithsonian Contr. Bot. 45: 20 (1980).
Fagraea berterana var. *ladronica* Fosberg in Smithsonian Contr. Bot. 45: 20 (1980).
Fagraea berterana var. *pogas* (Hosok.) Fosberg in Smithsonian Contr. Bot. 45: 21 (1980).
Fagraea berterana var. *sair* (Gilg & Benedict) Fosberg in Smithsonian Contr. Bot. 45: 21 (1980) without exact basionym page.

Geraniaceae

Geranium carolinianum var. *australe* (Benth.) Fosberg in Occas. Pap. Univ. Hawaii 32: 6 (1937).
Geranium cuneatum f. *rockii* (Skottsb.) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 12(16): 11 (1936).
Geranium cuneatum var. *menziesii* (A. Gray) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 12(16): 11 (1936).
Geranium cuneatum var. *tridens* (Hillebr.) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 12(16): 14 (1936).

Geranium humile var. *mauiense* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 12(16): 18 (1936).
Geranium multiflorum var. *ovatifolium* (A. Gray) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 16(15): 339 (1942).

Gesneriaceae

Cyrtandra ootensis var. *fatuhivensis* Fosberg & Sachet in Smithsonian Contr. Bot. 47: 30 (1981).
Cyrtandra ootensis var. *fatuhivensis* Fosberg & Sachet in Smithsonian Contr. Bot. 47: 30 (1981).
Cyrtandra ootensis var. *mollissima* Fosberg & Sachet in Smithsonian Contr. Bot. 47: 30 (1981).
Cyrtandra ootensis var. *mollissima* Fosberg & Sachet in Smithsonian Contr. Bot. 47: 30 (1981).
Cyrtandra ootensis var. *quaylei* Fosberg & Sachet in Smithsonian Contr. Bot. 47: 31 (1981).
Cyrtandra ootensis var. *quaylei* Fosberg & Sachet in Smithsonian Contr. Bot. 47: 31 (1981).
Cyrtandra revoluta Fosberg & Sachet in Smithsonian Contr. Bot. 47: 31 (1981).
Cyrtandra tahuatensis Fosberg & Sachet in Smithsonian Contr. Bot. 47: 31 (1981).
Cyrtandra thibaultii Fosberg & Sachet in Smithsonian Contr. Bot. 47: 28 (1981).

Goodeniaceae

Scaevola paulayi Fosberg in Micronesica 23: 3 (1990).
Scaevola sericea var *tuamotuensis* (St. John) Fosberg in Taxon 10: 226 (1961).

Hernandiaceae

Hernandia sonora var. *nymphaeifolia* (Presl) Fosberg in Micronesica 23: 142 (1990).

Hypericaceae

Hypericum degeneri Fosberg in Occas. Pap. Bernice P. Bishop Mus. 24(2): 21 (1969).
Hypericum hypericoides var. *multicaule* (Michx.) Fosberg in Castanea 30: 202 (1965).

Juncaceae

Luzula campestris var. *hawaiiensis* (Buch.) Degener & Fosberg in Degener, Fl. Haw. Fam. 66 Juncac.. [unpaged] (1937).
Luzula campestris var. *oahuensis* Degener & Fosberg in Degener, Fl. Haw. Fam. 66 Juncac.. [unpaged] (1937).

Lamiaceae (Labiatae)

Monarda fistulosa var. *brevis* Fosberg & Artz in Castanea 18: 130 (1953).
Phyllostegia mollis var. *resinosa* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 16(15): 345 (1942).

Lauraceae

Cryptocarya oahuensis (Degener) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 12(15): 3 (1936).

Liliaceae

Dianella saffordiana Fosberg & Sachet in Micronesica 20: 132 (1988 "1987").
Dianella sandwicensis var. *lavarum* (Degener) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 24(2): 12 (1969).
Dianella sandwicensis var. *multipedicellata* (Degener) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 24(2): 12 (1969).
Dracaena hawaiiensis (Degener) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 23(2): 32 (1962).

Loganiaceae

Fagraea berterana var. *marquisensis* Fosberg & Sachet in Phytologia 28: 471 (1974).
Geniostoma gagnae Fosberg & Sachet in Smithsonian Contr. Bot. 47: 18 (1981).
Geniostoma hallei Fosberg & Sachet in Smithsonian Contr. Bot. 21: 13 (1975).
Geniostoma hallei var. *fatuivense* Fosberg & Sachet in Smithsonian Contr. Bot. 47: 19 (1981).
Geniostoma hallei var. *hivaoense* Fosberg & Sachet in Smithsonian Contr. Bot. 47: 19 (1981).
Geniostoma micranthum var. *hoeferi* (Gilg & Benedict) Fosberg in Smithsonian Contr. Bot. 45: 23 (1980).
Geniostoma micranthum var. *paganense* Fosberg in Smithsonian Contr. Bot. 45: 23 (1980).
Geniostoma quadrangulare Fosberg in Smithsonian Contr. Bot. 21: 13 (1975).
Geniostoma rarotongensis Fosberg & Sachet in Smithsonian Contr. Bot. 47: 20 (1981).
Geniostoma sykesii Fosberg & Sachet in Smithsonian Contr. Bot. 47: 19 (1981).

Loranthaceae

Phoradendron bolleanum var. *capitellatum* (Trel.) Fosberg in Lloydia 4: 276 (1941).
Phoradendron bolleanum var. *densum* (Trel.) Fosberg in Lloydia 4: 276 (1941).
Phoradendron bolleanum var. *pauciflorum* (Torr.) Fosberg in Lloydia 4: 276 (1941).
Phoradendron flavescens (Nutt.) Fosberg in Lloydia 4: 279 (1941).
Phoradendron juniperinum var. *ligatum* (Trel.) Fosberg in Lloydia 4: 274 (1941).

Malvaceae

Abutilon asiaticum var. *albescens* (Miq.) Fosberg in Micronesica 2: 149 (1966).
Abutilon asiaticum var. *australiense* (Britten) Fosberg in Micronesica 2: 150 (1966).
Abutilon asiaticum var. *subasperum* Fosberg in Micronesica 2: 149 (1966).
Abutilon asiaticum var. *supraviride* Fosberg in Micronesica 2: 149 (1966).
Abutilon mangarevicum Fosberg in Smithsonian Contr. Bot. 47: 9 (1981).
Abutilon pitcairnense Fosberg in Smithsonian Contr. Bot. 47: 10 (1981).
Abutilon sachetianum Fosberg in Smithsonian Contr. Bot. 47: 7 (1981).
Abutilon whistleri Fosberg in Smithsonian Contr. Bot. 47: 10 (1981).

Hibiscus australensis Fosberg in Micronesica 2: 156 (1966).
Lebronnecia Fosberg in Adansonia, n. s. 6: 509 (1966).
Lebronnecia kokioides Fosberg in Adansonia, n. s. 6: 510 (1966).
Pavonia fryxelliana Fosberg & Sachet in Ceylon J. Sci., Biol. Sci. 15: 38 (1985 "1982").
Pavonia lourteigiae Fosberg & Sachet in Bull. Mus. Natl. Hist. Nat., B, Adansonia 1: 18 (1981).

Melastomataceae

Medinilla medinilliana (Gaudich.) Fosberg & Sachet in Smithsonian Contr. Bot. 45: 15 (1980).
Medinilla nodosa Fosberg in Lloydia 3: 115 (1940).
Melastoma malabathricum var. *mariannum* (Naudin) Fosberg & Sachet in Smithsonian Contr. Bot. 45: 15 (1980).

Meliaceae

Malleastrum leroyi Fosberg in Kew Bull. 29: 255 (1974).

Moraceae

Artocarpus altilis (Parkinson) Fosberg in J. Wash. Acad. Sci. 31: 95 (1941).
Batocarpus amazonicus (Ducke) Fosberg in Proc. Biol. Soc. Wash. 55: 101 (1942).
Ficus prolixa var. *carolinensis* (Warb.) Fosberg in Phytologia 5: 289 (1955).
Ficus prolixa var. *saffordii* (Merr.) Fosberg in Phytologia 5: 289 (1955).
Ficus tinctoria var. *neoebudarum* (Summerh.) Fosberg in Phytologia 5: 289 (1955).
Maillardia pendula Fosberg in Kew Bull. 29: 266 (1974).

Myrsinaceae

Maesa canfieldiae Fosberg & Sachet in Phytologia 44: 364 (1979).
Maesa carolinensis var. *kusaiensis* Fosberg & Sachet in Phytologia 44: 366 "365". (1979).
Maesa walkeri Fosberg & Sachet in Phytologia 44: 368 (1979).
Myrsine adamsonii Fosberg & Sachet in Smithsonian Contr. Bot. 21: 4 (1975).
Myrsine andersonii Fosberg & Sachet in Smithsonian Contr. Bot. 21: 4 (1975).
Myrsine brownii Fosberg & Sachet in Smithsonian Contr. Bot. 21: 5 (1975).
Myrsine carolinensis (Mez) Fosberg & Sachet in Smithsonian Contr. Bot. 45: 17 (1980).
Myrsine cheesemanii (Mez) Fosberg & Sachet in Smithsonian Contr. Bot. 21: 5 (1975).
Myrsine fasciculata (J. W. Moore) Fosberg & Sachet in Smithsonian Contr. Bot. 21: 6 (1975).
Myrsine fusca (J. W. Moore) Fosberg & Sachet in Smithsonian Contr. Bot. 21: 6 (1975).
Myrsine gracilissima Fosberg & Sachet in Smithsonian Contr. Bot. 21: 6 (1975).
Myrsine grantii Fosberg & Sachet in Smithsonian Contr. Bot. 21: 7 (1975).
Myrsine grantii var. *toviiensis* Fosberg & Sachet in Smithsonian Contr. Bot. 21: 8 (1975).

Myrsine hartii (M. L. Grant) Fosberg & Sachet in Smithsonian Contr. Bot. 21: 8 (1975).
Myrsine ledermannii (Mez) Fosberg & Sachet in Smithsonian Contr. Bot. 45: 17 (1980).
Myrsine naiuensis Fosberg & Sachet in Smithsonian Contr. Bot. 21: 8 (1975).
Myrsine nukuhivensis Fosberg & Sachet in Smithsonian Contr. Bot. 21: 9 (1975).
Myrsine obovata (J. W. Moore) Fosberg & Sachet in Smithsonian Contr. Bot. 21: 9 (1975).
Myrsine orohenensis (J. W. Moore) Fosberg & Sachet in Smithsonian Contr. Bot. 21: 9 (1975).
Myrsine ovalis var. *wilderi* Fosberg & Sachet in Smithsonian Contr. Bot. 21: 10 (1975).
Myrsine palauensis (Mez) Fosberg & Sachet in Smithsonian Contr. Bot. 45: 17 (1980).
Myrsine raiateensis (J. W. Moore) Fosberg & Sachet in Smithsonian Contr. Bot. 21: 10 (1975).
Myrsine rapensis (F. Br.) Fosberg & Sachet in Smithsonian Contr. Bot. 21: 10 (1975).
Myrsine ronuiensis (M. L. Grant) Fosberg & Sachet in Smithsonian Contr. Bot. 21: 10 (1975).
Myrsine st.-johnii (M. L. Grant) Fosberg & Sachet in Smithsonian Contr. Bot. 21: 10 (1975).
Myrsine tahuatensis Fosberg & Sachet in Smithsonian Contr. Bot. 21: 10 (1975).

Myrtaceae

Eugenia elliptica var. *levinervis* Fosberg in Kew Bull. 33: 134 (1978).
Pimenta racemosa var. *grisea* (Kiaersk.) Fosberg in Amer. Midl. Naturalist 27: 762 (1942).
Psidium cattleianum var. *littorale* (Raddi) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 23(2): 37 (1962).
Psidium littorale var. *longipes* (Berg) Fosberg in Proc. Biol. Soc. Washington 54: 180 (1941).
Psidium littorale var. *lucidum* (Degener) Fosberg in Proc. Biol. Soc. Washington 54: 180 (1941).

Nesogenaceae or Verbenaceae

Nesogenes euphrasioides var. *lineata* Fosberg in Micronesica 23: 2 (1990).
Nesogenes rotensis Fosberg & D. Herbst in Micronesica 19: 12 (1984 "1983").

Nyctaginaceae

Boerhavia albiflora Fosberg in Smithsonian Contr. Bot. 39: 11 (1978).
Boerhavia albiflora var. *heronensis* Fosberg in Brittonia 40: 59 (1988).
Boerhavia albiflora var. *powelliae* Fosberg in Smithsonian Contr. Bot. 39: 12 (1978).
Boerhavia crispifolia Fosberg in Smithsonian Contr. Bot. 39: 15 (1978).
Boerhavia fistulosa Fosberg in Brittonia 40: 57 (1988).
Boerhavia fistulosa var. *puberuliflora* Fosberg in Brittonia 40: 59 (1988).
Boerhavia herbstii Fosberg in Smithsonian Contr. Bot. 39: 17 (1978).
Boerhavia repens var. *maris-indici* Fosberg in Kew Bull. 33: 398 (1979) with type; et in Smithsonian Contr. Bot. 39: 9 (1978) without type.

Boerhavia repens var. *pubescens* (R. Br.) Fosberg in Smithsonian Contr. Bot. 39: 6 (1978).

Boerhavia rubicunda var. *stenophylla* (Boissier) Fosberg in Smithsonian Contr. Bot. 39: 14 (1978).

Pisonia wagneriana Fosberg in Phytologia 62: 177 (1987).

Oleaceae

Chionanthus sessiliflorus (Hemsl.) Fosberg in Micronesica 25: 197 (1992).

Onagraceae

Oenothera heterophylla var. *curtissii* (Rose) Fosberg in Amer. Midl. Naturalist 27: 763 (1942).

Oenothera heterophylla var. *rhombipetala* (Nutt.) Fosberg in Amer. Midl. Naturalist 27: 763 (1942).

Orchidaceae

Anoectochilus apiculatus L. O. Williams & Fosberg in Bull. Torrey Bot. Club 70: 387 (1943).

Habenaria setifera (Tuyama) Fosberg & Sachet in Micronesica 20: 142 (1988 "1987").

Liparis yamadae (Tuyama) Fosberg & Sachet in Micronesica 20: 141 (1988 "1987").

Malaxis calcarea (Schltr.) Fosberg & Sachet in Micronesica 20: 142 (1988 "1987").

Malaxis kerstingiana (Schltr.) Fosberg & Sachet in Micronesica 20: 143 (1988 "1987").

Malaxis trukensis (Fukuy.) Fosberg & Sachet in Micronesica 20: 143 (1988 "1987").

Malaxis volkensii (Schltr.) Fosberg & Sachet in Micronesica 20: 143 (1988 "1987").

Nervilia jacksoniae Rinehart & Fosberg in Micronesica 24: 81 (1991)

Rhynchophreatia carolinensis (Schltr.) Fosberg & Sachet in Micronesica 20: 152 (1988 "1987").

Rhynchophreatia pacifica (Fukuy.) Fosberg & Sachet in Micronesica 20: 152 (1988 "1987").

Oxalidaceae

Oxalis gagneorum Fosberg & Sachet in Smithsonian Contr. Bot. 47: 3 (1981).

Passifloraceae

Passiflora suberosa var. *perhastata* Fosberg in Micronesica 25: 193 (1992).

Piperaceae

Peperomia mariannensis f. *saipana* (C. DC.) Fosberg in Phytologia 13: 240 (1966).

Peperomia palauensis var *occidentalis* Fosberg in Smithsonian Contr. Bot. 24: 13 (1975).

Peperomia pallida var *anderssonii* (Yunck.) Fosberg & Sachet in Micronesica 8: 43 (1972).

Peperomia ponapensis var. *trukensis* (Yunck.) Fosberg in Phytologia 13: 241 (1966).
Piper betle f. *densum* (Blume) Fosberg in Phytologia 13: 235 (1966).
Piper betle f. *marianum* (Opiz) Fosberg in Phytologia 13: 236 (1966).
Piper guahamense f. *glabrum* (Yunck.) Fosberg in Phytologia 13: 235 (1966).
Piper hosokawae Fosberg in Phytologia 13: 237 (1966).

Poaceae (Gramineae)

Cynodon dactylon var. *parviglumis* (Ohwi) Fosberg & Sachet in Micronesica 18(2): 45 (1984 "1982").
Digitaria pruriens var. *microbachne* (Presl) Fosberg in Phytologia 5: 289 (1955).
Eragrostis whitneyi Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(3): 39 (1939).
Eragrostis whitneyi var *caumii* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(3): 41 (1939).
Isachne confusa var. *purpurascens* (Glassman) Fosberg & Sachet in Micronesica 18(2): 53 (1984 "1982").
Isachne miliacea var. *minutula* (Gaudich.) Fosberg & Sachet in Micronesica 18(2): 55 (1984 "1982").
Ischaemum longisetum var. *raulersoniae* Fosberg & Sachet in Micronesica 18(2): 62 (1984 "1982").
Ischaemum muticum var. *aristuliferum* Fosberg & Sachet in Micronesica 18(2): 64 (1984 "1982").
Ischaemum polystachyum var. *chordatum* (Trin.) Fosberg & Sachet in Micronesica 18(2): 66 (1984 "1982").
Ischaemum polystachyum var. *hillii* Fosberg & Sachet in Micronesica 18(2): 67 (1984 "1982").
Ischaemum polystachyum var. *intermedium* (Brongn.) Fosberg & Sachet in Micronesica 18(2): 67 (1984 "1982").
Lepturopetium marshallense Fosberg & Sachet in Micronesica 18(2): 72 (1984 "1982").
Lepturus gasparricensis Fosberg in Occas. Pap. Bernice P. Bishop Mus. 21(14): 293 (1955).
Lepturus repens var. *cinereus* (Burcham) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 21(14): 292 (1955).
Lepturus repens var. *occidentalis* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 21(14): 291 (1955).
Lepturus repens var. *septentrionalis* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 21(14): 291 (1955).
Lepturus repens var. *subulatus* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 21(14): 290 (1955).
Lepturus stoddartii Fosberg in Brittonia 40: 53 (1988).
Oplismenus hirtellus var. *imbecillis* (R. Br.) Fosberg & Sachet in Micronesica 18(2): 78 (1984 "1982").
Oplismenus hirtellus var. *microphyllus* (Honda) Fosberg & Sachet in Micronesica 18(2): 79 (1984 "1982").
Panicum reptans var. *burmanicum* (Hook. f.) Fosberg in Micronesica 2: 154 (1966).

Panicum reptans var. *marquisense* (F. Br.) Fosberg in Micronesica 2: 154 (1966).
Paspalum cartilagineum var. *biglumaceum* Fosberg & Sachet in Micronesica 18(2): 81 (1984 "1982").
Paspalum orbiculare var. *otobedii* Fosberg & Sachet in Micronesica 18(2): 83 (1984 "1982").
Pennisetum polystachion f. *viviparum* Fosberg & Sachet in Micronesica 18(2): 86 (1984 "1982").
Saccharum spontaneum var. *insulare* (Brongn.) Fosberg & Sachet in Micronesica 18(2): 89 (1984 "1982").
Sorghum bicolor var. *cafer* (Koern.) Fosberg & Sachet in Micronesica 18(2): 93 (1984 "1982").
Sorghum bicolor var. *obovatum* (Hack.) Fosberg & Sachet in Micronesica 18(2): 94 (1984 "1982").
Sorghum bicolor var. *rotundulum* (Snowden) Fosberg & Sachet in Micronesica 18(2): 94 (1984 "1982").
Sorghum bicolor var. *subglabrescens* (Steud.) Fosberg & Sachet in Micronesica 18(2): 95 (1984 "1982").
Sorghum bicolor var. *transiens* (Hack.) Fosberg & Sachet in Micronesica 18(2): 96 (1984 "1982").
Tridens flavus f. *cupreus* (Jacq.) Fosberg in Castanea 20: 58 (1955).
Triodia flava f. *cuprea* (Jacq.) Fosberg in Castanea 11: 67 (1946).

Polemoniaceae

Gilia aggregata var. *arizonica* (Greene) Fosberg in Amer. Midl. Naturalist 37: 764 (1942).

Polygonaceae

Eriogonum abertianum var. *bracteatum* Fosberg in Madroño 4: 192 (1938).
Eriogonum abertianum var. *cyclosepalum* (Greene) Fosberg in Madroño 4: 192 (1938).
Eriogonum abertianum var. *lappulaceum* Fosberg in Madroño 4: 193 (1938).
Eriogonum abertianum var. *villosum* Fosberg in Madroño 4: 191 (1938).
Eriogonum abertianum var.*gillespiei* Fosberg in Madroño 4: 193 (1938).
Rumex giganteus f. *coccineus* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 24(2): 16 (1969).

Portulacaceae

Lewisia pygmaea var. *nevadensis* (A. Gray) Fosberg in Amer. Midl. Naturalist 27: 256 (1942).
Portulaca mauritiensis var. *aldabrensis* Fosberg in Kew Bull. 32: 256 (1977).
Portulaca mauritiensis var. *grubbii* Fosberg in Kew Bull. 32: 258 (1977).
Portulaca oleracea var. *delicatula* Fosberg in Kew Bull. 32: 254 (1977).

Potamogetonaceae

Ruppia maritima f. *curvirostris* St. John & Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(16): 178 (1939).

Ruppia maritima f. *pacifica* St. John & Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(16): 177 (1939).

Ruppia maritima var. *pacifica* St. John & Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(16): 176 (1939).

Ranunculaceae

Anemone quinquefolia var. *lancifolia* (Pursh) Fosberg in Virginia J. Sci. 2: 108 (1941).

Rhamnaceae

Ceanothus dentatus var. *dickeyi* Fosberg in Amer. Midl. Naturalist 27: 256 (1942).

Gouania mangarevica Fosberg in Bull. Torrey Bot. Club 65: 607 (1939).

Rhamnus smithii var. *mulleri* Fosberg in Lloydia 4: 286 (1941).

Rhizophoraceae

Bruguiera gymnorhiza f. *alba* (B. C. Stone) Fosberg in Smithsonian Contr. Bot. 45: 15 (1980).

Rosaceae

Spiraea alba var. *septentrionalis* (Fern.) Fosberg in Castanea 30: 197 (1965).

Spiraea betulifolia f. *campii* Fosberg in Virginia J. Sci. 2: 109 (1941).

Rubiaceae

Subtr. *Coprosminae* Fosberg in Acta Phytotax. Geobot. 33: 75 (1982).

Bikkia mariannensis var. *longicarpa* (Valeton) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(20): 213 (1990).

Bobea platypes Fosberg in Phytologia 62: 179 (1987).

Calycosia macrocyatha Fosberg in Sargentia 1: 139 (1942).

Calycosia macrocyatha var. *kandavuensis* Fosberg in Sargentia 1: 140 (1942).

Canthium barbatum f. *calcicola* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 261 (1937).

Canthium barbatum f. *pitcairnense* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 260 (1937).

Canthium barbatum f. *rurutu* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 259 (1937).

Canthium barbatum f. *tubuai* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 259 (1937).

Canthium barbatum var. *australense* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 258 (1937).

Canthium barbatum var. *christianii* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 260 (1937).

Canthium barbatum var. *gambierense* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 261 (1937).

Canthium barbatum var. *huahinense* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 257 (1937).

Canthium barbatum var. *korrorense* (Valeton) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(20): 218 (1940).

Canthium barbatum var. *raiateense* (J. W. Moore) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 258 (1937).

Canthium barbatum var. *raivavaense* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 259 (1937).

Canthium barbatum var. *rapae* (Riley) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 260 (1937).

Canthium barbatum var. *rupestre* (Hosok.) Fosberg in Smithsonian Contr. Bot. 81: 52 (1993).

Canthium barbatum var. *societense* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 256 (1937).

Canthium barbatum var. *temehaniense* (J. W. Moore) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 258 (1937).

Canthium odoratum var. *tinianense* (Kaneh.) Fosberg in Phytologia 5: 291 (1955).

Coprosma cookei Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 289 (1937).

Coprosma esulcata (F. Br.) Fosberg in Brittonia 8: 178 (1956).

Coprosma longifolia var. *oppositifolia* Fosberg in Bull. Torrey Bot. Club 70: 394 (1943).

Coprosma oliveri Fosberg in Brittonia 20: 292 (1968).

Coprosma rapensis var. *benefica* (Oliver) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 288 (1937).

Coprosma rapensis var. *mangarevica* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 288 (1937).

Coprosma taitensis var. *glabrata* (J. W. Moore) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 284 (1937).

Coprosma taitensis var. *oliverii* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 284 (1937).

Coprosma taitensis var. *raiateensis* (J. W. Moore) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 284 (1937).

Coprosma velutina Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 285 (1937).

Coprosma velutina var. *andersonii* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 286 (1937).

Dolicholobium oblongifolium var. *degeneri* Fosberg in Sargentia 1: 119 (1942).

Dolicholobium oblongifolium var. *longissimum* (Seem.) Fosberg in Sargentia 1: 119 (1942).

Galium hypocarpium (L.) Fosberg in Sida 2: 386 (1966).

Geophila repens var. *asiatica* (Cham. & Schtdl.) Fosberg in Smithsonian Contr. Bot. 45: 27 (1980).

Gonzalagunia longithyrsa Fosberg in Sida 2: 387 (1966).

Gouldia hillebrandii Fosberg in Bernice P. Bishop Mus. Bull. 147: 59 (1937).

Gouldia hillebrandii f. *lancifolia* Fosberg in Bernice P. Bishop Mus. Bull. 147: 61 (1937).
Gouldia hillebrandii var. *hawaiiensis* Fosberg in Bernice P. Bishop Mus. Bull. 147: 61 (1937).
Gouldia hillebrandii var. *nodosa* Fosberg in Bernice P. Bishop Mus. Bull. 147: 60 (1937).
Gouldia st.-johnii Fosberg in Bernice P. Bishop Mus. Bull. 147: 62 (1937).
Gouldia st.-johnii var. *munroi* Fosberg in Bernice P. Bishop Mus. Bull. 147: 63 (1937).
Gouldia terminalis f. *acuminata* Fosberg in Bernice P. Bishop Mus. Bull. 147: 45 (1937).
Gouldia terminalis f. *acuta* Fosberg in Bernice P. Bishop Mus. Bull. 147: 55 (1937).
Gouldia terminalis f. *albicaulis* Fosberg in Bernice P. Bishop Mus. Bull. 147: 32 (1937).
Gouldia terminalis f. *cuneata* Fosberg in Bernice P. Bishop Mus. Bull. 147: 34 (1937).
Gouldia terminalis f. *heterophylla* Fosberg in Bernice P. Bishop Mus. Bull. 147: 52 (1937).
Gouldia terminalis f. *hirtellicostata* Fosberg in Bernice P. Bishop Mus. Bull. 147: 33 (1937).
Gouldia terminalis f. *hirtellifolia* Fosberg in Bernice P. Bishop Mus. Bull. 147: 55 (1937).
Gouldia terminalis f. *impressa* Fosberg in Bull. Torrey Bot. Club 70: 391 (1943).
Gouldia terminalis f. *kahili* Fosberg in Bernice P. Bishop Mus. Bull. 147: 33 (1937).
Gouldia terminalis f. *kalaupapa* Fosberg in Bernice P. Bishop Mus. Bull. 147: 51 (1937).
Gouldia terminalis f. *kauensis* Fosberg in Bernice P. Bishop Mus. Bull. 147: 55 (1937).
Gouldia terminalis f. *kehena* Fosberg in Bernice P. Bishop Mus. Bull. 147: 54 (1937).
Gouldia terminalis f. *latifolia* Fosberg in Bernice P. Bishop Mus. Bull. 147: 38 (1937).
Gouldia terminalis f. *lydgatei* Fosberg in Bernice P. Bishop Mus. Bull. 147: 53 (1937).
Gouldia terminalis f. *macrophylla* Fosberg in Bernice P. Bishop Mus. Bull. 147: 32 (1937).
Gouldia terminalis f. *makawaoensis* Fosberg in Bernice P. Bishop Mus. Bull. 147: 50 (1937).
Gouldia terminalis f. *maunahui* Fosberg in Bernice P. Bishop Mus. Bull. 147: 51 (1937).
Gouldia terminalis f. *membranacea* Fosberg in Bernice P. Bishop Mus. Bull. 147: 53 (1937).
Gouldia terminalis f. *molokaiensis* Fosberg in Bernice P. Bishop Mus. Bull. 147: 45 (1937).
Gouldia terminalis f. *nealiae* Fosberg in Bernice P. Bishop Mus. Bull. 147: 45 (1937).
Gouldia terminalis f. *oahuensis* Fosberg in Brittonia 8: 176 (1956).
Gouldia terminalis f. *oblonga* Fosberg in Brittonia 8: 176 (1956).

Gouldia terminalis f. *obovata* Fosberg in Bull. Torrey Bot. Club 70: 391 (1943).
Gouldia terminalis f. *parvithyrsa* Fosberg in Bernice P. Bishop Mus. Bull. 147: 37 (1937).
Gouldia terminalis f. *petiolata* Fosberg in Bernice P. Bishop Mus. Bull. 147: 53 (1937).
Gouldia terminalis f. *pittosporoides* Fosberg in Bernice P. Bishop Mus. Bull. 147: 39 (1937).
Gouldia terminalis f. *punaula* Fosberg in Bernice P. Bishop Mus. Bull. 147: 53 (1937).
Gouldia terminalis f. *rigidifolia* Fosberg in Bernice P. Bishop Mus. Bull. 147: 39 (1937).
Gouldia terminalis f. *rigidifolioides* Fosberg in Brittonia 8: 174 (1956).
Gouldia terminalis f. *robusta* Fosberg in Bernice P. Bishop Mus. Bull. 147: 29 (1937).
Gouldia terminalis f. *rockii* Fosberg in Bernice P. Bishop Mus. Bull. 147: 43 (1937).
Gouldia terminalis f. *russii* Fosberg in Bernice P. Bishop Mus. Bull. 147: 49 (1937).
Gouldia terminalis f. *sambucina* (Heller) Fosberg in Bernice P. Bishop Mus. Bull. 147: 36 (1937).
Gouldia terminalis f. *santalifolia* Fosberg in Bernice P. Bishop Mus. Bull. 147: 51 (1937).
Gouldia terminalis f. *sclerophylla* Fosberg in Bernice P. Bishop Mus. Bull. 147: 35 (1937).
Gouldia terminalis f. *storeyi* Fosberg in Bernice P. Bishop Mus. Bull. 147: 52 (1937).
Gouldia terminalis f. *subpilosa* Fosberg in Bernice P. Bishop Mus. Bull. 147: 56 (1937).
Gouldia terminalis f. *suehiroae* Fosberg in Bernice P. Bishop Mus. Bull. 147: 52 (1937).
Gouldia terminalis f. *teres* Fosberg in Bernice P. Bishop Mus. Bull. 147: 36 (1937).
Gouldia terminalis f. *violetae* Fosberg in Bull. Torrey Bot. Club 70: 392 (1943).
Gouldia terminalis f. *wailauensis* Fosberg in Bernice P. Bishop Mus. Bull. 147: 52 (1937).
Gouldia terminalis f. *waipioensis* Fosberg in Bernice P. Bishop Mus. Bull. 147: 37 (1937).
Gouldia terminalis var. *angustifolia* Fosberg in Bernice P. Bishop Mus. Bull. 147: 43 (1937).
Gouldia terminalis var. *antiqua* Fosberg in Bernice P. Bishop Mus. Bull. 147: 54 (1937).
Gouldia terminalis var. *arborescens* (Wawra) Fosberg in Bernice P. Bishop Mus. Bull. 147: 31 (1937).
Gouldia terminalis var. *aspera* Fosberg in Brittonia 8: 175 (1956).
Gouldia terminalis var. *bodeoides* Fosberg in Bernice P. Bishop Mus. Bull. 147: 37 (1937).
Gouldia terminalis var. *congesta* Fosberg in Bernice P. Bishop Mus. Bull. 147: 55 (1937).
Gouldia terminalis var. *cordata* (Wawra) Fosberg in Bernice P. Bishop Mus. Bull. 147: 44 (1937).

Gouldia terminalis var. *cordata* (Wawra) Fosberg in Bernice P. Bishop Mus. Bull. 147: 44 (1937).
Gouldia terminalis var. *coriacea* (Hook. & Arn.) Fosberg in Bernice P. Bishop Mus. Bull. 147: 47 (1937).
Gouldia terminalis var. *crassicaulis* Fosberg in Bernice P. Bishop Mus. Bull. 147: 54 (1937).
Gouldia terminalis var. *degeneri* Fosberg in Bernice P. Bishop Mus. Bull. 147: 39 (1937).
Gouldia terminalis var. *elongata* Fosberg in Bernice P. Bishop Mus. Bull. 147: 32 (1937).
Gouldia terminalis var. *forbesii* Fosberg in Bernice P. Bishop Mus. Bull. 147: 57 (1937).
Gouldia terminalis var. *glabra* Fosberg in Bernice P. Bishop Mus. Bull. 147: 36 (1937).
Gouldia terminalis var. *hathawayi* Fosberg in Brittonia 8: 174 (1956).
Gouldia terminalis var. *hosakai* Fosberg in Bernice P. Bishop Mus. Bull. 147: 38 (1937).
Gouldia terminalis var. *kaala* Fosberg in Bernice P. Bishop Mus. Bull. 147: 49 (1937).
Gouldia terminalis var. *kapuensis* Fosberg in Bernice P. Bishop Mus. Bull. 147: 39 (1937).
Gouldia terminalis var. *konaensis* Fosberg in Bernice P. Bishop Mus. Bull. 147: 37 (1937).
Gouldia terminalis var. *lanai* Fosberg in Bernice P. Bishop Mus. Bull. 147: 59 (1937).
Gouldia terminalis var. *macrocarpa* (Hillebr.) Fosberg in Bernice P. Bishop Mus. Bull. 147: 34 (1937).
Gouldia terminalis var. *macrothyrsa* Fosberg in Bernice P. Bishop Mus. Bull. 147: 40 (1937).
Gouldia terminalis var. *myrsinoidea* Fosberg in Brittonia 8: 176 (1956).
Gouldia terminalis var. *osteocarpa* Fosberg in Bernice P. Bishop Mus. Bull. 147: 33 (1937).
Gouldia terminalis var. *ovata* (Wawra) Fosberg in Bernice P. Bishop Mus. Bull. 147: 50 (1937).
Gouldia terminalis var. *parvifolia* (Wawra) Fosberg in Bernice P. Bishop Mus. Bull. 147: 56 (1937).
Gouldia terminalis var. *pedunculata* Fosberg in Bernice P. Bishop Mus. Bull. 147: 46 (1937).
Gouldia terminalis var. *pseudodichotoma* Fosberg in Bernice P. Bishop Mus. Bull. 147: 58 (1937).
Gouldia terminalis var. *pubescens* Fosberg in Bernice P. Bishop Mus. Bull. 147: 57 (1937).
Gouldia terminalis var. *pubistipula* Fosberg in Brittonia 20: 291 (1968).
Gouldia terminalis var. *purpurea* Fosberg in Bernice P. Bishop Mus. Bull. 147: 46 (1937).
Gouldia terminalis var. *quadrangularis* Fosberg in Bernice P. Bishop Mus. Bull. 147: 58 (1937).

Gouldia terminalis var. *rotundifolia* Fosberg in Bernice P. Bishop Mus. Bull. 147: 41 (1937).

Gouldia terminalis var. *sclerotica* Fosberg in Brittonia 8: 175 (1956).

Gouldia terminalis var. *skottsbergii* Fosberg in Bernice P. Bishop Mus. Bull. 147: 42 (1937).

Gouldia terminalis var. *stipulacea* (Wawra) Fosberg in Bernice P. Bishop Mus. Bull. 147: 42 (1937).

Gouldia terminalis var. *subcordata* Fosberg in Bernice P. Bishop Mus. Bull. 147: 44 (1937).

Gouldia terminalis var. *tenuicaulis* Fosberg in Bernice P. Bishop Mus. Bull. 147: 57 (1937).

Gouldia terminalis var. *wawrana* Fosberg in Bernice P. Bishop Mus. Bull. 147: 30 (1937).

Guettarda speciosa f. *tahitensis* (Nadeaud) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 262 (1937).

Gynochthodes ovalifolia var. *smithii* Fosberg in Bull. Torrey Bot. Club 67: 421 (1940).

Hedyotis sect. *Austrogouldia* Fosberg in Bernice P. Bishop Mus. Bull. 174: 28 (1943).

Hedyotis sect. *Bikkiocarpa* Fosberg in Bernice P. Bishop Mus. Bull. 174: 25 (1943).

Hedyotis sect. *Gouldiopsis* Fosberg in Bernice P. Bishop Mus. Bull. 174: 56 (1943).

Hedyotis sect. *Lignea* Fosberg in Allertonia 6: 202 (1991).

Hedyotis sect. *Protokadua* Fosberg in Bernice P. Bishop Mus. Bull. 174: 23 (1943).

Hedyotis sect. *Wiegmannia* (Meyen) Fosberg in Bernice P. Bishop Mus. Bull. 174: 29 (1943).

Hedyotis subg. *Diplophragma* (Wight & Arn.) Fosberg in Bernice P. Bishop Mus. Bull. 174: 21 (1943).

Hedyotis subg. *Kadua* (Cham. & Schltdl.) Fosberg in Bernice P. Bishop Mus. Bull. 174: 69 (1943).

Hedyotis subg. *Oceanica* Fosberg in Bernice P. Bishop Mus. Bull. 174: 67 (1943).

Hedyotis subg. *Oldenlandia* (L.) Fosberg in Bernice P. Bishop Mus. Bull. 174: 19 (1943).

Hedyotis subg. *Polynesiotis* Fosberg in Bernice P. Bishop Mus. Bull. 174: 22 (1943).

Hedyotis acuminata f. *alicarpa* Fosberg in Bernice P. Bishop Mus. Bull. 174: 82 (1943).

Hedyotis acuminata f. *alicarpoides* Fosberg in Brittonia 8: 171 (1956).

Hedyotis acuminata f. *allanii* Fosberg in Brittonia 8: 170 (1956).

Hedyotis acuminata f. *basipuba* Fosberg in Brittonia 20: 290 (1968).

Hedyotis acuminata f. *brevimucronata* Fosberg in Bernice P. Bishop Mus. Bull. 174: 76 (1943).

Hedyotis acuminata f. *brownii* Fosberg in Bernice P. Bishop Mus. Bull. 174: 79 (1943).

Hedyotis acuminata f. *calycosa* Fosberg in Brittonia 20: 289 (1968).

Hedyotis acuminata f. compacta Fosberg in Brittonia 8: 169 (1956).

Hedyotis acuminata f. *cylindrica* Fosberg in Bernice P. Bishop Mus. Bull. 174: 90 (1943).

Hedyotis acuminata f. *duripes* Fosberg in Bernice P. Bishop Mus. Bull. 174: 84 (1943).
Hedyotis acuminata f. *eamesii* Fosberg in Bernice P. Bishop Mus. Bull. 174: 86 (1943).
Hedyotis acuminata f. *elliptica* Fosberg in Bernice P. Bishop Mus. Bull. 174: 79 (1943).
Hedyotis acuminata f. *forbesii* Fosberg in Bernice P. Bishop Mus. Bull. 174: 88 (1943).
Hedyotis acuminata f. *grandis* (A. Gray) Fosberg in Bernice P. Bishop Mus. Bull. 174: 90 (1943).
Hedyotis acuminata f. *grayana* Fosberg in Bernice P. Bishop Mus. Bull. 174: 79 (1943).
Hedyotis acuminata f. *greenwelliae* Fosberg in Brittonia 8: 170 (1956).
Hedyotis acuminata f. *halawana* Fosberg in Bernice P. Bishop Mus. Bull. 174: 76 (1943).
Hedyotis acuminata f. *haupuensis* Fosberg in Bernice P. Bishop Mus. Bull. 174: 76 (1943).
Hedyotis acuminata f. *heteripes* Fosberg in Bernice P. Bishop Mus. Bull. 174: 85 (1943).
Hedyotis acuminata f. *hirtella* Fosberg in Bernice P. Bishop Mus. Bull. 174: 80 (1943).
Hedyotis acuminata f. *hirticalyx* Fosberg in Bernice P. Bishop Mus. Bull. 174: 89 (1943).
Hedyotis acuminata f. *honopui* Fosberg in Brittonia 8: 171 (1956).
Hedyotis acuminata f. *iaoensis* Fosberg in Bernice P. Bishop Mus. Bull. 174: 87 (1943).
Hedyotis acuminata f. *isae* Fosberg in Brittonia 20: 289 (1968).
Hedyotis acuminata f. *kaalae* (Wawra) Fosberg in Bernice P. Bishop Mus. Bull. 174: 78 (1943).
Hedyotis acuminata f. *koolauensis* Fosberg in Bernice P. Bishop Mus. Bull. 174: 78 (1943).
Hedyotis acuminata f. *lanaiensis* Fosberg in Bernice P. Bishop Mus. Bull. 174: 85 (1943).
Hedyotis acuminata f. *liberipes* Fosberg in Bernice P. Bishop Mus. Bull. 174: 75 (1943).
Hedyotis acuminata f. microliberipes Fosberg in Brittonia 8: 169 (1956).
Hedyotis acuminata f. *obovata* Fosberg in Bernice P. Bishop Mus. Bull. 174: 88 (1943).
Hedyotis acuminata f. *ovalicalyx* Fosberg in Bernice P. Bishop Mus. Bull. 174: 88 (1943).
Hedyotis acuminata f. *ovalifolia* (A. Gray) Fosberg in Bernice P. Bishop Mus. Bull. 174: 87 (1943).
Hedyotis acuminata f. *pilicalyx* Fosberg in Bernice P. Bishop Mus. Bull. 174: 82 (1943).

Hedyotis acuminata f. *quadricosta* Fosberg in Bernice P. Bishop Mus. Bull. 174: 84 (1943).
Hedyotis acuminata f. *sherffiana* Fosberg in Bernice P. Bishop Mus. Bull. 174: 77 (1943).
Hedyotis acuminata f. *skottsbergiana* Fosberg in Bernice P. Bishop Mus. Bull. 174: 89 (1943).
Hedyotis acuminata f. *sphaerocarpa* Fosberg in Bernice P. Bishop Mus. Bull. 174: 76 (1943).
Hedyotis acuminata f. *st.johnii* Fosberg in Bernice P. Bishop Mus. Bull. 174: 85 (1943).
Hedyotis acuminata f. *storeyi* Fosberg in Bernice P. Bishop Mus. Bull. 174: 84 (1943).
Hedyotis acuminata f. *subsessilis* Fosberg in Bernice P. Bishop Mus. Bull. 174: 87 (1943).
Hedyotis acuminata f. *toppingii* Fosberg in Bernice P. Bishop Mus. Bull. 174: 77 (1943).
Hedyotis acuminata f. *tuberculata* Fosberg in Bernice P. Bishop Mus. Bull. 174: 86 (1943).
Hedyotis acuminata f. *turbinata* Fosberg in Bernice P. Bishop Mus. Bull. 174: 89 (1943).
Hedyotis acuminata f. *variabilis* Fosberg in Bernice P. Bishop Mus. Bull. 174: 82 (1943).
Hedyotis acuminata f. *violetana* Fosberg in Bernice P. Bishop Mus. Bull. 174: 81 (1943).
Hedyotis acuminata f. *wailauensis* Fosberg in Bernice P. Bishop Mus. Bull. 174: 85 (1943).
Hedyotis albido-punctata (Merr.) Fosberg in Lloydia 3: 123 (1940).
Hedyotis albidopunctata (Merr.) Fosberg in Lloydia 32: 123 (1940).
Hedyotis angulata Fosberg in Field & Lab. 17: 166 (1949).
Hedyotis angusta Fosberg in Bernice P. Bishop Mus. Bull. 174: 48 (1943).
Hedyotis angusta var. *koolauensis* Fosberg in Brittonia 8: 167 (1956).
Hedyotis angusta var. *umbrosa* Fosberg in Bernice P. Bishop Mus. Bull. 174: 49 (1943).
Hedyotis auricularia var. *brevipila* Fosberg & Sachet in Allertonia 6: 208 (1991).
Hedyotis auricularia var. *dispersa* Fosberg & Sachet in Allertonia 6: 208 (1991).
Hedyotis auricularia var. *longipila* Fosberg & Sachet in Allertonia 6: 209 (1991).
Hedyotis auricularia var. *melanesica* Fosberg in Bull. Torrey Bot. Club 67: 419 (1940).
Hedyotis auricularia var. *tomentella* Fosberg & Sachet in Allertonia 6: 210 (1991).
Hedyotis caerulea f. *albiflora* (Millsp.) Fosberg in Castanea 19: 30 (1954).
Hedyotis caerulea f. *benkei* Fosberg in Castanea 19: 31 (1954).
Hedyotis caerulea var. *faxonorum* (Pease & A. H. Moore) Fosberg in Castanea 19: 30 (1954).
Hedyotis caerulea var. *minima* (Beck) Fosberg in Castanea 19: 31 (1954).
Hedyotis canadensis (Roem. & Schult.) Fosberg in Virginia J. Sci. 2: 110 (1941).

Hedyotis centranthoides f. *accrescens* Fosberg in Bernice P. Bishop Mus. Bull. 174: 65 (1943).
Hedyotis centranthoides f. *diffusa* Fosberg in Bernice P. Bishop Mus. Bull. 174: 62 (1943).
Hedyotis centranthoides f. *glomerata* (Hook. & Arn.) Fosberg in Bernice P. Bishop Mus. Bull. 174: 64 (1943).
Hedyotis centranthoides f. *hirta* Fosberg in Bernice P. Bishop Mus. Bull. 174: 63 (1943).
Hedyotis centranthoides f. *kamokuensis* Fosberg in Bernice P. Bishop Mus. Bull. 174: 63 (1943).
Hedyotis centranthoides f. *kohala* Fosberg in Bernice P. Bishop Mus. Bull. 174: 61 (1943).
Hedyotis centranthoides f. *laevis* (Wawra) Fosberg in Brittonia 8: 168. (1956).
Hedyotis centranthoides f. *mauiensis* Fosberg in Bernice P. Bishop Mus. Bull. 174: 65 (1943).
Hedyotis centranthoides f. *meeboldii* Fosberg in Bernice P. Bishop Mus. Bull. 174: 65 (1943).
Hedyotis centranthoides f. *vestita* Fosberg in Bernice P. Bishop Mus. Bull. 174: 62 (1943).
Hedyotis centranthoides f. *yunckeri* Fosberg in Bernice P. Bishop Mus. Bull. 174: 63 (1943).
Hedyotis centranthoides var. *laevis* (Wawra) Fosberg in Bernice P. Bishop Mus. Bull. 174: 63 (1943).
Hedyotis cookiana f. *brighamii* Fosberg in Bernice P. Bishop Mus. Bull. 174: 48 (1943).
Hedyotis cookiana f. *elatior* (Mann) Fosberg in Bernice P. Bishop Mus. Bull. 174: 47 (1943).
Hedyotis cookiana f. *oahuensis* Fosberg in Bernice P. Bishop Mus. Bull. 174: 48 (1943).
Hedyotis cookiana var. *ensiformis* Fosberg in Bernice P. Bishop Mus. Bull. 174: 46 (1943).
Hedyotis cookiana var. *herbacea* (H. Lév.) Fosberg in Bernice P. Bishop Mus. Bull. 174: 46 (1943).
Hedyotis corallicola Fosberg in Kew Bull. 33: 136 (1978).
Hedyotis coriacea f. *conostyla* (Gaudich.) Fosberg in Bernice P. Bishop Mus. Bull. 174: 25 (1943).
Hedyotis corymbosa var. *ampla* Fosberg in Allertonia 6: 220 (1991).
Hedyotis costata var. *lutescens* (Kaneh.) Fosberg in Smithsonian Contr. Bot. 45: 28 (1980).
Hedyotis cushingiae Fosberg in Allertonia 6: 221 (1991).
Hedyotis degeneri Fosberg in Bernice P. Bishop Mus. Bull. 174: 55 (1943).
Hedyotis degeneri var. *coprosmifolia* Fosberg in Bernice P. Bishop Mus. Bull. 174: 56 (1943).
Hedyotis divaricata var. *capillothyrsa* Fosberg in Allertonia 6: 224 (1991).
Hedyotis elatior (H. Mann) Fosberg in Brittonia 8: 167 (1956).

Hedyotis elatior f. *brighamii* Fosberg in Brittonia 8: 167 (1956).
Hedyotis elatior f. *ensiformis* Fosberg in Brittonia 8: 167 (1956).
Hedyotis elatior f. *herbacea* (H. Lév.) Fosberg in Brittonia 8: 167 (1956).
Hedyotis elatior f. *oahuensis* Fosberg in Brittonia 8: 167 (1956).
Hedyotis fluviatilis (C. N. Forbes) Fosberg in Bernice P. Bishop Mus. Bull. 174: 90 (1943).
Hedyotis fluviatilis f. *breviflora* Degener & Fosberg in Bernice P. Bishop Mus. Bull. 174: 91 (1943).
Hedyotis fluviatilis f. *hathewayi* Fosberg in Brittonia 8: 171 (1956).
Hedyotis fluviatilis f. *kamapuaana* (Degener) Fosberg in Bernice P. Bishop Mus. Bull. 174: 91 (1943).
Hedyotis fluviatilis var. *kamapuaana* (Degener) Fosberg in Bernice P. Bishop Mus. Bull. 174: 91 (1943).
Hedyotis fluviatilis var. *kauaiensis* Fosberg in Bernice P. Bishop Mus. Bull. 174: 93 (1943).
Hedyotis foetida var. *mariannensis* (Merr.) Fosberg in Phytologia 5: 291 (1955).
Hedyotis foggiana Fosberg in Bernice P. Bishop Mus. Bull. 174: 65 (1943).
Hedyotis foliosa (Hillebr.) Fosberg in Bernice P. Bishop Mus. Bull. 174: 44 (1943).
Hedyotis formosa (Hillebr.) Fosberg in Bernice P. Bishop Mus. Bull. 174: 26 (1943).
Hedyotis fruticulosa var. *atroglomerata* Fosberg in Allertonia 6: 228 (1991).
Hedyotis fruticulosa var. *yapensis* (Kaneh.) Fosberg in Allertonia 6: 228 (1991).
Hedyotis glaucifolia (A. Gray) Fosberg in Bernice P. Bishop Mus. Bull. 174: 41 (1943).
Hedyotis glaucifolia f. *nealiae* Fosberg in Bernice P. Bishop Mus. Bull. 174: 43 (1943).
Hedyotis glaucifolia var. *helleri* Fosberg in Bernice P. Bishop Mus. Bull. 174: 44 (1943).
Hedyotis glaucifolia var. *subimpressa* Fosberg in Brittonia 8: 166 (1956).
Hedyotis glaucifolia var. *waimeae* (Wawra) Fosberg in Bernice P. Bishop Mus. Bull. 174: 43 (1943).
Hedyotis grantii Fosberg in Bernice P. Bishop Mus. Bull. 174: 29 (1943).
Hedyotis greenmanii Fosberg in Field & Lab. 17: 167 (1949).
Hedyotis hookeri (K. Schum.) Fosberg in Allertonia 6: 199 (1991).
Hedyotis intricata Fosberg in Lloydia 4: 290 (1941).
Hedyotis kanehirae (Hatus.) Fosberg in Smithsonian Contr. Bot. 45: 28 (1980).
Hedyotis knudsenii (Hillebr.) Fosberg in Bernice P. Bishop Mus. Bull. 174: 57 (1943).
Hedyotis korrorensis var. *hosokawana* Fosberg in Allertonia 6: 230 (1991).
Hedyotis korrorensis var. *subglomerata* Fosberg in Allertonia 6: 231 (1991).
Hedyotis laciniata var. *takamatsui* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(20): 215 (1940).
Hedyotis lancifolia var. *brevipes* (Bremek.) Fosberg in Kew Bull. 33: 137 (1978).
Hedyotis littoralis (Hillebr.) Fosberg in Bernice P. Bishop Mus. Bull. 174: 53 (1943).
Hedyotis mannii Fosberg in Bernice P. Bishop Mus. Bull. 174: 49 (1943).
Hedyotis mannii var. *cuspidata* Fosberg in Brittonia 8: 168 (1956).

Hedyotis mannii var. *laxiflora* (Mann) Fosberg in Bernice P. Bishop Mus. Bull. 174: 50 (1943).
Hedyotis mannii var. *munroi* Fosberg in Bernice P. Bishop Mus. Bull. 174: 50 (1943).
Hedyotis mannii var. *scoposa* Fosberg in Bernice P. Bishop Mus. Bull. 174: 51 (1943).
Hedyotis michauxii f. *alba* (Alex.) Fosberg in Castanea 19: 32 (1954).
Hedyotis michauxii Fosberg in Amer. Midl. Naturalist 29: 786 (1943).
Hedyotis molokaiensis Fosberg in Bernice P. Bishop Mus. Bull. 174: 51 (1943).
Hedyotis mullerae Fosberg in Lloydia 4: 288 (1941).
Hedyotis nigricans (Lam.) Fosberg in Lloydia 4: 287 (1941).
Hedyotis nigricans var. *pulvinata* (Small) Fosberg in Castanea 19: 37 (1954).
Hedyotis nigricans var. *scabra* (Wats.) Fosberg in Lloydia 4: 288 (1941).
Hedyotis nuttalliana Fosberg in Virginia J. Sci. 2: 111 (1941).
Hedyotis parvula (A. Gray) Fosberg in Bernice P. Bishop Mus. Bull. 174: 54 (1943).
Hedyotis parvula f. *sessilis* Fosberg in Bernice P. Bishop Mus. Bull. 174: 55 (1943).
Hedyotis procumbens (J. F. Gmel.) Fosberg in Castanea 19: 32 (1954).
Hedyotis prolifera Fosberg in Kew Bull. 33: 138 (1978).
Hedyotis purpurea f. *albiflora* Fosberg in Castanea 19: 34 (1954).
Hedyotis purpurea f. *leucantha* (Standl.) Fosberg in Castanea 19: 36 (1954).
Hedyotis purpurea f. *pubescens* (Britton) Fosberg in Castanea 19: 33 (1954).
Hedyotis purpurea var. *calycosa* (A. Gray) Fosberg in Castanea 19: 33 (1954).
Hedyotis purpurea var. *ciliolata* (Torr.) Fosberg in Castanea 19: 34 (1954).
Hedyotis purpurea var. *floridana* (Standl.) Fosberg in Castanea 19: 36 (1954).
Hedyotis purpurea var. *longifolia* (Gaertn.) Fosberg in Castanea 19: 34 (1954).
Hedyotis purpurea var. *setiscaphia* (Carr) Fosberg in Castanea 19: 35 (1954).
Hedyotis purpurea var. *tenuifolia* (Nutt.) Fosberg in Castanea 19: 35 (1954).
Hedyotis raiateensis (J. W. Moore) Fosberg in Bernice P. Bishop Mus. Bull. 174: 28 (1943).
Hedyotis rapensis (F. Br.) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 250 (1937).
Hedyotis rapensis var. *taverana* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 250 (1937).
Hedyotis remyi (Hillebr.) Fosberg in Brittonia 8: 165 (1956).
Hedyotis remyi var. *nuttallii* (Fosberg) Fosberg in Brittonia 8: 166 (1956).
Hedyotis remyi var. *plana* (Fosberg) Fosberg in Brittonia 8: 166 (1956).
Hedyotis remyi var. *silvicola* Fosberg in Brittonia 8: 166 (1956).
Hedyotis rennellensis Fosberg in Lloydia 3: 122 (1940).
Hedyotis romanzoffiensis (Cham. & Schltdl.) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 248 (1937).
Hedyotis sachetiana Fosberg in Allertonia 6: 235 (1991).
Hedyotis scabridifolia var. *stonei* Fosberg in Allertonia 6: 237 (1991).
Hedyotis schlechtendahliana f. *dichotoma* Fosberg in Bernice P. Bishop Mus. Bull. 174: 34 (1943).
Hedyotis schlechtendahliana f. *glabrescens* Fosberg in Bernice P. Bishop Mus. Bull. 174: 34 (1943).

Hedyotis schlechtendahliana f. *glauca* (Meyen) Fosberg in Bernice P. Bishop Mus. Bull. 174: 36 (1943).
Hedyotis schlechtendahliana f. *hirtella* Fosberg in Bernice P. Bishop Mus. Bull. 174: 35 (1943).
Hedyotis schlechtendahliana f. *kaalensis* Fosberg in Bernice P. Bishop Mus. Bull. 174: 37 (1943).
Hedyotis schlechtendahliana f. *secundiflora* (Hillebr.) Fosberg in Bernice P. Bishop Mus. Bull. 174: 34 (1943).
Hedyotis schlechtendahliana subsp. *cordata* (Cham. & Schltdl.) Fosberg in Bernice P. Bishop Mus. Bull. 174: 32 (1943).
Hedyotis schlechtendahliana subsp. *remyi* (Hillebr.) Fosberg in Bernice P. Bishop Mus. Bull. 174: 40 (1943).
Hedyotis schlechtendahliana subsp. *rockii* Fosberg in Bernice P. Bishop Mus. Bull. 174: 37 (1943).
Hedyotis schlechtendahliana subsp. *tenuifolia* (Fosberg) Fosberg in Bernice P. Bishop Mus. Bull. 174: 39 (1943).
Hedyotis schlechtendahliana var. *cordata* (Cham. & Schltdl.) Fosberg in Bernice P. Bishop Mus. Bull. 174: 32 (1943).
Hedyotis schlechtendahliana var. *glauca* (Meyen) Fosberg in Bernice P. Bishop Mus. Bull. 174: 36 (1943).
Hedyotis schlechtendahliana var. *nitens* (Wawra) Fosberg in Bernice P. Bishop Mus. Bull. 174: 37 (1943).
Hedyotis schlechtendahliana var. *nuttallii* Fosberg in Bernice P. Bishop Mus. Bull. 174: 41 (1943).
Hedyotis schlechtendahliana var. *opaca* (Wawra) Fosberg in Bernice P. Bishop Mus. Bull. 174: 38 (1943).
Hedyotis schlechtendahliana var. *plana* Fosberg in Bernice P. Bishop Mus. Bull. 174: 41 (1943).
Hedyotis schlechtendahliana var. *remyi* (Hillebr.) Fosberg in Bernice P. Bishop Mus. Bull. 174: 40 (1943).
Hedyotis schlechtendahliana var. *reticulata* Fosberg in Bernice P. Bishop Mus. Bull. 174: 40 (1943).
Hedyotis schlechtendahliana var. *rigida* Fosberg in Bernice P. Bishop Mus. Bull. 174: 38 (1943).
Hedyotis schlechtendahliana var. *secundiflora* (Hillebr.) Fosberg in Bernice P. Bishop Mus. Bull. 174: 33 (1943).
Hedyotis schlechtendahliana var. *tenuifolia* Fosberg in Bernice P. Bishop Mus. Bull. 174: 39 (1943).
Hedyotis sieberi (Baker) Fosberg in Kew Bull. 33: 140 (1978).
Hedyotis strigulosa (DC.) Fosberg in Smithsonian Contr. Bot. 45: 28 (1980).
Hedyotis tayloriae Fosberg in Field & Lab. 17: 169 (1949).
Hedyotis thyrsoidea Fosberg in Bernice P. Bishop Mus. Bull. 174: 52 (1943).
Hedyotis thyrsoidea var. *hillebrandii* Fosberg in Bernice P. Bishop Mus. Bull. 174: 53 (1943).

Hedyotis verticillata var. *bartlettii* Fosberg & Sachet in Allertonia 6: 211 (1991).
Hedyotis vestita var. *lutescens* (Kaneh.) Fosberg in Allertonia 6: 244 (1991).
Hedyotis wrightii (A. Gray) Fosberg in Lloydia 4: 290 (1941).
Hillia hathewayi Fosberg in Sida 2: 387 (1966).
Hoffmannia steinvorthii Fosberg in Sida 2: 388 (1966).
Hydnophytum stewartii Fosberg in Lloydia 3: 123 (1940).
Ixora sect. *Vitixora* Fosberg in Sargentia 1: 124 (1942).
Ixora biflora Fosberg in J. Bot. 76: 235 (1938).
Ixora biflora var. *fleckeri* Fosberg in J. Bot. 76: 277 (1938).
Ixora brevipedunculata Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 271 (1937).
Ixora carolinensis var. *chartacea* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(20): 222 (1940).
Ixora carolinensis var. *lanceolata* (Kaneh.) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(20): 223 (1940).
Ixora carolinensis var. *ponapensis* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(20): 223 (1940).
Ixora carolinensis var. *volkensii* (Hosok.) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(20): 222 (1940).
Ixora casei var. *medialoba* Fosberg & Sachet in Baileya 23: 85 (1989).
Ixora coccinea f. *lutea* (Hutch.) Fosberg & Sachet in Baileya 23: 79 (1989).
Ixora coccinea var. *hermannii* Fosberg & Sachet in Baileya 23: 79 (1989).
Ixora coccinea var. *intermedia* Fosberg & Sachet in Baileya 23: 80 (1989).
Ixora foetida (L.f.) Fosberg in Allertonia 7: 78 (1993).
Ixora moorensis (Nadeaud) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 269 (1937).
Ixora queenslandica Fosberg in J. Bot. 76: 234 (1938).
Ixora raivavaensis Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 273 (1937).
Ixora setchellii Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 266 (1937).
Ixora st.-johnii Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 269 (1937).
Leptostigma longiflorum (Standl.) Fosberg in Acta Phytotax. Geobot. 33: 80 (1982).
Leptostigma pilosum (Benth.) Fosberg in Acta Phytotax. Geobot. 33: 79 (1982).
Leptostigma reptans (F. Muell.) Fosberg in Acta Phytotax. Geobot. 33: 82 (1982).
Leptostigma setulosum (Hook. f.) Fosberg in Acta Phytotax. Geobot. 33: 81 (1982).
Leptostigma weberbaueri Fosberg in Acta Phytotax. Geobot. 33: 80 (1982).
Morinda umbellata var. *archboldiana* Fosberg in Sargentia 1: 123 (1942).
Morinda umbellata var. *bucidifolia* (A. Gray) Fosberg in Sargentia 1: 123 (1942).
Morinda umbellata var. *forsteri* (Seem.) Fosberg in Sargentia 1: 123 (1942).
Morinda umbellata var. *glandulosa* (Merr.) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(20): 220 (1940).
Ophiorrhiza leptantha var. *yasawana* Fosberg in Bull. Torrey Bot. Club 67: 420 (1940).
Ophiorrhiza palauensis var. *biseta* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(20): 214 (1940).

Psychotria 1sect. *Pelagomapouria* Fosberg in Brittonia 16: 257 (1964).
Psychotria 1sect. *Straussia* (A. Gray) Fosberg in Brittonia 16: 264 (1964).
Psychotria adamsonii Fosberg in Notul. Syst. (Paris) 8: 172 (1939).
Psychotria andersonii Fosberg in Allertonia 6: 248 (1991).
Psychotria archboldiana Fosberg in Sargentia 1: 131 (1942).
Psychotria atricaulis Fosberg in Candollea 38: 456 (1983).
Psychotria aurantiocarpa Fosberg in Sargentia 1: 130 (1942).
Psychotria bowermaniae Fosberg in Notul. Syst. (Paris) 8: 170 (1939).
Psychotria brevicalyx Fosberg in Sargentia 1: 132 (1942).
Psychotria carolinensis (Valeton) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(20): 224 (1940).
Psychotria cheathamiana Fosberg in Allertonia 6: 249 (1991).
Psychotria chrysophylla Fosberg in Bull. Torrey Bot. Club 67: 423 (1940).
Psychotria cordata var. *podantha* Fosberg in Sargentia 1: 130 (1942).
Psychotria crassiflora Fosberg in Sargentia 1: 132 (1942).
Psychotria degeneri Fosberg in Sargentia 1: 134 (1942).
Psychotria eumorphanthus Fosberg in Sargentia 1: 127 (1942).
Psychotria fauriei (H. Lév.) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 23(2): 43 (1962).
Psychotria fragrans (Gillespie) Fosberg in Sargentia 1: 126 (1942).
Psychotria furcans Fosberg in Sargentia 1: 133 (1942).
Psychotria gibbsiae var. *velutina* Fosberg in Sargentia 1: 127 (1942).
Psychotria glabra (Turrill) Fosberg in Sargentia 1: 126 (1942).
Psychotria grantii Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 277 (1937).
Psychotria greenwelliae Fosberg in Brittonia 16: 269 (1964).
Psychotria griseifolia var. *unicarinata* Fosberg in Sargentia 1: 129 (1942).
Psychotria hathewayi Fosberg in Brittonia 16: 267 (1964).
Psychotria hathewayi var. *brevipetiolata* Fosberg in Brittonia 16: 267 (1964).
Psychotria hawaiiensis (A. Gray) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 23(2): 43 (1962).
Psychotria hawaiiensis var. *glabrithyrsa* Fosberg in Brittonia 16: 271 (1964).
Psychotria hawaiiensis var. *glomerata* (Rock) Fosberg in Brittonia 16: 271 (1964).
Psychotria hawaiiensis var. *hillebrandii* (Rock) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 23(2): 43 (1962).
Psychotria hawaiiensis var. *molokaiensis* (Rock) Fosberg in Brittonia 16: 271 (1964).
Psychotria hawaiiensis var. *rotundifolia* (Skottsb.) Fosberg in Brittonia 16: 271 (1964).
Psychotria hawaiiensis var. *scoriacea* (Rock) Fosberg in Brittonia 16: 270 (1964).
Psychotria hexandra f. *forbesii* Fosberg in Brittonia 16: 263 (1964).
Psychotria hexandra f. *hosakana* Fosberg in Brittonia 16: 262 (1964).
Psychotria hexandra f. *waialuana* Fosberg in Brittonia 16: 260 (1964).
Psychotria hexandra subsp. *oahuensis* Degener & Fosberg in Brittonia 16: 261 (1964).
Psychotria hexandra var. *hosakana* Fosberg in Brittonia 16: 262 (1964).
Psychotria hexandra var. *kealiae* Fosberg in Brittonia 16: 260 (1964).
Psychotria hexandra var. *oahuensis* (Degener & Fosberg) Degener & Fosberg in Brittonia 16: 261 (1964).

Psychotria hexandra var. *rockii* Fosberg in Brittonia 16: 262 (1964).
Psychotria hexandra var. *st.-johnii* Fosberg in Brittonia 16: 262 (1964).
Psychotria hivaoana Fosberg in Notul. Syst. (Paris) 8: 166 (1939).
Psychotria hombroniana (Baill.) Fosberg in Phytologia 5: 291 (1955).
Psychotria hombroniana var. *canfieldiae* Fosberg in Allertonia 6: 253 (1991).
Psychotria hombroniana var. *hirtella* (Valeton) Fosberg in Smithsonian Contr. Bot. 45: 29 (1980).
Psychotria hombroniana var. *kusaiensis* (Kaneh.) Fosberg in Smithsonian Contr. Bot. 45: 29 (1980).
Psychotria hombroniana var. *ladronica* (Hosok.) Fosberg in Allertonia 6: 255 (1991).
Psychotria hombroniana var. *malaspinae* (Merr.) Fosberg in Smithsonian Contr. Bot. 45: 29 (1980).
Psychotria hombroniana var. *mariannensis* (Kaneh.) Fosberg in Allertonia 6: 255 (1991).
Psychotria hombroniana var. *peliliuensis* Fosberg in Allertonia 6: 255 (1991).
Psychotria hombroniana var. *squarrosa* (Valeton) Fosberg in Smithsonian Contr. Bot. 45: 29 (1980).
Psychotria hosokawae Fosberg in Allertonia 6: 257 (1991).
Psychotria insularum var. *paradisii* Fosberg in Brittonia 16: 256 (1964).
Psychotria kaduana (Cham. & Schltdl.) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 23(2): 43 (1962).
Psychotria kaduana var. *longissima* (Rock) Fosberg in Brittonia 16: 266 (1964).
Psychotria kaduana var. *pubiflora* (Heller) Fosberg in Brittonia 16: 265 (1964).
Psychotria le-bronnecii Fosberg in Notul. Syst. (Paris) 8: 168 (1939).
Psychotria le-bronnecii var. *tahuatensis* Fosberg in Notul. Syst. (Paris) 8: 169 (1939).
Psychotria leptocarpa (Hillebr.) Fosberg in Brittonia 16: 266 (1964).
Psychotria leptothyrsa var. *leptothyrsoides* (Kaneh.) Fosberg in Allertonia 6: 259 (1991).
Psychotria leptothyrsa var. *yapensis* Fosberg in Allertonia 6: 260 (1991).
Psychotria macroserpens Fosberg in Sargentia 1: 131 (1942).
Psychotria magnifica (Gillespie) Fosberg in Sargentia 1: 126 (1942).
Psychotria marauensis Fosberg & Florence in Candollea 38: 456 (1983).
Psychotria mariniana (Cham. & Schltdl.) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 23(2): 43 (1962).
Psychotria mauiensis Fosberg in Brittonia 16: 266 (1964).
Psychotria merrillii var. *polyneura* (Valeton) Fosberg & Sachet in Allertonia 6: 264 (1991).
Psychotria monocarpa Fosberg in Sargentia 1: 130 (1942).
Psychotria pickeringii var. *solanoides* (Turrill) Fosberg in Sargentia 1: 128 (1942).
Psychotria pittosporifolia Fosberg in Sargentia 1: 134 (1942).
Psychotria ponapensis Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(20): 224 (1940).
Psychotria psychotrioides (Heller) Fosberg in Brittonia 16: 269 (1964).
Psychotria pubiflora (A. Gray) Fosberg in Sargentia 1: 126 (1942).

Psychotria raivavaensis Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 279 (1937).
Psychotria rotensis var. *palauensis* (Hosok.) Fosberg in Allertonia 6: 267 (1991).
Psychotria rufocalyx Fosberg in Sargentia 1: 127 (1942).
Psychotria serpens var. *parvula* (A. Gray) Fosberg in Sargentia 1: 131 (1942).
Psychotria st.-johnii Fosberg in Bull. Torrey Bot. Club 67: 423 (1940).
Psychotria tetragonoides Fosberg in Sargentia 1: 135 (1942).
Psychotria timonioides Fosberg in Sargentia 1: 136 (1942).
Psychotria tubuaiensis Fosberg in Occas. Pap. Bernice P. Bishop Mus. 13(19): 277 (1937).
Psychotria vitiensis Fosberg in Sargentia 1: 127 (1942).
Psychotria waianensis Fosberg in Brittonia 16: 268 (1964).
Psychotria whistleri Fosberg in Micronesica 23: 3 (1940).
Randia vitiensis (Seem.) Fosberg in Sargentia 1: 120 (1942).
Readea prismoclavata Fosberg in Sargentia 1: 137 (1942).
Readea roseata Fosberg in Sargentia 1: 136 (1942).
Spermacoce buckleyi Fosberg in Brittonia 40: 64 (1988).
Spermacoce dispersa (Hook. f.) Fosberg in Phytologia 62: 182 (1987).
Spermacoce ericifolia (Hook. f.) Fosberg in Phytologia 62: 182 (1987).
Spermacoce ernstii Fosberg & D. Powell in Smithsonian Contr. Bot. 45: 29 (1980).
Spermacoce everistiana Fosberg in Brittonia 40: 61 (1988).
Spermacoce linearifolia (Hook. f.) Fosberg in Phytologia 62: 182 (1987).
Spermacoce perpusilla (Hook. f.) Fosberg in Phytologia 62: 182 (1987).
Spermacoce repens (DC.) Fosberg & D. Powell in Smithsonian Contr. Bot. 45: 30 (1980).
Spermacoce rotundifolia (Anderss.) Fosberg in Phytologia 62: 183 (1987).
Spermacoce suberecta (Hook. f.) Fosberg in Phytologia 62: 183 (1987).
Tarenna sambucina var. *buruensis* (Miq.) Fosberg & Sachet in Allertonia 6: 272 (1991).
Tarenna sambucina var. *glabra* (Merr.) Fosberg & Sachet in Allertonia 6: 272 (1991).
Tarenna sambucina var. *oweniana* Fosberg in Allertonia 6: 272 (1991).
Tarenna sambucina var. *papuana* Fosberg in Allertonia 6: 273 (1991).
Tarenna sambucina var. *tahitensis* (Valeton) Fosberg & Sachet in Allertonia 6: 273 (1991).
Tarenna verdcourtiana Fosberg in Phytologia 41: 357 (1979).
Timonius affinis var. *sapotifolius* (A. Gray) Fosberg in Sargentia 1: 121 (1942).
Timonius corymbosus var. *takamatsui* Fosberg & Sachet in Micronesica 20: 159 (1988 "1987").
Timonius kajewskii (Guillaumin) Fosberg in Bull. Torrey Bot. Club 70: 393 (1943).
Timonius mollis var. *submollis* Fosberg & Sachet in Micronesica 20: 161 (1988 "1987").
Timonius mollis var. *villosissimus* (Kaneh.) Fosberg & Sachet in Micronesica 20: 161 (1988 "1987").
Timonius salsedoi Fosberg & Sachet in Micronesica 20: 162 (1988 "1987").
Timonius smithii Fosberg in Sargentia 1: 121 (1942).

Timonius subauritus var. *strigosus* Fosberg & Sachet in Micronesica 20: 163 (1988 "1987").
Trukia dryadum (S. Moore) Fosberg in Phytologia 62: 175 (1987).
Trukia fitzalanii (F. Muell.) Fosberg in Phytologia 62: 175 (1987).
Trukia macarthurii (F. Muell.) Fosberg in Phytologia 62: 176 (1987).
Trukia tahitensis (Nadeaud) Fosberg in Phytologia 62: 174 (1987).

Rutaceae

Zanthoxylum semiarticulatum f. *laiense* (Degener) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 24(2): 20 (1969).
Zanthoxylum semiarticulatum var. *sessile* (Degener) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 24(2): 19 (1969).

Santalaceae

Santalum ellipticum var. *latifolium* (A. Gray) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 23(2): 35 (1962).
Santalum insulare var. *alticola* Fosberg & Sachet in Candollea 40: 463 (1985).
Santalum insulare var. *deckeri* Fosberg & Sachet in Candollea 40: 467 (1985).
Santalum insulare var. *hendersonense* (F. Br.) Fosberg & Sachet in Candollea 40: 470 (1985).
Santalum insulare var. *raiateense* (J. W. Moore) Fosberg & Sachet in Candollea 40: 465 (1985).

Sapindaceae

Allophylus paniger Fosberg in Allertonia 7: 61 (1993).

Sapotaceae

Manilkara achras (Mill.) Fosberg in Taxon 13: 255 (1964).

Pouteria auahiensis (J. F. Rock) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 23(2): 40 (1962).
Pouteria aurantia (J. F. Rock) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 23(2): 40 (1962).
Pouteria calcarea (Hosok.) Fosberg in Smithsonian Contr. Bot. 45: 17 (1980).
Pouteria ceresolii (J. F. Rock) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 23(2): 39 (1962).
Pouteria grayana (St. John) Fosberg in Micronesica 25: 196 (1992).
Pouteria grayana var. *florencei* Fosberg in Micronesica 25: 196 (1992).
Pouteria micronesica (Kaneh.) Fosberg in Smithsonian Contr. Bot. 45: 17 (1980).
Pouteria rhynchosperma (J. F. Rock) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 23(2): 39 (1962).
Pouteria spathulata (Hillebr.) Fosberg in Occas. Pap. Bernice P. Bishop Mus. 23(2): 40 (1962).

Saxifragaceae

Broussaisia arguta f. *glabra* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(4): 58 (1939).
Broussaisia arguta f. *oppositifolia* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(4): 60 (1939).
Broussaisia arguta var. *pellucida* Fosberg in Occas. Pap. Bernice P. Bishop Mus. 15(4): 59 (1939).

Scrophulariaceae

Veronica virginica var. *purpurea* (Pursh) Fosberg in Castanea 20: 59 (1955).

Solanaceae

Solanum cheesmaniae (Riley) Fosberg in Phytologia 62: 181 (1987).
Solanum indicum var. *aldabrense* (C. H. Wright) Fosberg in Kew Bull. 33: 141 (1978).
Solanum lycopersicum var. *cerasiforme* (Dunal) Fosberg in Phytologia 5: 290 (1955).

Sterculiaceae

Melochia villosissima var. *compacta* (Hochr.) Fosberg in Micronesica 23: 149 (1990).
Sterculia ellipticifolia Fosberg in Willdenowia 20: 263 (1991).

Thymelaeaceae

Phaleria ixorioides Fosberg in Bull. Torrey Bot. Club 67: 418 (1940).

Tiliaceae

Corchorus torresianus var. *yunckeri* Fosberg in Micronesica 2: 147 (1966).
Tilia americana var. *neglecta* (Spach) Fosberg in Castanea 20: 58 (1955).

Triuridaceae

Sciaphila stemmermanniae Fosberg & Sachet in Pac. Sci. 34: 25 (1981).

Typhaceae

Typha domingensis var. *sachetiae* Fosberg in Bot. Bull. Acad. Sin. 30: 220 (1989).

Urticaceae

Elatostema divaricatum (Gaudich.) Fosberg in Smithsonian Contr. Bot. 45: 6 (1980).

Verbenaceae

Callicarpa candicans f. *glabriuscula* (H. J. Lam) Fosberg in Smithsonian Contr. Bot. 45: 25 (1980).
Callicarpa candicans var. *integrifolia* (H. J. Lam) Fosberg in Smithsonian Contr. Bot. 45: 25 (1980).
Callicarpa candicans var. *paucinervia* (Merr.) Fosberg in Smithsonian Contr. Bot. 45: 25 (1980).

Callicarpa candicans var. *ponapensis* Fosberg in Smithsonian Contr. Bot. 45: 26 (1980).

Clerodendrum glabrum var. *minutiflorum* (Baker) Fosberg in Kew Bull. 33: 143 (1978).

Lantana involucrata f. *candida* Fosberg in Rhodora 78: 113 (1976).

Lippia strigulosa f. *parvifolia* (Moldenke) Fosberg in Rhodora 78: 113 (1976).

ATOLL RESEARCH BULLETIN

NO. 391

ANNOTATED LIST OF THE KNOWN PUBLICATIONS OF F. RAYMOND FOSBERG

BY

ANNA L. WEITZMAN

ISSUED BY
NATIONAL MUSEUM OF NATURAL HISTORY
SMITHSONIAN INSTITUTION
WASHINGTON, D.C., U.S.A.
FEBRUARY 1994

ANNOTATED LIST OF THE KNOWN PUBLICATIONS OF F. RAYMOND FOSBERG

BY

ANNA L. WEITZMAN

INTRODUCTION

F. Raymond Fosberg kept a card file and reprints of scientific publications, reviews, popular articles, and less formally distributed writings. None of those sources is complete and I have filled in some gaps by searching through periodicals that he used frequently. There will undoubtedly be corrections and additions to this list. Scientific publications are numbered 1-625, with Dr. Fosberg's own numbering in parentheses following the sequential numbers I assigned (his numbering had many publications numbered out of order or unnumbered). I did not number republications of articles. Because this is an attempt to give a relatively complete summation of the published views of Dr. Fosberg, I have included reviews, published letters, published abstracts, anonymous committee reports that he attributed to himself, and informally published (often duplicated and distributed by Dr. Fosberg at meetings) documents in this list. These publications were not carefully documented and I am sure that this list is far from complete. Those categories are numbered separately as R1-89 (reviews), L1-20 (letters), and D1-86 (abstracts and informal documents) respectively.

In many instances, especially later in his career, large and small publications included information about named taxa. Many of those, such as the regional checklists, do not need further explanation, but some include other information about a number of taxa. I have included a list of genera discussed following the citation of the article. Those names are also indexed by citation and page numbers following the publication list. In nearly all cases I have omitted the names of taxa when the information given is merely distributional. I have made a judgment about what genera are included, necessarily subjective, but where there is information that may help the user understand Dr. Fosberg's views on the taxon or taxa, or help the user identify and apply the correct name to plants, the generic name is listed and indexed. I have sometimes included synonyms in the list because they are lectotypified, or because I thought it useful to include them.

I have also included a list of publications that are known (by the Botany Department at the National Museum of Natural History) to be in press or submitted for publication. I expect an additional paper of Pacific plant distribution notes based on manuscripts found in his office. There are other publications which are expected to be completed and published by co-authors including: The Vegetation of the Pacific Islands with Dieter Mueller-Dombois to be published by Fischer Verlag, a list of vascular plants of Kosrae with Jerome Ward, and various articles written with David Stoddart. Other publications which Dr. Fosberg was working on are unlikely to appear. Those include a checklist of vascular plants of the Society Islands; a supplement to the Micronesian checklists; a Marquesas checklist; Flora of Micronesia, part 6; the bulk of the planned Forster list; a *Spermacoce* (Rubiaceae) monograph; and an *Alyxia* (Apocynaceae) monograph. The treatments of Malvaceae and Rubiaceae for the Flora of Ceylon have been forwarded to others for completion. The Pacific plant checklists will be used in preparation of a planned checklist for all of Oceania. Readers who would like to use materials that Dr. Fosberg did not publish should contact the Botany Department of the National Museum of Natural History.

Periodical titles are abbreviated following *B-P-H* (G.H.M. Lawrence et al.'s 1968 *Botanico-Periodicum-Huntianum*) and its *Supplement* (Bridson and Smith, 1991). Unless marked with *, all citations

---

Department of Botany, MRC-166, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560.

were checked against original publications or reprints with original pagination. Where actual date of publication or distribution differs from that on the title page, the date on the title page is placed in brackets following the actual date of distribution according to Dr. Fosberg's records or other sources. A few citations verified by Lu Eldredge (Pacific Science Association) are indicated with **, one verified by Scott Miller (Bishop Museum) is indicated with ***. The assistance of Dan Nicolson throughout my work on this list is gratefully acknowledged.

A brief list of some published photographs and biographical information of F.R. Fosberg follows the list of publications. This is not intended to be a complete list, merely a compilation of what I found in compiling this list of publications.

KNOWN PUBLICATIONS OF F.R. FOSBERG

1929

1 (1). Fosberg, F.R. 1929. Preliminary notes on the fauna of the giant kelp, *Macrocystis pyrifera*. Pomona Coll. J. Ent. and Zool. 21: [3 unnumbered pages in reprint.]

1931

2 (2). Fosberg, F.R. 1931. Remarks on the taxonomy of the Cactaceae and some new combinations and names in that family. Bull. S. Calif. Acad. Sci. 30: 50-59. [in reprint pp. 1-10; *Coryphantha*, *Neomammillaria*, *Opuntia*.]

3 (3). ——. 1931. The cacti of the Pyramid Peak Region, Dona Ana County, New Mexico. Bull. S. Calif. Acad. Sci. 30: 67-73. [*Republished in Desert Mag. 5: 147-149, 1942?]

1932

4 (4). Fosberg, F.R. 1932. The study of the Cactaceae. Cact. Succ. J. (Los Angeles) 4: 270-272. [*Opuntia*.]

1933

5 (5). Pierce, W.M. and F.R. Fosberg. 1933. Notes on southwestern cacti. Bull. S. Calif. Acad. Sci. 32: 121-126. [*Opuntia*, *Echinocereus*, *Cereus*, *Echinocactus*, *Neomammillaria*.]

1934

6 (6). Fosberg, F.R. 1934. A key to the families of Monocotyledons in the Hawaiian Islands. Occas. Pap. Univ. Hawaii 18: 1-8.

7 (7). ——. 1934. The southern California Prickly-Pears. Bull. S. Calif. Acad. Sci. 33: 93-104. [(110a) republished in Desert Plant Life 21: 75-80, 1949.] [*Opuntia*.]

1935

8 (8). Fosberg, F.R. and J. Ewan. 1935. Notes on southwestern plants. Bull. S. Calif. Acad. Sci. 34: 177-183.

1936

9 (9). Fosberg, F.R. 1936. Plant collecting on Lanai, 1935. Mid-Pacific Mag. 49: 119-123.

10 (10). ——. 1936. Miscellaneous Hawaiian plant notes–1. Occas. Pap. Bernice P. Bishop Mus. 12(15): 3-11. [*Cryptocarya*, *Cassytha*, *Schiedea*, *Eurya*, *Phyllanthus*, *Antidesma*, *Diospyros*, *Phyllostegia*, *Rollandia*.]

11 (11). ——. 1936. The Hawaiian geraniums. Occas. Pap. Bernice P. Bishop Mus. 12(16): 1-19.

12 (12). ——. 1936. The varieties of the desert willow, *Chilopsis linearis*. Madroño 3: 362-366.

13 (14). ——. 1936. Plant remains in Shelter Cave, New Mexico. Bull. S. Calif. Acad. Sci. 35: 154-155.

*D1 (17a). ——. 1936. Vegetation of Vostok Island, central Pacific, [abstract.] Special Publ. Bernice Pauahi Bishop Mus. (Proc. Hawaiian Acad. Sci. 11) 30(24): 19.

*D2 (17b). ——. 1936. A study of the Hawaiian genus, *Gouldia*, [abstract.] Special Publ. Bernice Pauahi Bishop Mus. (Proc. Hawaiian Acad. Sci. 11) 30(24): 20.

*D3 (17c). St. John, H. and F.R. Fosberg. 1936. Vegetation of Flint Island, Central Pacific, [abstract.] Special Publ. Bernice Pauahi Bishop Mus. (Proc. Hawaiian Acad. Sci. 11) 30(24): 20.

1937

14 (15). Fosberg, F.R. 1937. Immigrant plants in the Hawaiian Islands. I. Occas. Pap. Univ. Hawaii 32: 3-11. [*Myrica*, *Atriplex*, *Spergularia*, *Geranium*, *Sida*, *Myriophyllum*, *Elephantopus*, *Eupatorium*, *Pluchea*.]

15 (18). ——. 1937. The genus *Gouldia* (Rubiaceae). Bernice P. Bishop Mus. Bull. 147: 1-82, 3 plates.

16 (19). ——. 1937. Some Rubiaceae of southeastern Polynesia. Occas. Pap. Bernice P. Bishop Mus. 13(19): 245-293. [*Hedyotis*, *Ophiorrhiza*, *Tarenna*, *Canthium*, *Guettarda*, *Timonius*, *Ixora*, *Psychotria*, *Nertera*, *Coprosma*, *Morinda*, *Borreria*.]

*17 (16). Degener, O. and F.R. Fosberg. 1937. *Luzula campestris* (L.) DC., *in* Degener, O., Flora Hawaiiensis, 2 pp.

18 (13). St. John, H. and F.R. Fosberg. 1937. Vegetation of Flint Island, Central Pacific. Occas. Pap. Bernice P. Bishop Mus. 12(24): 1-4.

1938

19 (20). Fosberg, F.R. 1938. The Lower Sonoran in Utah. Science 87: 39-40.

20 (22). ——. 1938. *Eriogonum abertianum* and its varieties. Madroño 4: 189-194.

21 (24a). ——. 1938. Two Queensland *Ixora*s. J. Bot. 76: 233-237.

22 (24b). ——. 1938. Additional Note on Queensland *Ixora*s. J. Bot. 76: 276-277.

23 (25). ——. 1938. A central repository for type-specimens. J. Bot. 76: 327-330.

24 (26). ——. 1938. Notes on plants of the Pacific Islands. I. Bull. Torrey Bot. Club 65: 607-614. [*Gouania*, *Diospyro*s, *Randia*.]

25 (21). Fosberg, F.R. and E.Y. Hosaka. 1938. An open bog on Oahu. Occas. Pap. Bernice P. Bishop Mus. 14(1): 1-6. [*Styphelia*, *Lobelia*.]

26 (23). St. John, H. and F.R. Fosberg. 1938. Identification of Hawaiian plants: a key to the families of dicotyledons of the Hawaiian Islands, descriptions of the families, and list of the genera. Occas. Pap. Univ. Hawaii 36: 1-53.

D4 (19a). Fosberg, F.R. 1938 [1937.] An aggressive *Lantana* mutation. Special Publ. Bernice Pauahi Bishop Mus. (Proc. Hawaiian Acad. Sci. 12) 31: 18.

1939

27 (27). Fosberg, F.R. 1939. Safeguarding type specimens. Science 89: 245.

28 (28). ——. 1939. Plant collecting manual for field anthropologists. Botanical Supply Dept., American Fiber-Velope Mfg. Co., 1-22, Philadelphia.

29 (29). ——. 1939. Nomenclature proposals for the 1940 Botanical Congress. Amer. J. Bot. 26: 229-231.

30 (30). ——. 1939. Notes on Polynesian grasses. Occas. Pap. Bernice P. Bishop Mus. 15(3): 37-48. [*Eragrostis*, *Digitaria*, *Paspalum*.]

31 (31). ——. 1939. Taxonomy of the Hawaiian genus *Broussaisia* (Saxifragaceae). Occas. Pap. Bernice P. Bishop Mus. 15(4): 49-60.

32 (32). ——. 1939. *Diospyros ferrea* (Ebenaceae) in Hawaii. Occas. Pap. Bernice P. Bishop Mus. 15(10): 119-131.

33 (33). ——. 1939. Taxonomy and hybridism. Chron. Bot. 5: 397-398.

34 (38). ——. 1939. *Psychotria* (Rubiaceae) in the Marquesas Islands. Notul. Syst. (Paris) 8: 161-173.

35 (104). ——. 1939. Reports on nature protection and related items for: Fanning Island, Christmas Island, Vostok Island, Flint Island, Henderson Island, Oeno Island, Pitcairn Island, Society Islands, Austral Islands, Rapa, Tuamotu Archipelago, Gambia Islands. Proc. Sixth Pacific. Sci. Congress 4: 501-504, 517-524.

36 (33b). St. John, H. and F.R. Fosberg. 1939. A new variety of *Ruppia maritima* (Ruppiaceae) from the tropical Pacific. Occas. Pap. Bernice P. Bishop Mus. 15(16): 175-178.

R1 (33a). Fosberg, F.R. 1939. Artistic tropical blooms, review of McLean, O.G. and M.D. Frear, Flowers of Hawaii, 1938. J. New York Bot. Gard. 40: 73.

1940

37 (34). Fosberg, F.R. 1940. Notes on Micronesian Rubiaceae. Occas. Pap. Bernice P. Bishop Mus. 15(20): 213-226. [*Bikkia, Uncaria, Ophiorrhiza, Hedyotis, Mussaenda, Randia, Timonius, Canthium, Gynochthodes, Morinda, Ixora, Psychotria.*]

38 (37). ——. 1940. Notes on plants of the Pacific Islands–II. Bull. Torrey Bot. Club 67: 417-425. [*Diospyros, Phaleria, Neonauclea, Hedyotis, Ophiorrhiza, Gynochthodes, Timonius, Morinda, Ixora, Psychotria, Digitaria.*]

39 (39). ——. 1940. Melanesian Vascular Plants. Lloydia 3: 109-124. [*Campium, Lycopodium, Ficus, Acalypha, Medinilla, Dischidia, Hoya, Acanthus, Pseuderanthemum, Hedyotis, Hydnophytum.*]

40 (40). ——. 1940. The aestival flora of the Mesilla Valley Region, New Mexico. Amer. Midl. Naturalist 23: 573-593.

41 (43). ——. 1940. Financing a taxonomic journal. Chron. Bot. 6: 55-56.

42 (44). ——. 1940. A taxonomic journal. Chron. Bot. 6: 127-128.

43 (54a). ——. 1940. Santalaceae of Nevada. Contributions toward a Flora of Nevada (U.S.D.A.) 5: 1-2. [*Comandra.*]

44 (54b). ——. 1940. Ulmaceae of Nevada. Contributions toward a Flora of Nevada (U.S.D.A.) 6: 1-3. [*Celtis.*]

45 (54c). ——. 1940. Chenopodiaceae of Nevada (in part). Contributions toward a Flora of Nevada (U.S.D.A.) 8: 1-18. [*Nitrophila, Allenrolfea, Salsola, Sarcobatus, Bassia, Halogeton, Grayia, Eurotia, Cycloloma, Monolepis.*]

46 (35). St. John, H. and F.R. Fosberg. 1940. Identification of Hawaiian plants: Part 2. A key to the families and genera of the gymnosperms and of the monocotyledons of the Hawaiian Islands, with descriptions of the families. Occas. Pap. Univ. Hawaii 41: 1-47.

R2 (33b). Fosberg, F.R. 1940. By airplane to a Stone-Age Island, review of Archbold, R., and A. L. Rand, New Guinea Expedition, 1940. J. New York Bot. Gard. 41: 19.

R3 (41). ——. 1940. Review of Gates, F.C., Flora of Kansas. Amer. Midl. Naturalist 24: 503-504.

R4 (42). ——. 1940. Review of Deam, C.C., Flora of Indiana, 1940. Chron. Bot. 6: 95.

1941

47. Fosberg, F.R. 1941. Names in *Amaranthus, Artocarpus*, and *Inocarpus*. J. Wash. Acad. Sci. 31: 93-96.

48 (54h). ——. 1941. Loganiaceae of Nevada. Contributions toward a Flora of Nevada (U.S.D.A.) 23: 1-2. [*Buddleja.*]

49 (54d). ——. 1941. Aizoaceae of Nevada. Contributions toward a Flora of Nevada (U.S.D.A.) 24: 1-3. [*Sesuvium, Mollugo.*]

50 (54e). ——. 1941. Haloragaceae (Haloragidaceae) of Nevada. Contributions toward a Flora of Nevada (U.S.D.A.) 25: 1-3. [*Hippuris, Myriophyllum.*]

51 (54f). ——. 1941. Elaeagnaceae of Nevada. Contributions toward a Flora of Nevada (U.S.D.A.) 26: 1-4. [*Elaeagnus.*]

52 (46). ——. 1941. For an open-minded taxonomy. Chron. Bot. 6: 368-370.

53 (47). ——. 1941. Observations on Virginia Plants, Part I. Virginia J. Sci. 2: 106-111. [*Abies, Anemone, Saxifraga, Spiraea, Veronica, Hedyotis.*]

54 (85). ——. 1941. Rubiaceae, pp. 94-95, *in* Hermann, F.J., Check-list of plants in the Washington–Baltimore area. Conference on the District Flora, Washington.

55 (48). ——. 1941. Varieties of the strawberry guava. Proc. Biol. Soc. Wash. 54: 179-180. [*Psidium.*]

56 (50). ——. 1941. Notes on Mexican plants. Lloydia 4: 274-290. [*Phoradendron, Mirabilis, Drymaria, Paronychia, Fendlera, Rhamnus, Hedyotis.*]

57 (51). ——. 1941. Notes on North American plants–I. Amer. Midl. Naturalist 26: 690-695. [*Chenopodium, Atriplex, Acer.*]

58 (52). ——. 1941. Observations on Virginia plants, Part II. Virginia. J. Sci. 2: 284-288.

59 (49). Fosberg, F.R. and E.H. Walker. 1941. A preliminary check list of plants in the Shenandoah National Park, Virginia. Castanea 6: 89-136.

60 (54g). McVaugh, R. and F.R. Fosberg. 1941. Index to the geographical names of Nevada. Contributions toward a Flora of Nevada (U.S.D.A.) 29: 1-216.

D5 (55). Fosberg, F.R. 1941. Care and housing of botanical type specimens. 7 pp., duplicated and distributed with Taxonomic Index.

D6 (56). ——. 1941. Local floras in relation to conservation. 4 pp., duplicated and distributed with Taxonomic Index.

1942

61 (57). Fosberg, F.R. 1942. Notes on North American plants–II. Amer. Midl. Naturalist 27: 253-258. [*Atriplex, Arenaria, Lewisia, Ceanothus, Echinocactus, Elaeagnus.*]

62 (58). ——. 1942. Uses of Hawaiian Ferns. Amer. Fern J. 32: 15-23.

63 (59). ——. 1942. Subspecies and variety. Rhodora 44: 153-157.

64 (60). ——. 1942. Coniferae (Coniferales) of the Washington-Baltimore area–preliminary keys. 5 pp., Conference on District Flora. [*Pinus, Tsuga, Taxodium, Chamaecyparis, Juniperus.*]

65 (61). ——. 1942. Rubiaceae, *in* Smith, A.C., Fijian Plant Studies II. Sargentia 1: 118-140.

66 (62). ——. 1942. The genus *Batocarpus* Karst (Moraceae). Proc. Biol. Soc. Wash. 55: 99-102.

67 (63). ——. 1942. Notes on North American plants–III. Amer. Midl. Naturalist 27: 761-765. [*Pimenta, Oenothera, Gilia, Richardia, Sambucus.*]

68 (64). ——. 1942. Scholarship and economic usefulness. Chron. Bot. 7: 154-155.

69 (65). ——. 1942. *Cornus sericea* L. (*C. stolonifera* Michx.) Bull. Torrey Bot. Club 69: 583-589.

70 (66). ——. 1942. Segregation of type specimens. Science 96: 515-516.

71 (66c). ——. 1942. Miscellaneous notes on Hawaiian plants–2. Occas. Pap. Bernice P. Bishop Mus. 16(15): 337-347. [*Dryopteris, Korthalsella, Geranium, Vaccinium, Lepechinia, Phyllostegia, Coprosma.*]

R5 (66a). ——. 1942. Reviews of Bailey, L.H. and E.Z. Bailey, Hortus Second, 1941 and Kelsey, H.P. and W.A. Dayton, Standardized Plant Names, ed. 2, 1942. Chron. Bot. 7: 283-285.

D7 (66b). [list by editors of Chron. Bot., assistance from others including F.R. Fosberg.] 1942. A list of plant scientists in Central and South America. Chron. Bot. 7: 97-133.

1943

72 (67). Fosberg, F.R. 1943. The Polynesian species of *Hedyotis* (Rubiaceae). Bernice P. Bishop Mus. Bull. 174: 1-102.

73 (68). ——. 1943. Notes on North American plants. IV. Amer. Midl. Naturalist 29: 785-786. [*Portulaca, Hedyotis.*]

74 (69). ——. 1943. Notes on plants of the Pacific Islands–III. Bull. Torrey Bot. Club 70: 386-397. [*Nephrolepis, Anectochilus, Spergularia, Malachra, Maurandya, Ruellia, Gouldia, Timonius, Coprosma, Elephantopus, Pseudelephantopus, Ageratum, Dubautia.*]

75 (70). ——. 1943. Colombian Cinchona Manual. Foreign Economic Administration, Bogotá, Colombia. 27 pp.

76 (72). ——. 1943. Proposal to conserve *Schizaea*. Chron. Bot. 7: 395.

77 (71). Fosberg, F.R. and E.H. Walker. 1943. First supplement to a preliminary check list of plants in the Shenandoah National Park. Castanea 8: 109-115.

1944

78 (74). Fosberg, F.R. 1944. Colombian Cinchona Manual, 2nd edition. Foreign Economic Administration, Bogotá, Colombia, 33 pp.

79 (73). ——. 1944. Manual de Quinas Colombianos. [Spanish translation by G. Sáenz Fety.] Foreign Economic Administration, Bogotá, Colombia, 40 pp. [*Cinchona.*]

80 (75). ——. 1944. El Páramo de Sumapaz, Colombia. J. New York Bot. Gard. 45: 226-234.

*D8 (73a). ——. 1944? Gifts of the Americas. Quinine. 1 p., place and date of publication unknown.

1945

81 (76). Fosberg, F.R. 1945. Principal economic plants of tropical America, pp. 18-35, *in* F. Verdoorn, ed., Plants and Plant Science in Latin America. Chronica Botanica Co. Waltham, Mass.

82 (77). ——. 1945. The Air Force's collection of aerial photographs. Science 102: 538-539.

83 (79). ——. 1945. The work of botanists of the Cinchona Mission in Colombia. Chron. Bot. 9: 119-121.

84 (86). ——. 1945. *Drymaria* and *Mollugophytum*, pp. 95-96, *in* Morton, C.V., Mexican Phanerogams described by M.E. Jones. Contr. U.S. Natl. Herb. 29: 87-116.

85 (87). ——. 1945. The Sleepy Hollow area [collecting projects in the local region.] Bull. Wash.-Balt. Flora 9: 4-5.

1946

86 (80). Fosberg, F.R. 1946. A biologist reflects upon old age and death. Sci. Monthly 63: 158-159.

87 (81). ——. 1946. Observations on Virginia Plants. III. Castanea 11: 66-69. [*Triodia.*]

88 (82). ——. 1946. Application of the name *Euphorbia maculata* L. Rhodora 48: 197-200.

89 (83). ——. 1946. The herbarium. Sci. Monthly 63: 429-434.

90 (84). ——. 1946. Rubiaceae, pp. 106-108, *in* Hermann, F.J., A checklist of plants in the Washington-Baltimore Area. Ed. 2., Conference on the District Flora, Washington.

91 (88a). ——. 1946. Gifts of the Americas: Quinine. Agriculture of the Americas, inside back cover. [*Cinchona.*]

R6 (78). ——. 1946. Vegetation of the Far East described for men in the Service, review of Merrill, E.D., Plant Life of the Pacific World, 1945. J. New York Bot. Garden 47: 44-45.

L1 (88). ——. 1946. Present status of foreign Herbaria and Museums, [letter to the editor.] Science 103: 282-283.

1947

92 (89). Fosberg, F.R. 1947. Observations on Virginia Plants. IV. Castanea 12: 59-62. [*Impatiens, Chelone, Taraxacum.*]

93 (90). ——. 1947. Formaldehyde in plant collecting. Science 106: 250.

94 (91). ——. 1947. Cinchona plantation in the New World. Econ. Bot. 1: 330-333.

95 (92). ——. 1947. *Euphorbia maculata* again. Bull. Torrey Bot. Club 74: 332-333.

96 (93). ——. 1947. Micronesian mangroves: a journey by motorized sampan to a peak development of land-building swamps in the Carolines. J. New York Bot. Gard. 48: 128-138.

97 (101). ——. 1947. Nyctaginaceae. Contributions toward a Flora of Idaho 36: 1-3. [*Mirabilis, Abronia.*]

98 (102). ——. 1947. Cornaceae of Idaho. Contributions toward a Flora of Idaho 77: 1-3. [*Cornus.*]

R7 (94). ——. 1947. General biology: philosophy and education, review of Noüy, L. du, Human Destiny, 1947. Quart. Rev. Biol. 22: 315-317.

1948

99 (95). Fosberg, F.R. 1948. Island Floras, pp. 18-21, *in* Coolidge, H.J., ed., Conservation in Micronesia. National Research Council, Washington, D.C.

100 (96). ——. 1948. Areas to be set aside, pp. 16-19, *in* Recommendations and selected papers from the Honolulu Conference on Conservation in Micronesia.

101 (96a). ——. 1948. Island Floras, pp. 16-19, *in* Recommendations and selected papers from the Honolulu Conference on Conservation in Micronesia.

102 (97). ——. 1948 [1946.] Preservation of natural areas for scientific reserves and watersheds. Botanical Report on Micronesia, U.S. Commercial Company, Economic Survey of Micronesia Vol. 13-1, pp. 17-19.

103 (98). ——. 1948. Artificial key to the Rubiaceae of the Washington-Baltimore Area. Bull. Wash.-Balt. Flora 12: 10-12.

104 (100). ——. 1948. Derivation of the flora of the Hawaiian Islands, pp. 107-118, *in* Zimmerman, E.C., Insects of Hawaii. Vol. 1. Univ. Press Hawaii, Honolulu.

105 (103). ——. 1948. Economic Botany–a modern concept of its scope. Econ. Bot. 2: 3-14.

106 (105). ——. 1948. Salinity and Atoll vegetation. Proc. Hawaiian Acad. Sci. 23: 8.

107 (106). ——. 1948. Immigrant plants in the Hawaiian Islands. II. Occas. Pap. Univ. Hawaii 46: 1-17. [*Musa, Spergularia, Kalanchoë, Bruguiera, Polyscias, Kigelia, Ixora, Hippobroma, Emilia, Eupatorium.*]

108 (99). Fosberg, F.R. and E.H. Walker. 1948. Second supplement to a preliminary check list of plants in the Shenandoah National Park. Castanea 13: 83-92.

D9 (109). Fosberg, F.R. 1948. Popular or profusely illustrated works on Hawaiian plants. 2 pp., duplicated and distributed by Workshop Committee, Summer Program Committee, Nature Study Classes, Honolulu.

1949

109 (107). Fosberg, F.R. 1949. Atoll vegetation and salinity. Pacific Sci. 3: 89-92.

110 (111). ——. 1949. A new *Drymaria* (Caryophyllaceae) from Mexico. Proc. Biol. Soc. Wash. 62: 147-148.

111 (113). ——. 1949. Flora of Johnston Island, central Pacific. Pacific Sci. 3: 338-339.

112 (114). ——. 1949. Early history of Cinchona. J. New York Bot. Gard. 50: 254-257.

113 (114a). ——. 1949. *Hedyotis angulata* Fosberg and *Hedyotis greenmanii* Fosberg, *in* Shinners, L.H., Transfer of Texas species of *Houstonia* to *Hedyotis* (Rubiaceae). *Field & Lab.* 17: 166-169.

114 (117). ——. 1949. Waipoua. New Zealand Sci. Rev. 7: 200-201.

115 (126). ——. 1949. Plant exploration–South America and the Pacific Islands. Bull. Hort. Soc. New York 20(4): 9-11.

R8 (110). ——. 1949. The Rules reprinted, review of Camp, W.H., H.W. Rickett, and C.A. Weatherby, International Rules of Botanical Nomenclature, 1947. J. New York Bot. Gard. 50: 92-93.

D10 (108). ——. 1949. Further nomenclatural considerations. 12 pp., distributed privately before 7th Int. Bot. Congress.

D11 (112). ——. 1949. The problem of rare and vanishing plant species. Duplicated for and distributed at IUPN Conference, UNESCO/IUPN/Conf. 2/IIf/8, Lake Success, 2 pp. [(199) republished 1950?. Proc. & Papers Internat. Tech. Conf. Protection Nature 502-504.]

*D12 (125). ——. 1949. A conservation program for Micronesia, [abstract.] Selected Abstracts and Final Resolutions of the Seventh Pacific Science Congress, Auckland, p. 12.

1950

116 (116). Fosberg, F.R. 1950. Official plant names? Rhodora 52: 1-7.

117 (118). ——. 1950. Notes on Micronesian Pteriodophytes. Amer. Fern J. 40: 132-147. [*Angiopteris, Marattia, Hymenophyllum, Trichomanes, Gleichenia, Lygodium, Schizaea, Lycopodium.*]

118 (120). ——. 1950. Translations of Japanese botanical papers. Pacific Sci. 4: 375.

119 (121). ——. 1950. Ecological notes on the upper Amazon. Ecology 31: 650-653.

120 (122). ——. 1950. Remarks on the factual basis of ecology. Ecology 31: 653-654.

121 (123). ——. 1950. Nature appreciation in the Netherlands. Nature 43: 482-484.

122 (118a). Diehl, W.W. and F.R. Fosberg. 1950. *Taxus* in Piedmont Virginia. Castanea 15: 129-131.

R9 (115). Fosberg, F.R. 1950. A much needed text for botany students, review of Newbigin, M.I., Plant and Animal Geography, 1949. J. New York Bot. Gard. 51: 16.

**D13 (124). [——.] 1950. Report on the Seventh International Botanical Congress. Pacific Sci. Assoc. Inform. Bull. 50(6): 3.

1951

123 (127). Fosberg, F.R. 1951. The American element in the Hawaiian Flora. Pacific Sci. 5: 204-206.

124 (128). ——. 1951. Museums in Pacific research. Proc. Seventh Pacific Sci. Congress 1: 91-93.

125 (131). ——. 1951. Regulations for the selection of generic names for conservation. II. Suggestions by F.R. Fosberg. Taxon 1: 15.

*126 (132). ——. 1951. Temprana historia de la quina. Revista Acad. Colomb. Ci. Exact. 8: 273-274.

127 (133). ——. 1951. Atoll Research Bulletin–Editorial Introduction. Atoll Res. Bull. 1: i-ii.

128 (134). ——. 1951. Ecological research on coral atolls. Atoll Res. Bull. 1: 6-8. [(714). republished 1992. Atoll Res. Bull. 355: 9-11.]

129 (135). ——. 1951. Flora and vegetation of coral atolls. Atoll Res. Bull. 1: 13-14.

130 (136). ——. 1951. Literature on coral atolls. Atoll Res. Bull. 1: 23-25.

131 (137). ——. 1951. Land ecology on coral atolls. Atoll Res. Bull. 2: 7-11.

132 (129). Tweedie, M.W.F. and F.R. Fosberg. 1951. The research museum or herbarium. Proc. Seventh Pacific Sci. Congress 1: 97.

R10 (137a). ——. 1951. Plants of a coral atoll, review of Taylor, W.R., Plants of Bikini, 1950. Sci. Monthly 72: 196-197.

R11 (137b). ——. 1951. Before men came, review of Braun, E.L., Deciduous Forests of Eastern North America, 1950. Sci. Monthly 73: 66-67.

R12 (137c). ——. 1951. Regional ecology, review of Pearsall, W.H., Mountains and Moorlands, 1950. Sci. Monthly 73: 135.

R13 (137d). ——. 1951. Earth's largest ocean, review of Freeman, O.W., ed., Geography of the Pacific, 1951. Sci. Monthly, 73: 203-204.

**D14 (130). [——.] 1951. Interim report on the activities of the Standing Committee on Pacific Conservation. Pacific Sci. Assoc. Inform. Bull. 51(8): 3-4.

1952

133 (140). Fosberg, F.R. 1952. Introduction and chapter 6: Botany, pp. 1, 43-51, 55-56, *in* Sachet, M.-H., ed., Handbook for Atoll Research, preliminary edition.

*134 (150). ——. 1952. Lignes biogéographiques dans l'ouest du Pacifique. Compt. Rend. Sommaire Séances Soc. Biogéogr. ?(256): 161-166. [No volume number on reprint.]

135 (139). Fosberg, F.R. and H. St. John. 1952. Végétation et flore de l'atoll Maria, îles Australes. Rev. Sci. Bourbonnais Centr. France. 1951: 1-7 [translated into French by M.-H. Sachet.]

136 (138). Degener, O. and F.R. Fosberg. 1952. A central Pacific *Sesuvium*. Occas. Pap. Bernice P. Bishop Mus. 21(14): 45-47.

R14 (140a). Fosberg, F.R. 1952. Keys to local woody plants, review of Blackburn, B., Trees and shrubs in Eastern North America, 1952. Castanea 17: 142-144.

R15 (151). ——. 1952. Review of Porsild, A.E., Botany of Southeastern Yukon adjacent to the Canol Road, 1951. Quart. Rev. Biol. 27: 394.

D15 (140b). ——. 1952. Plants suitable for Naval station, Kwajalein, and suggestions for their cultivation. [Prepared for Commanding Officer, U.S. Naval Station, Kwajalein.]

1953

137 (141). Fosberg, F.R. 1953. Nomenclature of *Premna obtusifolia* R. Br. Taxon 2: 88-89.

138 (142). ——. 1953. Proposal to conserve the generic name *Citrullus* Schrader. Taxon 2: 99-101.

139 (143). ——. 1953. Proposals to amend the Stockholm Code of Botanical Nomenclature. Taxon 2: 107-109.

*140 (145). ——. 1953. La flora de los atolones de Oceania. Rev. Geogr. Chile 9: 30-42.

141 (147). ——. 1953. Typification of *Euphorbia maculata* L. Rhodora 55: 241-242.

142 (149). ——. 1953. Vegetation for a southern California arboretum. Annéc Biol. 29: 429-442.

143 (155). ——. 1953. A conservation programme for Micronesia. Proc. Seventh Pacific Sci. Congress 4: 670-673.

144 (152a). ——. 1953. Directions for studying vegetation and flora, pp. 44-56, *in* Fosberg, F.R. and M.-H. Sachet, eds. Handbook for Atoll Research (second preliminary edition). Atoll Res. Bull. 17: 1-129.

145 (157a). ——. 1953. Chapter 6–Botany, pp. 44-56, *in* Fosberg, F.R. and M.-H. Sachet, eds., Handbook for Atoll Research, second preliminary edition.

146 (157). ——. 1953. Vegetation of central Pacific atolls, a brief summary. Atoll Res. Bull. 23: 1-26.

147 (148). Fosberg, F.R. and L. Artz. 1953. The varieties of *Monarda fistulosa* L. Castanea 18: 128-130.

148 (144). Fosberg, F.R. and M.-H. Sachet. 1953. Reinstatement of *Eranthemum pulchellum* Andr. Taxon 2: 135-136.

149 (151a). Fosberg, F.R. and M.-H. Sachet, eds. 1953. Handbook for Atoll Research (second preliminary edition). Atoll Res. Bull. 17: 1-129.

R16 (151). Fosberg, F.R. 1953. Review of Lawrence, G.H.M., Taxonomy of Vascular Plants, 1951. Quarterly Rev. Biol. 28: 58-61.

1954

150 (146). Fosberg, F.R. 1954. Comments on recent nomenclature proposals. Taxon 3: 1-3.

151 (152). ——. 1954. Notes on plants of the Eastern United States. Castanea 19: 25-37. [*Equisetum*, *Acer*, *Oenothera*, *Hedyotis*.]

152 (154). ——. 1954. Soils of the northern Marshall atolls, with special reference to the Jemo Series. Soil Sci. 78: 99-107.

*153 (156). ——. 1954. Vanishing island floras and vegetation. Proces-verbaux et rapports de la reunion technique, Caracas, 1952, IUPN 538-543.

154 (156a). ——. 1954. The synopsis of proposals for the 8th Congress. Taxon 3: 150-151.

155 (153). Dandy, J.E. and F.R. Fosberg. 1954. The type of *Amaryllis bella-donna* L. Taxon 3: 231-232.

R17 (156a). Fosberg, F.R. 1954. Review of Good, R., The Geography of the Flowering Plants, ed. 2, 1953. Science 120: 132.

**D16 (210). [——.] 1954. Note on Eighth International Botanical Congress. Pacific Sci. Assoc. Inform. Bull. 6(3): 6.

**D17 (211). [——.] 1954. Conservation in the U.S. Trust Territory of the Pacific. Pacific Sci. Assoc. Inform. Bull. 6(3): 6-7.

**D18 (209). [——.] 1954. Eighth International Botanical Congress. Pacific Sci. Assoc. Inform. Bull. 6(6): 10.

1955

156 (158). Fosberg, F.R. 1955. Ants and dermestids on a mountain top. Ecology 36: 367-368.

157 (160). ——. 1955. Northern Marshall Islands Expedition, 1951-1952. Narrative. Atoll Res. Bull. 38: 1-36.

158 (161). ——. 1955. Northern Marshall Islands Expedition, 1951-1952. Land biota: vascular plants. Atoll Res. Bull. 39: 1-22.

159 (164). ——. 1955. Observations on Virginia plants V. Castanea 20: 58-60. [*Tridens*, *Tilia*, *Monotropa*, *Veronica*, *Campanula*.]

160 (168). ——. 1955. Observations on *Hedyotis caerulea* var. *minor*. Castanea 20: 104-106.

161 (173). ——. 1955. Systematic notes on Micronesian Plants. Phytologia 5: 289-292. [*Digitaria*, *Ficus*, *Melanolepis*, *Maytenus*, *Polyscias*, *Solanum*, *Pseuderanthemum*, *Canthium*, *Hedyotis*, *Psychotria*, *Wedelia*.]

162 (172). ——. 1955. Pacific forms of *Lepturus* R. Br. (Gramineae). Occas. Pap. Bernice P. Bishop Mus. 21(14): 285-294.

*163 (159). Fosberg, F.R., P. Dansereau, and W.R.B. Oliver. 1955. Botanical report on Ambuklao. [perhaps published in The Ambuklao Symposium by IUPN]

164 (165). Fosberg, F.R. and E.H. Walker. 1955. Third supplement to a preliminary check list of plants in the Shenandoah National Park. Castanea 20: 61-70.

*165 (163). Sachet, M.-H. and F.R. Fosberg. 1955. Island Bibliographies: Micronesian Botany, land environment and ecology of coral atolls, vegetation of tropical Pacific Islands. National Academy of Sciences–National Research Council, publication #335, 577 pp.

R18 (162). Fosberg, F.R. 1955. Review of Gressitt, J. L., Insects of Micronesia. vol. 1, Introduction, 1954. Science, 121: 560-561.

*R19 (259). ——. 1955. Review of Odum, E.P. Fundamentals of Ecology. Austral. J. Sci. 18: 37-38.

R20 (260). ——. 1955. Review of Gates Clarke, J.F., Catalogue of the type specimens of Microlepidoptera in the British Museum (Natural History) described by Edward Meyrick, vols. 1 & 2, 1955. Science 122: 1274-1275.

1956

166 (174). Fosberg, F.R. 1956. Studies in Pacific Rubiaceae: I-IV. Brittonia 8: 165-178. [*Hedyotis*, *Gouldia*, *Coprosma*.]

167 (175). ——. 1956. Disposition of *Urera gaudichaudiana* Henslow. Ann. Mag. Nat. Hist., ser. 12, 9: 423-424.

*168 (179). ——. 1956. Le Rôle des réserves dans la conservation d'espéces et d'associations végétales, pp. 28-33, *in* Heim et al. Derniers refuges. Atlas commenté des Réserves Naturelles dans le monde.

169 (169a). ——. 1956. *Citrullus, Citrullus vulgaris* Schrader still correct. Nomina conservanda proposita. Taxon 5: 15.

170 (169). Fosberg, F.R. and M.-H. Sachet. 1956. The Indo-Pacific strand *Scaevola*. Taxon 5: 7-10.

171 (170). Moore, H.E., Jr. and F.R. Fosberg. 1956. The palms of Micronesia and the Bonin Islands. Gentes Herb. 8: 422-478. [*Livistona, Metroxylon, Heterospathe, Areca, Pinanga, Gulubia, Clinostigma, Ptychosperma, Cocos, Nypa.*]

*D19 (166). Fosberg, F.R. 1956. Coral atoll ecology. Working paper for UNESCO Humid Tropics Committee. Preparatory Meeting, Kandy, Ceylon, UNESCO/NS/HT/47, Paris, 5 pp.

*D20 (167). ——. 1956. The ecology of Man in the tropics. UNESCO Humid Tropics Committee Background Paper. UNESCO/NS/HT/44, Paris, 5 pp.

L2 (179a). ——. 1956. On Axis deer, [letter to the editor.] Honolulu Advertiser, 3 March.

1957

172 (176). Fosberg, F.R. 1957. The community ecologist. A.I.B.S. Bull. 7: 24-25. [(*176a.) republished 1957. Audubon Magazine 59: 197-198; (*265.) republished 1960. Bio-dynamics 56: 24-28.]

173 (177). ——. 1957. Some geological processes at work on coral atolls. Trans. New York Acad. Sci., ser. 2, 19: 411-421.

174 (181). ——. 1957. Slicks on ocean surface downwind from coral reefs. Atoll Res. Bull. 53: 1-4.

175 (182). ——. 1957. The Maldive Islands, Indian Ocean. Atoll Res. Bull. 58: 1-37.

176 (183). ——. 1957. Description and occurrence of atoll phosphate rock in Micronesia. Amer. J. Sci. 255: 584-592.

177 (184). ——. 1957. Lonely Pokak. Living Wilderness 22(62): 1-4.

178 (185). ——. 1957. The naturalized flora of Micronesia and World War II. Proc. Eighth Pacific Sci. Congress 4: 229-234.

179 (186). ——. 1957. The vegetation provinces of the Pacific. Proc. Eighth Pacific Sci. Congress 4: 15-23.

180 (187). ——. 1957. Vegetation of the Oceanic province of the Pacific. Proc. Eighth Pacific Sci. Congress 4: 48-55.

181 (207). ——. 1957. Notes on the vegetation of Iriomote-Zima, Ryukyu Islands. Sci. Bull. Agric. and Home Economics Div., Univ. Ryukyus, 4: 123-130.

**182 (222). ——. 1957. Soils, vegetation and agriculture on coral atolls. Proc. Eighth Pacific Sci. Congress 3A: 1037-1047.

183 (204). ——. 1957 [1956.] The protection of nature in the islands of the Pacific. Comptes Rendus des séances, Huitième Congress International de Botanique, Paris, 1954, Sect. 21-27: 104-116.

184 (180). Fosberg, F.R. and M.-H. Sachet. 1957. Plantes récoltées en Micronésie au XIX^{e} Siècle. Bull. Mus. Hist. Nat. (Paris), 2nd sér., 29: 428-438.

*185 (189). Jenkins, A.E. and F.R. Fosberg. 1957. Records of citrus canker and sweet potato stem and foliage scab in Micronesia. Pl. Dis. Reporter 41(12): 1055-1056.

R21 (197a). Fosberg, F.R. 1957. Review of Zaneveld, J.S., Economic marine algae of tropical south and east Asia and their utilization, 1955. Quart. Rev. Biol. 32: 396-397.

L3 (197b). ——. 1957. Botanists are essential for success, [letter to the editor.] Honolulu Star-Bulletin, [copy undated, after 1 November.]

L4 (197c). ——. 1957. Advice on a botanical garden, [letter to the editor.] Honolulu Star-Bulletin, 9 November.

D21 (178). ——. undated but distributed 1957. Preliminary list of botanists interested in Pacific Basin problems. 41 pp., duplicated and distributed by Pacific Science Association Standing Committee on Pacific Botany.

D22 (188). ——. 1957. Report on the implementation of the botanical resolutions passed at the various Pacific Science Congresses. Proc. Eighth Pacific Sci. Congress 4: 2-8.

D23 (195). ——. 1957. Dynamics of atoll vegetation, [abstract.] Ninth Pacific Sci. Congress Abstracts, pp. 42-43.

D24 (192). ——. 1957. Tropical Pacific grasslands and savannas, [abstract.] Ninth Pacific Sci. Congress Abstracts, p. 43.

D25 (194). ——. 1957. Qualitative description of the coral atoll ecosystem, [abstract.] Ninth Pacific Sci. Congress Abstracts, p. 56.

D26 (193). ——. 1957. The herbarium as a research museum, [abstract.] Ninth Pacific Sci. Congress Abstracts, pp. 149-150.

D27 (196). ——. 1957. Introduction [to Symposium on climate, vegetation, and rational land utilization in the humid tropics; abstract.] Ninth Pacific Sci. Congress Abstracts, p. 253.

D28 (197). ——. 1957. The preservation of man's environment, [abstract.] Ninth Pacific Sci. Congress Abstracts, pp. 264-265.

D29 (205). ——. 1957. List of botanists interested in Pacific Basin problems. Duplicated and distributed by Pacific Science Association Standing Committee on Pacific Botany, pp. 1-64.

1958

186 (198). Fosberg, F.R. 1958. Notes on Micronesian Pteridophyta, II. Amer. Fern J. 48: 35-39. [*Ceratopteris.*]

187 (200). ——. 1958. Vascular flora of Pagan Island, Northern Marianas. Pacific Sci. 12: 17-20.

188 (201). ——. 1958. Mapping of vegetation types. Study of Tropical Vegetation, UNESCO, 219-220.

189 (202). ——. 1958. Vegetation of the islands of Oceania. Study of Tropical Vegetation, UNESCO 54-60.

190 (203). ——. 1958 [1956.] Habitat availability and the development of floras. Comptes Rendus des séances, Huitième Congress International de Botanique, Paris, 1954, Sects. 3-6: 96-104.

191 (206). ——. 1958. *Zanthoxylum* L., "*Xanthoxylon* Mill.", and *Thylax* Raf. Taxon 7: 94-96.

192 (212). ——. 1958 [1957.] List of plant species reported from Pagan, p. 107, *in* [Corwin, G., L.D. Bonham, M.H. Terman, and G.W. Viele,] U.S. Army Engineers, U.S. Geological Survey, Military Geology of Pagan Mariana Islands, Intelligence Division, Office of Engineer, Headquarters, U. S. Air Force (Far East), Tokyo. [Table is four pages long.]

193 (213). ——. 1958. Nomenclature proposals for the Montreal Congress. Taxon 7: 149-151.

*194 (216). ——. 1958. Algunos campos de investigacion basica significativos en la evaluacion de los recursos naturales, [translated by T. Arango B.] Econ. Colomb. 19(54): 43-52.

195 (217). ——. 1958. Una experiencia Colombiana, [translated by T. Arango B.]. Revista Nac. Agric. 641: 15-21.

196 (218). ——. 1958. A new *Trichosanthes* (Cucurbitaceae) from Palau. Occas. Pap. Bernice P. Bishop Mus. 22(1): 67-69.

197 (220). ——. 1958. Vascular plants from Rennell and Bellona Islands, pp. 101-102, *in* Wolff, T., The Natural History of Rennell Island, British Solomon Islands, Danske Rennelleskpedition, 1951, vol. 3.

198 (199). Fosberg, F.R. and G. Corwin. 1958. A fossil flora from Pagan, Mariana Islands. Pacific Sci. 12: 3-16. [*Pteris, Freycinetia, Pandanus, Miscanthus, Cocos, Alocasia, Dianella, Spathoglottis, Trema, Hernandia, Macaranga, Melanolepis, Aglaia, Tristiropsis, Elaeocarpus, Eurya, Premna.*]

L5 (215). Fosberg, F.R. 1958 [1957.] Forestry at the Ninth Pacific Science Congress, [letter to the editor.] Malayan Forester 21: 201-202.

D30 (214). ——. 1958. Man as a dispersal agent. 1-5, 1958. Duplicated for and distributed at Missouri Bot. Gard. Annual Systematics Symposium.

D31 (219). ——. 1958. Natural areas as a botanical resource. 4 pp. Duplicated by Nature Conservancy for distribution at American Society of Plant Taxonomists annual meeting.

**D32 (208). [——.] 1958. [List of standing committee on Pacific Botany.] Pacific Sci. Assoc. Inform. Bull. 10(6): 2-3.

1959

199 (221). Fosberg, F.R. 1959. Upper limits of vegetation on Mauna Loa, Hawaii. Ecology 40: 144-146.

200 (223). ——. 1959. *Pinus contorta* and its variations. Baileya 7: 7-10.

201. ——. 1959. [Proposal] 308 [amend] Article 24 [Montreal Congress.] Taxon 8:19.
202. ——. 1959. [Proposal] 312 [amend] Article 73 [Montreal Congress.] Taxon 8: 19.
203 (224). ——. 1959. Nomenclatural notes on *Datura* L. Taxon 8: 52-57.
204 (225). ——. 1959. *Serianthes dilmyi* nomen novum. Taxon 8: 65.
205 (226). ——. 1959. Typification of *Zanthoxylum* L. Taxon 8: 103-105.
206 (227). ——. 1959. Long-term effects of radioactive fallout on plants? Atoll Res. Bull. 61: 1-11.
207 (228). ——. 1959. Vegetation and flora of Wake Island. Atoll Res. Bull. 67: 1-20.
208 (229). ——. 1959. Additional records of phanerogams from the northern Marshall Islands. Atoll Res. Bull. 68: 1-9.
209 (232). ——. 1959. Plants and fall-out. Nature 183: 1448.
210 (234). ——. 1959 [1958.] Man as a dispersal agent. Southw. Naturalist 3: 1-6.
211 (236). ——. 1959 [1958.] Climate, vegetation, and rational land utilization in the humid tropics. Introduction. Proc. Ninth Pacific Sci. Congress 20: 1-3.
212 (237). ——. 1959. The preservation of man's environment. Proc. Ninth Pacific Sci. Congress 20: 159-161.
*213 (241). ——. 1959. The research frontier. Saturday Review 42(46): 72-73.
*214 (242). ——. 1959. Who will identify the plants? Pl. Sci. Bull. 5(5): 4.
215 (244). ——. 1959 [1958.] The herbarium as a research museum. Proc. Ninth Pacific Sci. Congress 14: 13-14.
216 (247). ——. 1959. Conservation situation in Oceania. Proc. Ninth Pacific Sci. Congress 7: 30-31.
217 (249). ——. 1959. Notes on the Shenandoah National Park flora. Castanea 24: 135-143. [*Thelypteris, Setaria, Monarda.*]
218 (250). ——. 1959. Vegetation [of Guam], pp. 167-217, *in* Tracey, J.I. Jr., C.H. Stensland, D.B. Doan, H.G. May, S.O. Schlanger, and J.T. Stark, Military geology of Guam, Mariana Islands, Parts I and II. Intelligence Div., Office of the Engineer, U.S. Army Pacific.
219 (252). ——. 1959. The importance of biological research in the Pacific region. Gard. Bull. Singapore 17: 219-224.
220 (252c). ——. 1959. Flora and Fauna of Peru, Flora of Melanesia, Flora of Colombia. [Articles in the 1959 edition of Collier's Encyclopedia, cited from page proof.]
221 (238). Fosberg, F.R. and J.R. Swallen. 1959. Agnes Chase. Taxon 8: 145-151.
222 (246). [Fosberg, F.R.] 1959 [1958.] The vegetation of Micronesia. Dept. of the Army, Office, Chief of Engineers, Engineer Intelligence Study # 257, xviii + 160 pp. [also published as: Fosberg, F.R. 1959. Scientific Investigations in Micronesia 1949-; The vegetation of Micronesia–Part 1. Pacific Science Board, National Research Council, National Academy of Sciences, xx + 158 pp.]
223 (230). [Fosberg, F.R., ed.]. 1959. Atoll news and comment. Atoll Res. Bull. 70: 1-7.
224 (171). [Fosberg, F.R., T. Arnow, and F.S. MacNeil.] 1959 [1956.] U.S. Army Engineers, U.S. Geological Survey. Military geography of the Northern Marshalls. Intelligence Division, Office of Engineer. Headquarters, U. S. Air Force (Far East), Tokyo, ix + 320 pp.
R22 (245). Fosberg, F.R. 1959. Tropical ecology. review of Misra, R. and G.S. Puri, Indian manual of plant ecology, 1958. Ecology 40: 753-754.
R23 (252a). ——. 1959. Review of Koedoe, [Journal for Scientific Research in the National Parks of the Union of South Africa] vol. 1, 1958. National Parks Mag. 33: 14-15.
R24 (252b). ——. 1959. Review of Gates Clarke, J.F., Catalogue of the Type Specimens of Microlepidoptera in the British Museum (Natural History) described by Edward Meyrick, vol. 3, 1958. Science 130: 1246.
L6 (231). ——. 1959. Balance in cultivated ecosystems, [letter to the editor.] Science 129: 1499.
*D33 (222a). ——. 1959. Maps of the humid tropics: Report of the Bloomington Conference. Working paper for Abidjan Meeting. UNESCO/NS/HT/82. 5 pp.
D34 (233). ——. 1959. Summation by the Rapporteur Général of the Symposium of the vegetation of the humid tropics. Berita Madjelis Ilmu Pengetahuan Indonesia. (Council for Sciences of Indonesia) 1: 16-21. [(*243.) republished 1959. Humid Tropics Newslett. 1: 2-7.]

D35 (235). ——. 1959 [1958.] Report on the symposium on climate, vegetation, and rational land utilization in the humid tropics. Proc. Ninth Pacific Sci. Congress 20: v-vi.

D36 (239). ——. 1959. Structural-functional classification of vegetation for small-scale mapping, [abstract.] Proc. Ninth International Bot. Congress 2: 118.

D37 (240). ——. 1959. Vegetation and the geologist, [abstract.] Proc. Ninth International Bot. Congress 2: 118-119.

1960

225 (248). Fosberg, F.R. 1960. The vegetation of Micronesia. 1. General descriptions, the vegetation of the Marianas Islands, and a detailed consideration of the vegetation of Guam. Bull. Amer. Mus. Nat. Hist. 119: 1-76 + 40 plates.

226 (251). ——. 1960. Check-list of the seed plants of Guam. i-ii, 1-51. Military Geology Branch, U.S. Geological Survey. Duplicated by U.S. Navy, Agana, Guam).

227 (253). ——. 1960. Classification of vegetation for small scale mapping purposes (Symposium on Forest Classification). Bull. Trop. Ecol. 1(1): 17-18.

*228 (254). ——. 1960. Amateur scientific studies on natural areas. Ecol. Stud. Leafl. 1: 1.

*229 (255). ——. 1960. A plant census of a natural area. Ecol. Stud. Leafl. 2: 1.

230 (256). ——. 1960. Introgression in *Artocarpus* (Moraceae) in Micronesia. Brittonia 12: 101-113.

231 (257). ——. 1960. Plant collecting as an anthropological field method. El Palacio 67: 125-139.

232 (258). ——. 1960. Vegetation [of Ishigaki-Shima], pp. 51-84, *in* H.L. Foster, C.H. Stensland, H.G. May, F.R. Fosberg, and R.J. Alvis, Military Geology of Ishigaki-Shima, Ryūkyū-Rettō. Intelligence Division, Office of the Engineer, U.S. Army Pacific).

233 (261). ——. 1960. *Serianthes* Benth. (Leguminosae–Mimosoideae–Ingeae). Reinwardtia 5: 293-317.

234 (262). ——. 1960. Vegetation [of the Miyako Archipelago], pp. 165-187, *in* Doan, D.B., J.E. Paseur, and F.R. Fosberg, Military Geology of the Miyako Archipelago, Ryūkyū-Rettō. Intelligence Division, Office of the Engineer, U.S. Army Pacific.

235 (263). ——. 1960. Le rôle de la végétation dans la conservation du sol et de l'eau. Comptes rendus de la Réunion Technique d'Athènes de l'U.I.C.N. 2: 31-36.

236 (264). ——. 1960. Random notes on West African palms. Pricipes 4: 125-131.

*237 (266). ——. 1960. Statement, *in* "Bör Torneträsk regleras?". Kung. Svenska Vetenskapsakad. Skrifter Naturskyddsärenden 50: 92-93.

*238 (267). ——. 1960. Our country's landscape–its beauty and diversity, pp. 4-18, *in* Woodward, C.H., The Vanishing Natural Areas of the United States. (Nature Conservancy Brochure).

239 (268). ——. 1960. Remarks on superfluous names and later homonyms. Taxon 9: 243-244.

*240 (268a). ——. 1960. Saturday Review, 14 November. [quoted from by G. Ashford, Conservation? Of Course–But What Shall We Conserve? San Antonio Express and News, p. 8-G, 10 January.

241 (269). ——. 1960. Notes on the vegetation of Spruce Knob, West Virginia. Castanea 25: 120-122.

L7 (269a.) ——. 1960. Our brand of smog, [letter to the editor.] The Evening Star (Washington, D.C.) 26 April.

L8 (269b.) ——. 1960. Of mice and men, [letter to the editor.] The Evening Star (Washington, D.C.) 3 September.

1961

242 (270). Fosberg, F.R. 1961. Humid tropics vegetation. Science 133: 904-906.

243 (273). ——. 1961. Pacific vegetation progress report (1956-1958). Proc. Symposium on Humid Tropics Vegetation, UNESCO, Tjiawe, Indonesia, 1958, 32-33.

244 (274). ——. 1961. On the possibility of a rational general classification of humid tropical vegetation. Proc. Symposium on Humid Tropics Vegetation, UNESCO, Tjiawe, Indonesia, 1958, 34-59.

245 (275). ——. 1961. The study of vegetation in Europe. A.I.B.S. Bull. 11(3): 17-19.

246 (277). ——. 1961. Guide to excursion III. Tenth Pacific Science Congress and University of Hawaii, Honolulu, ix + 207 pp.

247 (282). ——. 1961. *Scaevola sericea* Vahl versus *S. taccada* (Gaertn.) Roxb. Taxon 10: 225-226.

248 (283). ——. 1961. What should we map? Colloq. Internat. Centre Nac. Recherche Sci. 97: 23-35.

249 (288). ——. 1961. Vegetation-free zone on dry mangrove coasts. U.S. Geol. Survey Prof. Pap. 424-D: 216-218.
250 (306). ——. 1961. Soils, pp. 47-50, *in* Blumenstock, D.I., ed. A report on typhoon effects upon Jaluit Atoll. Atoll Res. Bull. 75: 1-105.
251 (306a). ——. 1961. Flora and vegetation, pp. 51-55, *in* Blumenstock, D.I., ed. A report on typhoon effects upon Jaluit Atoll. Atoll Res. Bull. 75: 1-105.
252 (306b). ——. 1961. Typhoon effects on individual species of plants. Pp. 57-68, in: Blumenstock, D.I., ed. A report on typhoon effects upon Jaluit Atoll. Atoll Res. Bull. 75: 1-105.
253 (306c). ——. 1961. Table of plant species by Islets, pp. 95-104, *in* Blumenstock, D.I., ed. A report on typhoon effects upon Jaluit Atoll. Atoll Res. Bull. 75: 1-105.
254 (289). ——. 1961. Qualitative description of the coral atoll ecosystem. Atoll Res. Bull. 81: 1-11. [(328.) reprinted 1963 [1962.] Proc. Ninth Pacific Sci. Congress, 1957. 4: 161-167.]
255 (290). ——. 1961. Description of Heron Island. Atoll Res. Bull. 82: 1-4.
256 (293). ——. 1961. Southern distribution of *Botrychium oneidense* and *B. multifidum*. Amer. Fern J. 51: 175-180.
257 (295). ——. 1961. A classification of vegetation for general purposes. Trop. Ecol. 2: 1-28.
258 (302). ——. 1961. Conservation, pp. 270-273, *in* Gray, P., ed., The Encyclopedia of the Biological Sciences. Reinhold Publishing Corp., New York.
259 (303). ——. 1961. Rubiales, pp. 895-897, *in* Gray, P., ed., The Encyclopedia of the Biological Sciences. Reinhold Publishing Corp., New York.
260 (276). Fosberg, F.R., B.J. Garnier, and A.W. Küchler. 1961. Delimitation of the humid tropics. Geogr. Rev. 51: 333-347. [(276a.) partially republished 1961. Ekistics 12: 448-452.]
261 (291). Fosberg, F.R. and R.F. Thorne. 1961. Vascular plants of Heron Island. Atoll Res. Bull. 82: 5-13.
262 (292). [Fosberg, F.R., ed.]. 1961. Atoll news and comment. Atoll Res. Bull. 84: 1-14.
263 (271). Blumenstock, D.I., F.R. Fosberg, and C.G. Johnson. 1961. The re-survey of typhoon effects on Jaluit Atoll in the Marshall Islands. Nature 189(4765): 618-620.
R25 (287). Fosberg, F.R. 1961. The salt-marsh ecosystem, review of Chapman, V.J., Salt marshes and salt deserts of the world, 1960. Ecology 42: 847-848.
L9 (291a). ——. 1961. Against Billboards, [letter to the editor.] The Evening Star (Washington, D.C.), p. A-7, 27 January.
L10 (291b). ——. 1961. Our smog rating, [letter to the editor.] The Evening Star (Washington, D.C.), 10 December.
D38 (272). ——. 1961. Report of representative on the National Research Council. Bull. Ecol. Soc. Amer. 42: 26-29.
D39 (279). ——. 1961. An inventory of the rare and vanishing plants of the Pacific Basin, [abstract.] Abstracts Symp. Pap. Tenth Pacific Sci. Congress, pp. 131-132.
D40 (280). ——. 1961. Plant dispersal in the Pacific, [abstract.] Abstracts Symp. Pap. Tenth Pacific Sci. Congress, pp. 225-226.
D41 (281). ——. 1961. The ecosystem concept: Introduction, [abstract.] Abstracts Symp. Pap. Tenth Pacific Sci. Congress, pp. 473-474.
*D42 (285). ——. 1961. Introduction to Symposium on Pacific Basin Biogeography: Tropical Pacific Relationships. Duplicated for and distributed at Tenth Pacific Sci. Congress, Honolulu.
*D43 (286). ——. 1961. Plant dispersal in the Pacific. Duplicated for and distributed at Tenth Pacific Sci. Congress, Honolulu.
D44 (278). Fosberg, F.R. and M.S. Doty. 1961. List of botanists of the Pacific area. Duplicated for and distributed at the Tenth Pacific Science Congress, 126 pp.

1962

264 (294). Fosberg, F.R. 1962. Limits of effective publication. Taxon 11: 27.
265 (299). ——. 1962. Status of the name *Geophila* D. Don (Rubiaceae). Taxon 11: 180-181.
266 (300). ——. 1962. The Indo-Pacific strand *Scaevola* again. Taxon 11: 181.

267 (304). ——. 1962. Miscellaneous notes on Hawaiian plants–3. Occas. Pap. Bernice P. Bishop Mus. 23(2): 29-44. [*Ophioglossum, Thelypteris, Dracaena, Santalum, Chenopodium, Argemone, Leucaena, Bruguiera, Psidium, Pouteria, Ipomoea, Vitex, Asarina, Psychotria, Sambucus.*]

268 (308). ——. 1962. A brief study of the cays of Arrecife Alacran, a Mexican atoll. Atoll Res. Bull. 93: 1-25+6 unnumbered pages.

269 (307). Fosberg, F.R. and M.-H. Sachet. 1962. Vascular plants recorded from Jaluit Atoll. Atoll Res. Bull. 92: 1-39.

**270 (305). Oliver, W.R.B., P. Dansereau, and F.R. Fosberg. 1962 [1961]. Report on a botanical inspection of Ambuklao Dam site and drainage basin. Proc. Eighth Pacific Sci. Congress 6: 210-212.

271 (309). [Fosberg, F.R. and M.-H. Sachet, eds.] 1962. Atoll news and comments. Atoll Res. Bull. 94: 1-19.

D45 (296). Fosberg, F.R. 1962. Report of representative on the National Research Council. Bull. Ecol. Soc. Amer. 43: 16-17.

D46 (325). ——. 1962. Report of the chairman of the Standing Committee on Pacific Botany. Proc. Ninth Pacific Sci. Congress 4: 1-3.

L11 (297). ——. 1962. Heredity, environment, and culture, [letter to the editor.] Science 136: 914.

*L12 (298). ——. 1962. Rails, rand, and service, [letter to the editor.] Saturday Review 45: 17-18.

L13 (309a). ——. 1962. Wasted resource, [letter to the editor.] The Evening Star (Washington, D.C.) 21 May.

R26 (301). ——. 1962. Review of Reid, G.K., Ecology of inland waters and estuaries, 1961. Atlantic Naturalist 17: 203-205.

R27. ——. 1962. Flora of the Tremblor Range, review of Twisselmann, E.C., Flora of the Tremblor Range and the neighboring part of the San Joaquin valley, Wasmann J. Biol. 14(2): 161-300, 1956. Taxon 11: 205.

1963

272 (311). Fosberg, F.R. 1963. *Serianthes dilmyi* again. Taxon 12: 34-35.

273 (313). ——. 1963. The physical background of the humid tropics–substratum, pp. 35-37, *in* Symposium on the impact of man on humid tropics vegetation. UNESCO and New Guinea Government. 402 pp.

274 (314). ——. 1963. A theory on the origin of the coconut, pp. 73-75, *in* Symposium on the impact of man on humid tropics vegetation. UNESCO and New Guinea Government. 402 pp.

275 (315). ——. 1963. Grazing animals and the vegetation of oceanic islands, pp. 168-169, *in* Symposium on the impact of man on humid tropics vegetation. UNESCO and New Guinea Government. 402 pp.

276 (316). ——. 1963. Nature and detection of plant communities resulting from activities of early man, pp. 251-262, *in* Symposium on the impact of man on humid tropics vegetation. UNESCO and New Guinea Government. 402 pp.

277 (318). ——. 1963. Standley and tropical American botany, pp. 97-99, *in* Williams, L.O., ed., Homage to Standley, Chicago Natural History Museum, Chicago.

278 (320). ——. 1963. A buttressed elm from Ontario. Rhodora 65: 366.

279 (326). ——. 1963 [1962.] Tropical Pacific grasslands and savannas. Proc. Ninth Pacific Sci. Congress 4: 118-123.

280 (327). ——. 1963 [1962.] Dynamics of atoll vegetation. Proc. Ninth Pacific Sci. Congress 4: 114-117.

281 (284, 344). ——. 1963. The island ecosystem, pp. 1-6, *in* Fosberg, F.R., ed., Man's place in the island ecosystem, a symposium. Tenth Pacific Sci. Congress, Honolulu.

282 (345). ——. 1963. Introduction [to section 1-B, Tropical relationships], pp. 187-188, *in* Gressitt, J.L., ed., Pacific Basin Biogeography, a symposium. Tenth Pacific Sci. Congress, Honolulu.

283 (346). ——. 1963. Plant dispersal in Pacific, pp. 273-281, *in* Gressitt, J.L., ed., Pacific Basin Biogeography, a symposium. Tenth Pacific Sci. Congress, Honolulu.

284 (347). ——. 1963. Disturbance in island ecosystems, pp. 557-561, *in* Gressitt, J.L., ed., Pacific Basin Biogeography, a symposium. Tenth Pacific Sci. Congress, Honolulu.

285 (343). Fosberg, F.R., ed. 1963. Man's place in the island ecosystem, a symposium. Tenth Pacific Sci. Congress, Honolulu. Bishop Museum Press, Honolulu, viii + 264 pp.

286 (330). [Fosberg, F.R. and M.-H. Sachet, eds.] 1963. Atoll news and comment. Atoll Res. Bull. 100: 1-16.

R28 (310). Fosberg, F.R. 1963. Physical geography: effects of nuclear explosions on vegetation comment on Shields, L.M. and P.V. Wells, Effects of nuclear testing on desert vegetation (Science 135: 38-40, 1962). Geogr. Rev. (New York) 53: 135-137.

R29 (317). ——. 1963. Pesticides and ecology, review of Carson, R., Silent Spring, 1962. Ecology 44: 624.

*D47 (312). ——. 1963. Report of the Ecological Society of America Representative on the National Research Council. Bull. Ecol. Soc. Amer. 44: 15-16.

D48 (319). ——. 1963. UNESCO meetings (report). Newslett. Hawaiian. Bot. Soc. 2: 110.

D49 (347a). ——. 1963. Report of the standing committee on Pacific Botany, pp. 169-186, *in* Tuthill, L.D., ed., Proc. Tenth Pacific Sci. Congress, Honolulu.

D50 (347b). Fosberg, F.R. [chairman] et al. 1963. Report of the American Association for the Advancement of Science council study committee on natural areas as research facilities. 80 pp. + appendices.

1964

287 (322). Fosberg, F.R. 1964. Conversations on ecology IX. Garden J. New York Bot. Gard. 14: 63-64.

288 (329). ——. 1964. Studies in Pacific Rubiaceae: V. Brittonia 16: 255-271. [*Psychotria.*]

289 (331). ——. 1964. Comments on Dr. Donk's proposals. Taxon 13: 175-177.

290 (332). ——. 1964. Do we want a code or a committee? Taxon 13: 177-178.

291 (334). ——. 1964. The correct name of the chiclé. Taxon 13: 254-255. [*Manilkara.*]

*292 (335). ——. 1964. The question of collecting specimens. Ecol. Stud. Leafl. 3: 4.

*293 (336). ——. 1964. How to investigate the history of a natural area. Ecol. Stud. Leafl. 4: 5-6.

*294 (338). ——. 1964. Phenological and autecological studies of plant species in natural areas. Ecol. Stud. Leafl. 5: 7-9.

*295 (339). ——. 1964. Quiet observation. Ecol. Stud. Leafl. 5: 9-10.

296 (340). ——. 1964. Résumé of the Cycadaceae. Federation Proceedings 23(6) (Part I [Proceedings of the third conference on the Toxicity of Cycads]): 1340-1341.

297 (340a). [Fosberg, F.R. and M.-H. Sachet, eds.] 1964. Atoll news and comment. Atoll Res. Bull. 108: 1-8.

R30 (321). Fosberg, F.R. 1964. The illness of the world ecosystem, review of Dasmann, R.F., The last horizon, 1963. Ecology 45: 201-202.

R31 (356). ——. 1964. Review of, Lawrence, G.H.M., ed., Adanson, the Bicentennial of Adanson's "Familles des Plantes" Part One. Hunt Monograph Series 1, 1963. Torreya 91: 508-509.

R32 (333). ——. 1964. Peñalosa–Tiburon Flora, review of Peñalosa, J., A flora of the Tiburon Peninsula, Marin County, California (The Wasmann Journal of Botany 21(1): 1-74, 1963). Taxon 13: 219-220.

*R33 (337). ——. 1964. Studies at Pine Hills, review of McCormick, Vascular Flora of Shades State Park and Pine Hills Natural Area, Indiana. Ecol. Stud. Leafl. 4: 6.

L14 (340b). ——. 1964. Rights and wrongs, [letter to the editor.] The Evening Star (Washington, D.C.) 27 April.

D51 (323). ——. 1964. Report of Representative on the National Research Council. Bull. Ecol. Soc. Amer. 45: 24-25.

D52 (324). [Ross, R. and F.R. Fosberg.] 1964. Report of the special committee on neotypes. Taxon 13: 110-114.

1965

298 (341). Fosberg, F.R. 1965. Natural bird refuges in the Galapagos. Elepaio 25: 60-67.

299 (348). ——. 1965. Revision of *Albizia* Sect. *Pachysperma* (Leguminosae–Mimosoideae). Reinwardtia 7: 71-90.

300 (349). ——. 1965. Nomenclature of the Horseradish (Cruciferae). Baileya 13: 1-4. [*Cochlearia, Armoracia.*]

301 (350). ——. 1965. Lauryl pentachlorphenate protecting herbarium specimens: Application with brushes. Taxon 14: 165-166.

302 (351). ——. 1965. The entropy concept in ecology, pp. 157-163, *in* Symposium on ecological research in humid tropics vegetation. UNESCO, Kuching, Sarawak.

303 (352). ——. 1965. Field excursions during and after the symposium, pp. 271-288, *in* Symposium on ecological research in humid tropics vegetation. UNESCO, Kuching, Sarawak.

304 (355). ——. 1965. Vegetation and the geologist. Trop. Ecol. 6: 3-18. [(355a.) republished (date unknown), The International Society for Tropical Ecology, Varansi, India, pp. 1-18.]

305 (358a). ——. 1965. Introduction, *in* Fosberg, F.R. and D. Carroll, eds. Terrestrial sediments and soils of the northern Marshall Islands. Atoll Res. Bull. 113: 1-6.

306 (358b). ——. 1965. Geology, *in* Fosberg, F.R. and D. Carroll, eds. Terrestrial sediments and soils of the northern Marshall Islands. Atoll Res. Bull. 113: 7-22 + 22 plates.

*307 (360, 382). ——. 1965. Nature Conservancy registry of sites of special scientific interest. Nature Conservancy News 15: 6.

308 (358d). Fosberg, F.R. and D. Carroll. 1965. Unconsolidated sediments considered as soils, *in* Fosberg, F.R. and D. Carroll, eds. Terrestrial sediments and soils of the northern Marshall Islands. Atoll Res. Bull. 113: 43-65 + 4 plates, 6 tables.

309 (358). Fosberg, F.R. and D. Carroll, eds. 1965. Terrestrial sediments and soils of the northern Marshall Islands. Atoll Res. Bull. 113: 1-156.

310 (381). Fosberg, F.R. and P.M. Mazzeo. 1965. Further notes on Shenandoah National Park plants. Castanea 30: 191-205. [*Spiraea, Oxalis, Euphorbia, Tilia, Viola, Galium.*]

311 (354). Fosberg, F.R. and M.-H. Sachet. 1965. Manual for tropical herbaria. Regnum Veg. 39: 1-132.

*312 (357). Fosberg, F.R., M.-H. Sachet, J.M. Goldberg, and A. Reimer. 1965. World distribution of soil, rock, and vegetation. U.S. Dept. of the Interior, Geological Survey Report TEI-865: 1-37.

313 (368). Fosberg, F.R. and B.C. Stone. 1965. *Leucaena insularum* in Guam. Micronesica 2: 67-70.

314 (358c). Fosberg, F.R. [with J.W. Wells, M.S. Doty, and R. Todd.] 1965. Other features, *in* Fosberg, F.R. and D. Carroll, eds. Terrestrial sediments and soils of the northern Marshall Islands. Atoll Res. Bull. 113: 23-30 + 5 plates.

315 (340b). [Fosberg, F.R. and M.-H. Sachet, eds.] 1965. Atoll news and comment. Atoll Res. Bull. 112: 1-14.

*R34 (353). Fosberg, F.R. 1965. Review of Carson, R., The sense of wonder. Nature Conservancy News 15: 15.

L15 (360a). ——. 1965. Perils of Pesticides, [letter to the editor.] The Evening Star (Washington, D.C.) p. A-8, 12 January.

L16 (360b). ——. 1965. De Gaulle's Gall, [letter to the editor.] The Evening Star (Washington, D.C.) 2 March.

D53 (342). ——. 1965. [Report of the] Representative on National Research Council. Bull. Ecol. Soc. Amer. 46: 20.

*D54 (383). [Fosberg, F.R.] 1965. Inter-American specialized conference to deal with problems relating to the conservation of renewable natural resources in the Western Hemisphere. Nature Conservancy News 15(4): 5. [Excerpts from report to Nature Conservancy by F.R. Fosberg.]

1966

316 (359). Fosberg, F.R.. 1966. Northern Marshall Islands land biota: birds. Atoll Res. Bull. 114: 1-35.

317 (362). ——. 1966. Miscellaneous notes on Hawaiian plants–4. Occas. Pap. Bernice P. Bishop Mus. 23(8): 129-138. [*Dryopteris, Xyris, Canavalia, Prosopis, Osmanthus, Emilia.*]

318 (365). ——. 1966. Vegetation as a geological agent in tropical deltas, pp. 227-233, *in* Scientific problems of the Humid tropical zone deltas and their implications. Symposium. UNESCO, Dacca, Pakistan.

319 (366). ——. 1966. Concluding remarks [of symposium], pp. 409-413, *in* Scientific problems of the humid tropical zone deltas and their implications. Symposium. UNESCO, Dacca, Pakistan. [(*367.) republished in part 1966. Nature and Resources ll: 1-5.]

320 (369). ——. 1966. Systematic notes on Micronesian plants. 2. Phytologia 13: 233-241. [*Piper*, *Peperomia*.]

321 (370). ——. 1966. *Scirpus americanus* Persoon (Cyperaceae) in Costa Rica. Sida 2: 347-348.

322 (371). ——. 1966. Studies in American Rubiaceae 1. New and noteworthy Costa Rican species. Sida 2: 386-389. [*Galium*, *Gonzalagunia*, *Hillia*, *Hoffmannia*, *Psychotria*.]

323 (372). ——. 1966. Restoration of lost and degraded habitats, pp. 503-515, *in* Darling, F.F. and J.P. Melton, eds., Future environments of North America. Natural History Press.

324 (373). ——. 1966. The oceanic volcanic island ecosystem, pp. 55-61, *in* Bowman, R.I., ed. The Galápagos. University of California Press, Berkeley.

325 (375). ——. 1966. The correct name of the horseradish (Cruciferae). Baileya 14: 60. [*Cochlearia*, *Armoracia*.]

***326 (376). ——. 1966. Vascular plants, pp. 153-238, *in* Doty, M.S. and D. Mueller-Dombois, Atlas for bioecology studies in Hawaii Volcanoes National Park. Hawaii Bot. Sci. Pap. no. 2, University of Hawaii, Honolulu, iii + 507 pp. [republished 1972. Hawaii Agricultural Experiment Station Miscellaneous Publication no. 89.]

*327 (384). ——. 1966. Some ecological effects of wild and semi-wild exotic species of vascular plants. Pacific Vegetation Project, National Research Council, Washington, D.C. IUCN/R.T.10/III/1.2. [(394.) republished 1967. IUCN pub. n.s., 9: 98-109.]

328 (387). ——. 1966. Critical notes on Pacific Island plants. 1. Micronesica 2: 143-152. [*Casuarina*, *Alternanthera*, *Desmodium*, *Tristellateia*, *Corchorus*, *Abutilon*, *Ambroma*, *Bruguiera*, *Ipomoea*, *Hemigraphis*.]

329 (363). Fosberg, F.R., E.W. Groves, and D.C. Sigee. 1966. List of Addu vascular plants, pp. 75-92, *in* Stoddart, D.R., ed., Reef Studies at Addu Atoll, Maldive Islands: preliminary results of an expedition to Addu Atoll in 1964. Atoll Res. Bull. 116: 1-122.

330 (374). Fosberg, F.R. and W.L. Klawe. 1966. Preliminary list of plants from Cocos Island, pp. 187-189, *in* R.I. Bowman, ed. The Galápagos. University of California Press, Berkeley.

331 (380). Fosberg, F.R. and M.-H. Sachet. 1966. *Lebronnecia*, gen. nov. (Malvaceae) des Iles Marquises. Adansonia, n.s., 6: 507-510.

332 (386). —— and ——. 1966. Plants of southeastern Polynesia. Micronesica 2: 153-159. [*Panicum*, *Crotalaria*, *Hibiscus*, *Pavonia*, *Terminalia*, *Cordia*, *Blumea*, *Vernonia*.]

333 (364). [Fosberg, F.R. and M.-H. Sachet, eds.] 1966. Atoll news and comments. Atoll Res. Bull. 117: 1-8.

R35 (377). Fosberg, F.R. 1966. Review of Steele, A.R., Flowers for the King: the expedition of Ruiz and Pavón and the Flora of Peru, 1964. Bull. Torrey Bot. Club 93: 283.

R36 (378). ——. 1966. Review of Harris, D.R., Plants, animals and man in the Outer Leeward Islands, West Indies, 1965. Bull. Torrey Bot. Club 93: 284.

D55 (361). ——. 1966. [Report of the] Representative on the National Research Council. Bull. Ecol. Soc. Amer. 47: 26-27.

D56 (379). ——. 1966. Observations on vegetation patterns and dynamics on Hawaiian and Galapageian volcanoes, [abstract.] Proc. Eleventh Pacific Sci. Congress 5(3): 3.

D57 (379a). ——. 1966. Report to the Nature Conservancy on the [Ninth] I.U.C.N. General Assembly. 21 pp. [Duplicated for the Nature Conservancy.]

1967

334 (385). Fosberg, F.R. 1967. The Smithsonian Tropical Biology Program [presidential address.] Symposium on Recent advances in Tropical Ecology, Varanasi, India: 7-12. [(410.) also republished separately, pp. 1-10.]

335 (389). ——. 1967. Unique Aldabra. Atlantic Naturalist 22: 160-165.

336 (391). ——. 1967. The cult of the expert and numerical taxonomy. Taxon 16: 369-370.

337 (395). ——. 1967. Appendix 1, a classification of vegetation for general purposes, pp. 73-120, *in* Peterken, G.F., Guide to the Check Sheet of IBP Areas, IBP Handbook No. 4.

338 (398). ——. 1967. Opening remarks: Island ecosystem symposium. Micronesica 3: 3-4.

339 (400). ——. 1967. Deistveniya podchod k kartirovaniyn Rastetelnocti v praktisheckich tselich (A pragmatic approach to the practical vegetation mapping). Geobot. Kartogr. 1967: 9-17. [in Russian].

340 (403). ——. 1967. Observations on vegetation patterns and dynamics on Hawaiian and Galapageian volcanoes. Micronesica 3, 129-134.

341 (407). ——. 1967. Succession and condition of ecosystems. J. Indian Bot. Soc. 46(4): 351-355.

342 (416). ——. 1967. Some relations between ecosystem size and cultural evolution. Proc. Symp. Recent Adv. Trop. Ecol., Varanasi, India, pp. 702-704.

343 (404). [Fosberg, F.R. and M.-H. Sachet, eds.] 1967. Atoll news and comment. Atoll Res. Bull. 119: 1-6.

344 (388). Buechner, H.K. and F.R. Fosberg. 1967. A contribution toward a world program in tropical biology. BioScience 17: 532-538.

345 (465). Ripley, S.D. 1967. Perspectives in tropical biology. BioScience 17: 538-540. [Text of address delivered by S.D. Ripley, slightly paraphrased from text written by F.R. Fosberg at Panama Conference on Tropical Biology, 9 November 1966.]

R37 (392). Fosberg, F.R. 1967. Botanical lingua franca, review of Stearn, W.T., Botanical Latin, 1966. Ecology 48: 175-176.

R38 (393). ——. 1967. Observing bamboos, review of McClure, F.A., The Bamboos–a fresh perspective, 1966. Ecology 48: 176.

R39 (409). ——. 1967. Review of Wenkam, R., Kauai and the park country of Hawaii, 1967. Atlantic Naturalist 22: 233-234.

D58 (390). ——. 1967. [Report of the] Representative on the National Research Council. Bull. Ecol. Soc. Amer. 48: 27-28.

D59 (405). Fosberg, F.R., C. Cottam, A.M. Stebler, and J. Major. 1967. An ecological context for the use and conservation of natural resources. 6 pp. duplicated and distributed by Applied Ecol. Sect., Ecol. Soc. Amer.

1968

346 (397). Fosberg, F.R. 1968. Systematic notes on Micronesian plants, 3. Phytologia 15: 496-502. [*Sagittaria, Egeria, Lepturus, Crinum, Spathoglottis, Lepidium, Mimosa, Cassia, Clitoria, Cordia.*]

347 (406). ——. 1968. Investigation of Aldabra Atoll. Bull. Regional Centre for Science and Technology for Africa, Nairobi, Kenya 3(2): 39-41.

348 (408). ——. 1968. *Polypodium vulgare* on Long Island. Amer. Fern J. 58: 153-154.

349 (411). ——. 1968. Studies in Pacific Rubiaceae: VI-VII. Brittonia 20: 287-294. [*Hedyotis, Gouldia, Coprosma.*]

350 (429). ——. 1968. Critical notes on Pacific Island plants. 2. Micronesica 4: 255-259. [*Thelypteris, Crassula, Desmodium, Alyxia, Scaevola.*]

351 (434). ——. 1968. Scientific need for parks and reserves, pp. 380-381, *in* Conservation in tropical South East Asia, IUCN Publ., new series vol. 10.

R40 (396). ——. 1968. Gigantic grasses, review of McClure, F.A., The Bamboos, a fresh perspective, 1966. BioScience 18: 55.

R41 (399). ——. 1968. An oceanographic encyclopedia, review of Fairbridge, R.W., ed., The encyclopedia of oceanography, 1966. Ecology 49: 187-188.

R42 (401). ——. 1968. A comprehensive text, review of Küchler, A.W., Vegetation Mapping, 1967. BioScience 18: 143-144.

R43 (413). ——. 1968. Review of Twisselmann, E.C., A Flora of Kern County, California, 1967. Taxon 17: 565-566.

R44 (402). ——. 1968. A major synthesis of biology, review of Platt, R.B. and G.K. Reid, Bioscience, 1967. BioScience 18: 248-249.

1969

352 (417). Fosberg, F.R. 1969. Aura of pollution. Biol. Conservation 1: 231-232.

353 (421). ——. 1969. Sabah (North Borneo), Malaysia: Sepilok Forest Endangered. Biol. Conservation 1: 339-340.

354 (422). ——. 1969. The problem of isolation in the lowland tropical rain forest. Eleventh Int. Bot. Congress Abst. 62.

355 (423). ——. 1969. Miscellaneous notes on Hawaiian plants–5. Occas. Pap. Bernice P. Bishop Mus. 24(2): 9-24. [*Gleichenia, Adiantum, Polypodium, Thelypteris, Setaria, Dianella, Arundina, Odontochilus, Santalum, Polygonum, Rumex, Lepidium, Fragaria, Cassia, Medicago, Zanthoxylum, Abutilon, Hypericum.*]

356. ——. 1969. Correction on *Serianthes dilmyi* (Leguminosae). Taxon 18: 351-352.

357 (424). ——. 1969. The nomenclature of *Sphenomeris chinensis* [Filic.]. Taxon 18: 596-598.

358 (425). ——. 1969. Plants of Satawal Island, Caroline Islands. Atoll Res. Bull. 132: 1-13.

359 (428). ——. 1969. Observations on the Green Turtle in the Marshall Islands, in Island news and comment. Atoll Res. Bull. 135: 9-12.

360 (431). ——. 1969. Commentary–A Balanced Ecology. Ecology, 50: 463-464.

361 (433). ——. 1969. Paleobotany of the oceanic Pacific Islands, *in* Leopold, E.B., Miocene pollen and spore flora of Eniwetok, Marshall Islands. U.S.G.S. Prof. Pap. 260-II: 1140.

*362 (437). ——. 1969. Diversity and cooperation among conservation organizations. II Simposio y Foro de Biología Tropical Amazonica. Leticia, Colombia: 164-167.

363 (426). Fosberg, F.R. and M. Evans. 1969. A collection of plants from Fais, Caroline Islands. Atoll Res. Bull. 133: 1-15.

364 (414). Fosberg, F.R. and M.-H. Sachet. 1969. Wake Island vegetation and flora, 1961-1963. Atoll Res. Bull. 123: 1-15.

365 (415). [Fosberg, F.R. and M.-H. Sachet, eds.] 1969. Island news and comment. Atoll Res. Bull. 126: 1-19.

366 (427). [Fosberg, F.R. and M.-H. Sachet, eds.] 1969. Island news and comment. Atoll Res. Bull. 135: 1-17.

R45 (412). Fosberg, F.R. 1969. The California Islands, review of Philbrick, R.N., ed., Proceedings of the symposium on the biology of the California islands, 1967. Ecology 50: 167.

*R46 (418). ——. 1969. Review of Brower, K., ed., Galapagos, the Flow of Wildness, 2 vols., photographs by E. Porter, Sierra Club, 1968. [reprint does not show place of publication.]

R47 (418a). ——. 1969. Review of Nelson, B., Galapagos, Islands of Birds, 1968. Atlantic Naturalist 24: 224-225.

R48 (430). ——. 1969. Vegetation map bibliography, review of Küchler, A.W., ed., International bibliography of vegetation maps. Vol. 3–U.S.S.R., Asia & Australia, 1968. Ecology 50: 749-750.

D60 (419). ——. 1969. Remarks on the International Code and proposals to change it. I.-X. Duplicated for and distributed at the Eleventh International Botanical Congress, Seattle, pp. 1-9.

*D61 (420). ——. 1969. Geomorphic cycle on Aldabra–hypothesis, [abstract.] Mandapam symposium on corals and coral reefs, abstracts, pp. 26-27.

1970

367 (432). Fosberg, F.R. 1970. Desert Wilderness. The Living Wilderness, 34(109): 17-24.

368 (436). ——. 1970. The tropical agriculture panacea. BioScience 20: 793.

369 (445). ——. 1970. The problem of isolation in the lowland tropical rain-forest. Trop. Ecol. 11: 162-168.

370 (448). ——. 1970. Island faunas and floras, pp. 309-311, *in* McGraw-Hill Encyclopedia of Science and Technology, ed. 3.

371 (440). Fosberg, F.R. and T. Blunt. 1970 [1969.] Vernon Black Gum Swamp. Rhodora 72: 280-282.

372 (441a). Fosberg, F.R. and S.A. Renvoize. 1970. Plants of Farquhar Atoll, pp. 27-34, *in* Stoddart, D.R., ed., Coral Islands of the Western Indian Ocean. Atoll Res. Bull. 136: 1-224.

373 (441b). —— and ——. 1970. Plants of Cosmoledo Atoll, pp. 57-66, *in* Stoddart, D.R., ed., Coral Islands of the Western Indian Ocean. Atoll Res. Bull. 136: 1-224.

374 (441c). —— and ——. 1970. Plants of Astove, pp. 101-112, *in* Stoddart, D.R., ed., Coral Islands of the Western Indian Ocean. Atoll Res. Bull. 136: 1-224.

375 (441d). —— and ——. 1970. Plants of Assumption Island, pp. 147-154, *in* Stoddart, D.R., ed., Coral Islands of the Western Indian Ocean. Atoll Res. Bull. 136: 1-224.

376 (441e). —— and ——. 1970. Plants of Desroches, pp. 167-170, *in* Stoddart, D.R., ed., Coral Islands of the Western Indian Ocean. Atoll Res. Bull. 136: 1-224.

377 (441f). —— and ——. 1970. Plants of Remire (Eagle) Island Amirantes, pp. 183-186, *in* Stoddart, D.R., ed., Coral Islands of the Western Indian Ocean. Atoll Res. Bull. 136: 1-224.

378 (441g). —— and ——. 1970. Plants of African Banks (Iles Africaines), pp. 193-194, *in* Stoddart, D.R., ed., Coral Islands of the Western Indian Ocean. Atoll Res. Bull. 136: 1-224.

379 (441). Doty, M.S., F.R. Fosberg, and D. Mueller-Dombois. 1970. Initial site studies for the international program in the tropical and far western Pacific. Micronesica 5: 283-293.

R49 (438). Fosberg, F.R. 1970. S.E. Asiatic Floras, review of Reed, C.F., Bibliography to Floras of Southeast Asia, 1969. Taxon 19: 432.

R50 (439). ——. 1970. A local flora from San Francisco, review of McClintock, E., W. Knight, and N. Fahy, A Flora of the San Bruno Mountains, San Mateo County, California, 1968. Taxon 19: 432.

L17 (435). ——. 1970. Floating gobs of oil, [letter to the editor.] Science 168: 917.

L18 (445a). ——. 1970. Insect overkill, [letter to the editor.] The Evening Star (Washington, D.C.), 19 June.

1971

380 (442). Fosberg, F.R. 1971. Preliminary survey of Aldabra vegetation. Philos. Trans., Ser. B, 260: 215-225.

381 (446). ——. 1971. Endangered island plants. Bull. Pacific Trop. Bot. Gard. 1(3): 1-7.

382 (451). ——. 1971. The Fern Vegetation of Aldabra Atoll. Amer. Fern J. 61: 97-101. [*Acrostichum*.]

383 (452). ——. 1971. *Psidium* L. (Myrtaceae) in Ceylon. Ceylon J. Sci., Biol. Sci. 9: 58-60.

384 (456). ——. 1971. Mangroves v. Tidal Waves. Biol. Conservation 4: 38-39.

385 (447). Fosberg, F.R. and A.A. Bullock. 1971. List of Diego Garcia vascular plants, *in* Stoddart, D.R. & J.D. Taylor, eds. Geography and ecology of Diego Garcia Atoll, Chagos Archipelago. Atoll Res. Bull. 149: 143-160.

386 (444). [Fosberg, F.R., M.-H. Sachet, and D.R. Stoddart, eds.] 1971. Island news and comment. Atoll Res. Bull. 148: 1-38.

387 (461). Sachet, M.-H. and Fosberg, F.R. 1971. Island bibliographies supplement–Micronesian botany; land, environment, and ecology of coral atolls; vegetation of tropical Pacific islands. National Academy of Sciences, Washington D.C., 427 pp.

388 (443). Stoddart, D.R., J.D. Taylor, F.R. Fosberg, and G.E. Farrow. 1971. Geomorphology of Aldabra Atoll. Philos. Trans., Ser. B, 260: 31-65.

R51 (449). Fosberg, F.R. 1971. Review of Wiggins, I.L. and D.M. Porter, Flora of the Galapagos Islands, 1971. Atlantic Naturalist 26: 139-141.

R52 (450). ——. 1971. Review of Howell, J.T., Marin Flora, second ed., 1970. Taxon 20: 369.

R53 (457). ——. 1971. Amazonia, review of Meggers, B.J., Amazonia Man and Culture in a Counterfeit Paradise, 1971. Ecology 52: 952.

1972

389 (453). Fosberg, F.R. 1972. The axis deer problem, pp. 201-202, *in* Mueller-Dombois, D., Island ecosystems stability and evolution subprogram. U. S. International Biological Program Techn. Rept. 2.

390 (454). ——. 1972. Synopsis of views of F.R. Fosberg relative to the harvesting of koa and hapuu on the Big Island, p. 205, *in* D. Mueller-Dombois, Island ecosystems stability and evolution subprogram, U. S. International Biological Program Techn. Rept. 2.

391 (455). ——. 1972. Man's effects on island ecosystems, pp. 869-880, *in* Farvar, M.T. and J. P. Milton, The Careless Technology, Natural History Press, Garden City, New York.

392 (464). ——. 1972. Guide to excursion III, Tenth Pacific Science Congress, revised edition. University of Hawaii, Honolulu, x + 249 pp.

393 (466). ——. 1972. Our native plants–a look to the future. National Parks and Conservation Magazine 46(11): 17-21.

394 (467). ——. 1972. On the importance of preserving diversity in ecosystems. Comptes Rendus Conf. Int. Cons. Nat. Res. Madagascar, I.U.C.N. N.S. Suppl. 36: 81-84.

395 (469). ——. 1972. *Emilia* (Compositae) in Ceylon. Ceylon J. Sci., Biol. Sci. 10: 61-69.

396 (470). ——. 1972. The value of systematics in the environmental crisis. Taxon 21: 631-634.

397 (479). ——. 1972. Geomorphic cycle on Aldabra–hypothesis. Proc. Symp. Corals and Coral Reefs (Mar. Biol. Assoc. India): 469-475.

398 (495). ——. 1972. List of vascular flora, pp. 9-13, *in* Stoddart, D.R., Reef islands of Rarotonga. Atoll Res. Bull. 160: 1-14 + 7 figs.

399 (497a). ——. 1972. Morotiri (Bass Rocks) Austral Islands, *in* Island news and comment. Atoll Res. Bull. 162: 9-10.

400 (458). Fosberg, F.R. and M.-H. Sachet. 1972. *Thespesia populnea* (L.) Solander ex Correa and *Thespesia populneoides* (Roxburgh) Kosteletsky (Malvaceae). Smithsonian Contr. Bot. 7: 1-13.

401 (460). —— and ——. 1972. Three Indo-Pacific *Thelypteris* species reinterpreted and a new African species described. Smithsonian Contr. Bot. 8: 1-10.

402 (468). —— and ——. 1972. Status of floras of western Indian Ocean islands. Comptes Rendus Conf. Int. Cons. Nat. Res. Madagascar, I.U.C.N. N.S. Suppl. 36: 152-155

403 (471). —— and ——. 1972. Plants of southeastern Polynesia. 2. Micronesica 8: 43-49. [*Peperomia*, *Ascarina*, *Weinmannia*, *Alstonia*, *Ochrosia*, *Neiosperma*.]

404 (497). [Fosberg, F.R., M.-H. Sachet, and D.R. Stoddart, eds.] 1972. Island news and comment. Atoll Res. Bull. 162: 1-26.

405 (496). Stoddart, D.R. and F.R. Fosberg. 1972. South Indian sand cays. Atoll Res. Bull. 161: 1-23.

R54 (459). Fosberg, F.R. 1972. Island biology, review of Stern, W.L., ed., Adaptive aspects of insular evolution, 1971. BioScience 22: 261.

R55 (463). ——. 1972. Small island ecosystem, review of van Zinderen Bakker, Sr., J.M. Winterbottom, and R.A. Dyer, eds., Marion and Prince Edward Islands. Report on the South African Biological and Geological Expedition, 1965-1966, 1971. Science 176: 662-663.

D62 (462). ——. 1972. The Ceylon flora project status report, 1972. Duplicated, 17 pp.

1973

406 (472). Fosberg, F.R. 1973. Temperate zone influence on tropical forest land use: a plea for sanity., pp. 345-350, *in* Meggers, B.J., E.S. Ayensu, and W.D. Duckworth, Tropical Forest Ecosystems in Africa and South America. A comparative review. Smithsonian Institution Press, Washington, D.C., viii + 350 pp.

407 (473). ——. 1973. *Caesalpinia major* a legitimate name. Taxon 22: 162-163.

408 (474). ——. 1973. Reflections after the symposium on systematic biological collections, July 6-8, 1972. Pl. Sci. Bull. 19(1): 4-6.

409 (475). ——. 1973. Vascular plants–widespread island species, pp. 167-169, *in* Costin, A.B., and R.H. Groves, Nature Conservation in the Pacific, Australian National University Press, Canberra.

410 (476). ——. 1973. Past, present and future conservation problems of oceanic islands, pp. 209-215, *in* Costin, A.B., and R.H. Groves, Nature Conservation in the Pacific, Australian National University Press, Canberra.

411 (480). ——. 1973. On present condition and conservation of forests in Micronesia. Pacific Sci. Assoc. Standing Comm. on Pacific Bot. Symposium: Planned Utilization of the Lowland Tropical Forest, Bogor, Indonesia, 1971: 165-171.

412 (481). ——. 1973. The name of the Octopus Tree. Baileya 19: 45-46. [*Brassaia.*]

413 (484). ——. 1973. Type specimens of *Buxus sempervirens* Linnaeus. Boxwood Bull. 13(2): 18-21.

414 (483). Sachet, M.-H. and F.R. Fosberg. 1973. Remarks on *Halophila* (Hydrocharitaceae). Taxon 22: 439-443.

R56 (477). Fosberg, F.R. 1973. Review of Lewis, D., We, the navigators, 1972. Geogr. Rev. (New York) 63: 428-430.

R57 (485). ——. 1973. Review of Zwinger, A.H. and B.E. Willard, Land Above the Trees, 1972. Biol. Conservation 5: 317-318.

*L19 (482). ——. 1973. Letter on the proposed road through Abisko from Kiruna to Narvik, p. 21, *in* Andersson et al, Project K-N, Royal Academy of Sciences, Stockholm.

D63 (478). Sachet, M.-H. and F.R. Fosberg. 1973. The Marquesas in Pacific Biogeography, [abstract.] Island Ecosystem, I.R.P. Techn. Rept. 26: 37.

1974

415 (486). Fosberg, F.R. 1974. Sketch of the St. Croix flora, pp. 239-244, *in* Multer, H.G. and L.C. Gerhard, eds., Guidebook to the Geology and ecology of some marine and terrestrial environments of St. Croix. Special publication No. 5, West Indies Laboratory, Fairleigh Dickinson University, Christiansted, St. Croix, 304 pp.

416 (487). ——. 1974. Notes on Micronesian Pteridophyta, III. *Ophioglossum nudicaule* in the Caroline Islands. Amer. Fern J. 64: 1-2.

417 (489). ——. 1974. Studies in American Rubiaceae 2. Ayuque, *Balmea stormae*, an endangered Mexican species. Sida 5: 268-270.

418 (494). ——. 1974. Miscellaneous notes on the flora of Aldabra and neighboring islands: III. Kew Bull. 29: 253-266. [*Flacourtia, Calophyllum, Malleastrum, Poupartia, Lactuca, Plumbago, Ehretia, Ipomoea, Lagrezia, Acalypha, Euphorbia, Maillardia.*]

419 (490). Fosberg, F.R. and M.V.C. Falanruw. 1974. A new Micronesian *Terminália* (Combretaceae). Phytologia 28: 469-470.

420 (491). Fosberg, F.R. and M.-H. Sachet. 1974. A new variety of *Fagraea berteriana* (Gentianaceae). Phytologia 28: 470-472.

421 (493). —— and ——. 1974. Plants of southeastern Polynesia. 3. Micronesica 10: 251-256. [*Waltheria, Alyxia, Ochrosia, Neiosperma.*]

422 (492). Grant, M.L., F.R. Fosberg, and H.M. Smith. 1974. Partial flora of the Society Islands: Ericaceae to Apocynaceae. Smithsonian Contr. Bot. 17: 1-85. [*Vaccinium, Styphelia, Ardisia, Rapanea, Plumbago, Palaquium, Manilkara, Planchonella, Lucuma, Chrysophyllum, Styrax, Olea, Jasminum, Geniostoma, Fagraea, Allamanda, Lepinia, Plumeria, Alstonia, Catharanthus, Ervatamia, Alyxia, Ochrosia, Cerbera, Thevetia, Nerium.*]

423 (498). Mueller-Dombois, D. and F.R. Fosberg. 1974. Vegetation map of Hawaii Volcanoes National Park (at 1: 52,000). Cooperative Nat. Park Resources Unit: Tech. Rept. 4: 1-44, map sheets 1-25.

R58 (488). Fosberg, F.R. 1974. Review of Polunin, N., ed., The Environmental Future, 1972. Geogr. Rev. (New York) 64: 445-447.

1975

424 (500). Fosberg, F.R. 1975. The deflowering of Hawaii. National Parks and Conservation Magazine 49: 4-10.

425 (501). ——. 1975. Dr. Raven's proposals. Taxon 24: 192-193.

426 (502). ——. 1975 [1974.] Phytogeography of atolls and other coral islands. Proceedings of the Second International Coral Reef Symposium. 1: 389-396.

427 (503). ——. 1975. Revised check-list of vascular plants of Hawaii Volcanoes National Park. Cooperative National Park Resources Studies Unit Hawaii, Technical Report no. 5: 1-19.

428 (511). ——. 1975. Identification of vascular flora of Namoluk Atoll, eastern Caroline Islands, *in* Marshall, M. the natural history of Namoluk Atoll, eastern Caroline Islands. Atoll Res. Bull. 189: 23-48.

429 (512). ——. 1975. Typification and author citation of *Merremia tridentata* ssp. *hastata* Van Ooststroom. Taxon 24: 541.

430 (513). ——. 1975. Vascular plants of Aitutaki, pp. 73-84, *in* Stoddart, D.R. and P.E. Gibbs, eds., Almost-Atoll of Aitutaki: Reef Studies in the Cook Islands, South Pacific. Atoll Res. Bull. 190: 1-158.

431 (558). ——. 1975. Phytogeography of Micronesian mangroves, pp. 23-42, *in* Walsh, G., S. Snedaker, and H. Teas, Proceedings of International Symposium on Biological Management of Mangroves, The University of Florida Press, Gainesville.

432 (507). Fosberg, F.R., M.V.C. Falanruw, and M.-H. Sachet. 1975. Vascular flora of the northern Marianas islands. Smithsonian Contr. Bot. 22: 1-45.

433 (508). Fosberg, F.R. and M.V.C. Falanruw. 1975. Noteworthy Micronesian Plants. 1. Micronesica 11: 77-80. [*Eustachys, Boehmeria, Canavalia, Euphorbia, Ochrosia, Eupatorium.*]

434 (499). Fosberg, F.R. and D. Herbst. 1975. Rare and endangered species of Hawaiian vascular plants. Allertonia 1: 1-72.

435 (505). Fosberg, F.R. and M.-H. Sachet. 1975. Flora of Micronesia, 1. Gymnospermae. Smithsonian Contr. Bot. 20: 1-15. [*Cycas, Araucaria, Podocarpus, Pinus, Cryptomeria, Cupressus, Juniperus, Gnetum.*]

436 (506). —— and ——. 1975. Flora of Micronesia. 2. Casuarinaceae, Piperaceae, and Myricaceae. Smithsonian Contr. Bot. 24: 1-28. [*Casuarina, Peperomia, Piper, Myrica.*]

437 (509). —— and ——. 1975. Noteworthy Micronesian Plants. 2. Micronesica 11: 81-84. [*Portulaca, Connarus, Salomonia, Bacopa, Limnophila, Striga.*]

438 (510). —— and ——. 1975. Polynesian plant studies. 1-5. Smithsonian Contr. Bot. 21: 1-25.
1. *Vaccinium cereum* (L.f.) Forster f. in Tahiti and the Marquesas, pp. 1-3.
2. *Myrsine* L. in eastern Polynesia, pp. 3-11.
3. Three species of *Geniostoma* J. R. & G. Forster, pp. 11-14.
4. *Ipomoea tiliacea* (Willdenow) Choisy in the Pacific, pp. 14-15.
5. Annotations to the Hawaiian flora, pp. 15-23. [*Adiantum, Salicornia, Crotalaria, Melochia, Waltheria, Plantago, Hedyotis.*]

439 (510a). [Fosberg, F.R. and M.-H. Sachet, eds.] 1975. Island news and comments. Atoll Res. Bull. 185: 1-39.

R59 (515). Fosberg, F.R. 1975. Review of Faulkner, D. This Living Reef, 1974. AAAS Science Books and Films 11: 74.

D64 (504). ——. 1975. Outline of the contents of Biogeography. Two page duplicated excerpt from talk, distributed to audience at talks Geography, Ecology, and Biogeography at AAG annual meeting, Milwaukee, Wisconsin, 21 April.

D65 (515c). ——. 1975. Biogeoclimatic patterns in Micronesia, [abstract.] 13th Pacific Science Congress, Vancouver, Proc. 1, Abstracts of papers, pp. 97-98.

D66 (515d). ——. 1975. An overview of natural area preservation in the world, [abstract.] 13th Pacific Science Congress, Vancouver, Proc. 1, Abstracts of papers, p. 139.

D67 (515e). ——. 1975. Development of ecosystem concept, [abstract.] 13th Pacific Science Congress, Vancouver, Proc. 1, Abstracts of papers, pp. 248-249.

D68 (515b). Fosberg, F.R. and M.-H. Sachet. 1975. Micronesia: status of floristic knowledge, [abstract.] 13th Pacific Science Congress, Vancouver, Proc. 1, Abstracts of papers. p. 98.

D69 (515a). Sachet, M.-H. and F.R. Fosberg. 1975. The Marquesas in Pacific plant geography, [abstract.] 13th Pacific Science Congress, Vancouver, Proc. 1, Abstracts of papers, p. 110.

1976

440 (514). Fosberg, F.R. 1976. Coral island vegetation. Chapter 8, pp. 255-277, *in* Jones, O.A. and R. Endean, Biology and Geology of Coral Reefs. Volume III Biology 2, Academic Press, New York.

441 (516). ——. 1976. Status of the name *Chloris barbata* (L.) Swartz. Taxon 25: 176-178.
442 (517). ——. 1976. Typification of *Sadleria hillebrandii* Robinson. Taxon 25: 187-188.
443 (518). ——. 1976. *Bobea elatior* again. Taxon 25: 188.
444 (519). ——. 1976. Revisions in the Flora of St. Croix, U.S. Virgin Islands. Rhodora 78: 79-119. [*Jatropha*, *Lantana*, *Lippia*.]
445 (520). ——. 1976. Geography, ecology, and biogeography. Ann. Assoc. Amer. Geogr. 66: 117-128.
446 (521). ——. 1976. *Ipomoea indica* taxonomy: a tangle of morning glories. Bot. Not. 129: 35-38.
447 (526). ——. 1976. Distributional extensions of marine Spermatophytes. Micronesica 12: 317-318.
R60 (522). ——. 1976. Review of Whitmore, T.C., Tropical Rain Forests of the Far East, 1975. Taxon 25: 510.
R61 (523). ——. 1976. Review of Udvardy, M.D.F., A Classification of the Biogeographical Provinces of the World, 1975. Environm. Conservation 3: 313-314.
R62 (528). ——. 1976. Review of Carlquist, S., Island Biology, 1974. Economic Botany 30: 6-7.
R63 (529). ——. 1976. Review of Everist, S.L., Poisonous Plants of Australia, 1974. Economic Botany 30: 6.
R64. ——. 1976. Review of Sterling, T., The Amazon, 1975. Taxon 25: 658.

1977

448 (533). Fosberg, F.R. 1977. *Paspalum distichum* again. Taxon 26: 201-202.
449 (534). ——. 1977. Miscellaneous notes on the flora of Aldabra and neighbouring islands: IV. A new *Bulbostylis* and observations on *Cyperus* (Cyperaceae). Kew Bull. 31: 829-835.
450 (535). ——. 1977. Miscellaneous notes on the flora of Aldabra and neighbouring islands: V. *Pandanus tectorius* Parkinson, sensu latissimo (Pandanaceae). Kew Bull. 31: 837-840.
451 (539). ——. 1977. Miscellaneous notes on the flora of Aldabra and neighbouring islands: VI. *Portulaca* (Portulacaceae) in the Aldabra Group. Kew Bull. 32: 253-258.
452 (551). ——. 1977. Documentation of identifications in ecological work. Trop. Ecol. 18: 97-98.
453 (541). Fosberg, F.R., P. Boiteau, and M.-H. Sachet. 1977. Nomenclature of the Ochrosiinae (Apocynaceae): 2. Synonymy of *Ochrosia* Juss. and *Neiosperma* Raf. Adansonia, n.s., 17: 23-33.
454 (532). Fosberg, F.R., M.V.C. Falanruw, and M.-H. Sachet. 1977. Additional records of vascular plants from the northern Mariana Islands. Micronesica 13: 27-31.
455 (524). Fosberg, F.R. and M.-H. Sachet. 1977. Flora of Micronesia. 3. Convolvulaceae. Smithsonian Contr. Bot. 36: 1-34. [*Aniseia*, *Argyreia*, *Cuscuta*, *Evolvulus*, *Ipomoea*, *Merremia*, *Operculina*, *Stictocardia*.]
456 (540). —— and ——. 1977. Nomenclature of the Ochrosiinae (Apocynaceae): 1. Application of the Names *Neiosperma* Raf. and *Calpicarpum* G. Don. Adansonia, n.s., 17: 19-22.
457 (536). [Fosberg, F.R., D.R. Stoddart, and M.-H. Sachet, eds.] 1977. Island news and comment. Atoll Res. Bull. 219: 1-30.
458 (542). Tsuda, R. T., F.R. Fosberg, and M.-H. Sachet. 1977. Distribution of seagrasses in Micronesia. Micronesica 13: 191-198.
R65 (527). Fosberg, F.R. 1977. Review of Wace, N.M. and M.W. Holdgate, Man and Nature in the Tristan da Cunha Islands. Environm. Conservation 4: 73.
R66 (530). ——. 1977. Review of Dasmann, R.R., Environmental Conservation, 4th ed. 1976. Environm. Conservation 4: 155-156.
R67 (531). ——. 1977. Review of Hoare, M.E., The Tactless Philosopher: Johann Reinhold Forster 1729-1798, 1975. Taxon 26: 120-121.
R68 (537). ——. 1977. Review of Chapman, V.J., Mangrove Vegetation, 1976. Taxon 26: 113.
R69 (538). ——. 1977. Review of Herklots, G., Flowering Tropical Climbers, 1976. Taxon 26: 119.
L18 (525). ——. 1977. Expert on Hawaiian plants responds [reader comment.] National Parks and Conservation Magazine 51(2): 28-29.

1978

459 (543). Fosberg, F.R. 1978. Studies in the genus *Boerhavia* L. (Nyctaginaceae), 1-5. Smithsonian Contr. Bot. 39: 1-20.
1. Introduction to the genus *Boerhavia* L., pp. 1-4.
2. Clarification of *Boerhavia diffusa* L. and *Boerhavia repens* L., pp. 4-5.
3. Typification of *Boerhavia mutabilis* R. Brown and *Boerhavia pubescens* R. Brown, pp. 5-8.
4. *Boerhavia repens* group, pp. 8-13.
5. *Boerhavia rubicunda* Steudel and somewhat similar species, pp. 13-18.

460 (545). ——. 1978 [1977.] A fossil *Garcinia* fruit from the New Hebrides, Melanesia. Pacific Sci. 31: 293-297.

461 (546). ——. 1978. Miscellaneous notes on the flora of Aldabra and neighbouring islands: VII. *Eugenia elliptica* var. *levinervis* (Myrtaceae). Kew Bull. 33: 133-134.

462 (547). ——. 1978. Miscellaneous notes on the flora of Aldabra and neighbouring islands: VIII. *Hedyotis* subgenus *Oldenlandia* (Rubiaceae). Kew Bull. 33: 135-140.

463 (548). ——. 1978. Miscellaneous notes on the flora of Aldabra and neighbouring islands: IX. The native Aldabra *Solanum*. Kew Bull. 33: 141-142.

464 (549). ——. 1978. Miscellaneous notes on the flora of Aldabra and neighbouring islands: X. The Aldabra *Clerodendrum* (Verbenaceae). Kew Bull. 33: 143-144.

465 (550). ——. 1978. Miscellaneous notes on the flora of Aldabra and neighbouring islands: XI. Critical notes on Euphorbiaceae. Kew Bull. 33: 181-190. [*Euphorbia*, *Margaritaria*, *Phyllanthus*.]

R70 (544). ——. 1978. Review of Bryson, R.A. and T.J. Murray, Climates of Hunger: Mankind and the World's Changing Weather. Environm. Conservation 5: 75.

R71 (544a). ——. 1978. Review of Heintze, C., Summit Lake, Four Seasons in the Sierras, 1976. Environm. Conservation 5: 160.

1979

466 (552). Fosberg, F.R. 1979. The woody Rubiaceae of Aldabra Island (Indian Ocean). Phytologia 41: 347-362. [*Canthium*, *Guettarda*, *Polysphaeria*, *Psychotria*, *Tarenna*, *Triainolepis*, *Tricalysia*.]

467 (554). ——. 1979. Miscellaneous notes on the flora of Aldabra and neighbouring islands: XII. *Boerhavia repens* L. var. *maris-indici* Fosberg (Nyctaginaceae) validated. Kew Bull. 33: 398.

468 (561). ——. 1979. Tropical floristic botany–concepts and status–with special attention to tropical islands, pp. 89-105, *in* Larsen, K. and B. Holm-Nielsen, Tropical Botany. Academic Press, London. xi + 453.

469 (562b). ——. 1979. Plants of D'arros Island, pp. 19-25, *in* Stoddart, D.R., M.J. Coe, and F.R. Fosberg. D'arros and St. Joseph, Amirante Islands. Atoll Res. Bull. 223: 1-48.

470 (562c). ——. 1979. Plants of St. Joseph Atoll, pp. 43-48, *in* Stoddart, D.R., M.J. Coe, and F.R. Fosberg. D'arros and St. Joseph, Amirante Islands. Atoll Res. Bull. 223: 1-48.

471 (574). ——. 1979. Conservation of diversity. Environm. Aware. 2: 109-130.

472 (553). Fosberg, F.R. and M.-H. Sachet. 1979. *Callicarpa erioclona* Schauer (sensu stricto). Phytologia 41: 363-365.

473 (555). —— and ——. 1979. *Maesa* (Myrsinaceae) in Micronesia. Phytologia 44: 362-369.

474 (555a). —— and ——. 1979. Correction to *Maesa* (Myrsinaceae) in Micronesia. Phytologia 44: 502.

475 (557). Fosberg, F.R., M.-H. Sachet, and R.L. Oliver. 1979. A geographical checklist of the Micronesian Dicotyledonae. Micronesica 15: 41-295.

476 (562a). Stoddart, D.R., M.J. Coe, and F.R. Fosberg. 1979. D'arros and St. Joseph, Amirante Islands. Atoll Res. Bull. 223: 1-48.

1980

477 (562). Fosberg, F.R. 1980. Whither terrestrial ecosystems? Preservation of the habitat of man, pp. 64-93, *in* Polunin, N., ed. Growth without Ecodisasters?. MacMillan Press, London and Basingstoke, xxvi + 675 pp.

478 (567). ——. 1980. The plant eco-system for Moenjodaro. UNESCO, Restricted Technical Report RP/1977-78/4.121.6:1-15.

479 (556). Fosberg, F.R., D. Otobed, M.-H. Sachet, R.L. Oliver, D.A. Powell, and J.E. Canfield. 1980. Vascular plants of Palau with vernacular names. Duplicated, Smithsonian Institution, 43 pp.

480 (560). Fosberg, F.R. and S.A. Renvoize. 1980. The flora of Aldabra and neighbouring islands. Kew Bull., Additional Series, 7: 1-358. [*Acrostichum, Nephrolepis, Annona, Cissampelos, Brassica, Capparis, Cleome, Gynandropsis, Maerua, Flacourtia, Ludia, Portulaca, Calophyllum, Abutilon, Gossypium, Hibiscus, Sida, Thespesia, Corchorus, Grewia, Triumfetta, Erythroxylum, Tribulus, Oxalis, Citrus, Suriana, Ochna, Malleastrum, Xylocarpus, Apodytes, Maytenus, Mystroxylon, Colubrina, Gouania, Scutia, Allophylus, Dodonaea, Macphersonia, Operculicarya, Moringa, Caesalpinia, Cassia, Delonix, Tamarindus, Calliandra, Dichrostachys, Abrus, Canavalia, Clitoria, Crotalaria, Erythrina, Indigofera, Sophora, Tephrosia, Teramnus, Vigna, Brexia, Bruguiera, Cassipourea, Ceriops, Rhizophora, Lumnitzera, Terminalia, Eugenia, Pemphis, Sonneratia, Turnera, Passiflora, Carica, Cucumis, Cucurbita, Lagenaria, Momordica, Peponium, Trichosanthes, Sesuvium Trianthema, Mollugo, Canthium, Guettarda, Hedyotis, Polysphaeria, Psychotria, Tarenna, Triainolepis, Tricalysia, Bidens, Launaea, Melanthera, Synedrella, Tridax, Vernonia, Scaevola, Plumbago, Sideroxylon, Jasminum, Azima, Salvadora, Carissa, Catharanthus, Pandaca, Pentopetia, Pleurostelma, Sarcostemma, Pleurostelma, Tylophora, Cordia, Ehretia, Tournefortia, Evolvulus, Ipomoea, Capsicum, Datura, Nicotiana, Solanum, Bacopa, Bryodes, Striga, Tabebuia, Asystasia, Barleria, Hypoestes, Justicia, Ruellia, Avicennia, Clerodendrum, Conega, Lantana, Premna, Stachytarpheta, Nesogenes, Leonotis, Ocimum, Boerhavia, Mirabilis, Pisonia, Achyranthes, Alternanthera, Amaranthus, Deeringia, Lagrezia, Arthrocnemum, Cassytha, Hernandia, Bakerella, Viscum, Acalypha, Euphorbia, Margaritaria, Pedilanthus, Phyllanthus, Ricinus, Laportea, Obetia, Ficus, Maillardia, Casuarina, Acampe, Angraecum, Hederorkis, Dioscorea, Agave, Asparagus, Dracaena, Lomatophyllum, Commelina, Cocos, Phoenix, Pandanus, Najas, Cymodocea, Halodule, Ruppia, Syringodium, Thalassodendron, Halophila, Thalassia, Bulbostylis, Cyperus, Fimbristylis, Bambusa, Cenchrus, Cymbopogon, Dactyloctenium, Daknopholis, Digitaria, Eleusine, Enteropogon, Eragrostis, Eriochloa, Ischaemum, Lepturus, Panicum, Paspalum, Pennisetum, Sclerodactylon, Sporobolus, Stenotaphrum, Zea.*]

481 (559). Fosberg, F.R. and M.-H. Sachet. 1980. Systematic Studies of Micronesian Plants. Smithsonian Contr. Bot. 45: 1-40. [*Hymenophyllum, Trichomanes, Gleichenia, Thelypteris, Centosteca, Rhaphidophora, Elatostema, Calliandra, Stylosanthes, Acalypha, Loeseneriella, Calophyllum, Garcinia, Flacourtia, Citrullus, Zehneria, Bruguiera, Medinilla, Melastoma, Osmoxylon, Myrsine, Pouteria, Fagraea, Geniostoma, Heliotropium, Callicarpa, Pseuderanthemum, Geophila, Hedyotis, Psychotria, Spermacoce, Vernonia, Wollastonia.*]

482 (565). —— and ——. 1980. Flora of Micronesia. 4. Caprifoliaceae-Compositae. Smithsonian Contr. Bot. 46: 1-71. [*Sambucus, Hippobroma, Scaevola, Adenostemma, Ageratum, Artemisia, Aster, Bidens, Blumea, Chromolaena, Chrysanthemum, Cichorium, Conyza, Coreopsis, Cosmos, Crassocephalum, Cynara, Eclipta, Elephantopus, Emilia, Epaltes, Erigeron, Gaillardia, Glossogyne, Lactuca, Mikania, Pluchea, Pseudo-Elephantopus, Pseudogynoxys, Sonchus, Spilanthes, Synedrella, Tagetes, Tithonia, Tridax, Vernonia, Wedelia, Wollastonia, Youngia, Zinnia.*]

483 (566). Dassanayake, M.D. and F.R. Fosberg, eds. 1980. A Revised Handbook to the Flora of Ceylon. Vol. 1. Amerind Publishing Co. Pvt. Ltd., New Delhi, 508 pp.

R72 (562)a. Fosberg, F.R. 1980. Reviews of Heikoff, J.M., Coastal resources management: institutions and programs, 1977, and Barnes, R.S.K., ed., The Coastline: a contribution to our understanding of its ecology and physiography in relation to land-use and management and the pressures to which it is subject, 1977. Environm. Conservation 7: 81-82.

R73 (563). ——. 1980. Island botany, review of Bramwell, D., ed., Plants and Islands, 1979. Nature 285: 680-681.

R74 (564). ——. 1980. Review of Bramwell, D., ed., Plants and Islands, 1979. Environm. Conservation 7: 251.

D70 (568). [Fosberg, F.R.] 1980. Island ecosystems, a review. United Nations Environmental Program Report No. 3, 1-34, Nairobi. [retyped, duplicated, and published from a manuscript review furnished to UNEP by Fosberg in 1979.]

D71 (569). [Fosberg, F.R.] 1980. Coastal ecosystems, a review, United Nations Environmental Program Report No. 4, 1-65, Nairobi. [retyped, duplicated, and published from a manuscript review furnished to UNEP by Fosberg in 1979.]

1981

484 (573). Fosberg, F.R. 1981. The names published in Stickman's Herbarium Amboinense or *Casuarina litorea* L., a valid Rumphian name. Taxon 30: 218-227.

485 (575). ——. 1981. Introduction, p. 1, *in* Raulerson, L. (ed.). Plant Biogeography of Guam. Univ. of Guam, Marine Lab. Tech. Report. 69.

486 (586). ——. 1981. An overview of natural area preservation in the world, pp. 1-6. *in* Foster, J.B., ed. Ecological Reserves. [British Columbia Provincial Museum] Heritage Record No. 12.

487 (590, 622). ——. 1981 [1980.] A revision of the Flora of Ceylon (Sri Lanka). Spolia Zeylanica 35(1-2): 9-14, 19.

488 (578). Fosberg, F.R. and J. Canfield. 1981 [1980.] Noteworthy Micronesian Plants 3. Micronesica 16: 189-200. [*Tricomanes, Humata, Nephrolepis, Panicum, Eriocaulon, Aneilema, Achyranthes, Piriqueta, Ammannia, Eugenia, Melaleuca, Leucas, Utricularia, Andrographis, Hedyotis, Spermacoce, Timonius.*]

489 (579). Fosberg, F.R. and M.V.C. Falanruw. 1981 [1980.] Noteworthy Micronesian Plants. 4. Micronesica 16: 201-210. [*Digitaria, Lemna, Achyranthes, Galphimia, Kolreuteria, Lepisanthes, Eugenia, Allamanda.*]

490 (580). Fosberg, F.R., M.V.C. Falanruw, and M.-H. Sachet. 1981 [1980.] Additional records of vascular plants from the northern Marianas. 2. Micronesica. 16: 211-214. [*Randia, Aidia, Setaria, Hedyotis, Eupatorium, Chromolaena, Bidens, Cosmos, Wedelia, Wollastonia.*]

491 (570). Fosberg, F.R. and M.-H. Sachet. 1981 [1980.] A New *Sciaphila* (Triuridaceae) from Palau Islands. Pacific Sci. 34: 25-27.

492 (571). —— and ——. 1981 [1980.] Typification of the genus *Ochrosia* Jussieu, pp. 211-215, *in* Gunawardana, T.T.P. et al, eds., P.E.P. Deraniyagala Commemoration Volume, Lake House Investments, Ltd, Colombo, Sri Lanka.

493 (572). —— and ——. 1981. Polynesian plant studies 6-18. Smithsonian Contr. Bot. 47: i-iv, 1-38.

6. *Tricholaena* Schrader (Poaceae) in the Pacific Islands, pp. 1-3.
7. A new woody *Oxalis* L. (Oxalidaceae) from the Marquesas, pp. 3-5.
8. A new *Claoxylon* A. Jussieu (Euphorbiaceae) from the Marquesas, pp. 5-6.
9. *Abutilon* Miller (Malvaceae) in southeastern Polynesia and Samoa: The *Abutilon sachetianum* Group, pp. 6-11.
10. New combinations in *Zehneria* Endlicher (Cucurbitaceae), pp. 11-13.
11. *Terminalia* L. (Combretaceae) in eastern Polynesia, pp. 13-17.
12. Further notes on *Myrsine* L. (Myrsinaceae) in eastern Polynesia, p. 18.
13. New *Geniostoma* J. R. & G. Forster (Loganiaceae) taxa, pp. 18-21.
14. A new *Rauvolfia* L. (Apocynaceae) from the Marquesas, pp. 21-24.
15. *Leucas* R. Brown (Lamiaceae) in the Pacific Islands, pp. 24-26.
16. Observations on *Cyrtandra* J. R. & G. Forster (Gesneriaceae) in the Marquesas Islands, pp. 26-33.
17. Nomenclature of *Dichrocephala integrifolia* (L.f.) O. Kuntze (Asteraceae), pp. 33-35.
18. Miscellaneous taxonomic and distributional notes, pp. 35-37. [*Vigna, Melicoccus, Triumfetta, Miconia, Cordia.*]

494 (583). —— and ——. 1981. Clarification of *Hygrophila triflora* (Acanthaceae). Baileya 21: 145-148.

495 (584). —— and ——. 1981. *Pavonia* (Malvaceae) in Society Islands. Bull. Mus. Natl. Nat. Hist., B, Adansonia 1: 15-18.

496 (585). —— and ——. 1981. Nomenclatural notes on Micronesian Ferns. Amer. Fern J. 71: 82-84. [*Thelypteris*, *Trichomanes*.]

497 (576). Dassanayake, M.D. and F.R. Fosberg, eds. 1981. A Revised Handbook to the Flora of Ceylon. Vol. II. Amerind Publishing Co. Pvt. Ltd., New Delhi, 511 pp.

498 (587). —— and ——, eds. 1981. A Revised Handbook to the Flora of Ceylon. Vol. III. Amerind Publishing Co. Pvt. Ltd., New Delhi, 499 pp.

499 (577). Macnae, W. and F.R. Fosberg. 1981. Rhizophoraceae, pp. 487-500, *in* Dassanayake, M.D. and F.R. Fosberg, eds., A Revised Handbook to the Flora of Ceylon. Vol. II. Amerind Publishing Co. Pvt. Ltd., New Delhi, 511 pp. [*Anisophyllea*, *Bruguiera*, *Ceriops*, *Kandelia*, *Rhizophora*.]

500 (588). —— and ——. 1981. Lecythidaceae, pp. 195-201, *in* Dassanayake, M.D. and F.R. Fosberg, eds., A Revised Handbook to the Flora of Ceylon. Vol. III. Amerind Publishing Co. Pvt. Ltd., New Delhi, 499 pp. [*Barringtonia*, *Careya*, *Couroupita*.]

501 (589). —— and ——. 1981. Sonneratiaceae, pp. 450-453, *in* Dassanayake, M.D. and F.R. Fosberg, eds., A Revised Handbook to the Flora of Ceylon. Vol. III. Amerind Publishing Co. Pvt. Ltd., New Delhi, 499 pp. [*Sonneratia*.]

502 (595). Stoddart, D.R. and F.R. Fosberg. 1981. Bird and Denis Island, Seychelles. Atoll Res. Bull. 252: 1-55.

503 (596). —— and ——. 1981. Topographic and floristic changes, Dry Tortugas Florida, 1904-1977. Atoll Res. Bull. 253: 1-76.

R75 (581). Fosberg, F.R. 1981 [1980]. Review of van Steenis, C.G.G.J, ed., Flora Malesiana, series 1, vol. 8. Micronesica 16: 365-366.

R76 (582). ——. 1981 [1980.] Review of Vogel, E.F. de, Seedlings of Dicotyledons; structure, development, types, descriptions of 150 woody Malesian taxa. Micronesica 16: 366-367.

1982

504 (594). Fosberg, F.R. 1982. A preliminary conspectus of the genus *Leptostigma* (Rubiaceae). Acta Phytotax. Geobot. 33: 73-83.

505 (599). Fosberg, F.R. and M.-H. Sachet. 1982. Notes on *Sphenomeris chinensis* (L.) Maxon ex Kramer. Micronesica 18(1): 129-133.

506 (598). Fosberg, F.R., M.-H. Sachet, and R.L. Oliver. 1982. Geographical checklist of Micronesian Pteridophyta and Gymnospermae. Micronesica 18(1): 23-82.

507 (593). Fosberg, F.R., D.R. Stoddart, M.-H. Sachet, and D.L. Spellman. 1982. Plants of the Belize cays. Atoll Res. Bull. 258: 1-77.

508 (597). Stoddart, D.R. and F.R. Fosberg. 1982. Species-area relationships on small islands: floristic data from Belizean sand cays, pp. 527-539, *in* Rützler, K. and I.G. MacIntyre, eds., The Atlantic Barrier Reef Ecosystem at Carrie Bow Cay, Belize, 1: Structure and Communities. Smithsonian Contr. Mar. Sci. 12: 1-539.

509 (592). Stoddart, D.R., F.R. Fosberg, and M.-H. Sachet. 1982. Ten years of change on the Glover's Reef cays. Atoll Res. Bull. 257: 1-17 + 24 pp. figs. and plates.

510 (591). Stoddart, D.R., F.R. Fosberg, and D.L. Spellman. 1982. Cays of the Belize barrier reef and lagoon. Atoll Res. Bull. 256: 1-76.

1983

511 (602). Fosberg, F.R. 1983. The human factor in the biogeography of oceanic islands. Comt. Rend. Séances Soc. Biogéogr. 59: 147-190.

512 (606). ——. 1983. Two new species of *Psychotria* from the Society Islands. Candollea 38: 455-458.

513 (607). ——. 1983. A possible new pathogen affecting *Metrosideros* in Hawaii. Newslett. Hawaiian Bot. Soc. 22: 13-16.

514 (614). ——. 1983. Natural history of Cousin Island. Atoll Res. Bull. 273: 7-38.

515 (605). Fosberg, F.R. and M.-H. Sachet. 1983. Henderson Island threatened. Environm. Conservation 10: 171-173.

516 (611a). ——and ——. 1983. Plants of the Society Islands, pp. 76-107, *in* Carr, D.J., ed., Sydney Parkinson, artist of Cook's Endeavour voyage. University of Hawaii Press, Honolulu, xvi + 300 pp.

517 (608). Fosberg, F.R., M.-H. Sachet, and D.R. Stoddart. 1983. Henderson Island (southeastern Polynesia): summary of current knowledge. Atoll Res. Bull. 272: 1-47, pl. 1-12.

518 (615). ——, ——, and ——. 1983. List of the recorded vascular flora of Agalega, *in* Sachet, M.-H., D.R. Stoddart, and F.R. Fosberg, eds., Floristics and ecology of western Indian Ocean islands. Atoll Res. Bull. 273: 109-142.

519 (601). Dassanayake, M.D. and F.R. Fosberg, eds. 1983. A Revised Handbook to the Flora of Ceylon. Vol. IV. Amerind Publishing Co. Pvt. Ltd., New Delhi, 532 pp.

520 (600). Roane, M.K. and F.R. Fosberg. 1983. A new pyrenomycete associated with *Metrosideros collina* subspecies *polymorpha* (Myrtaceae). Mycologia 75: 163-166.

521 (619). Robertson, I.A.D., S.A. Robertson, and F.R. Fosberg. 1983. List of plants collected on Alphonse Island, Amirantes. Atoll Res. Bull. 273: 177-184.

522 (616). Robertson, S.A. and F.R. Fosberg. 1983. List of plants collected on Coetivy Island, Seychelles. Atoll Res. Bull. 273: 143-156.

523 (617). —— and ——. 1983. List of plants collected on Platte Island, Seychelles . Atoll Res. Bull. 273: 157-164.

524 (618). —— and ——. 1983. List of plants of Poivre Island, Amirantes. Atoll Res. Bull. 273: 165-176.

525 (611). Sachet, M.-H. and F.R. Fosberg. 1983. An ecological reconnaissance of Tetiaroa Atoll, Society Islands. Atoll Res. Bull. 275, 1-67, pl. 1-42.

526 (610a). Sachet, M.-H., D.R. Stoddart, and F.R. Fosberg, eds. 1983. Floristics and ecology of western Indian Ocean islands. Atoll Res. Bull. 273, 1-253.

R77 (603). Fosberg, F.R. 1983. Review of Mueller-Dombois, D., K.W. Bridges, and H.L. Carson, eds., Island Ecosystems: Biological Organization in Selected Hawaiian Communities, 1981. Environm. Conservation 10: 82-33.

R78 (604). ——. 1983. Review of Hayward, S.J., V.H. Gomez, and W. Sterrer, eds., Bermuda's Delicate Balance--People and the Environment, 1981. Environm. Conservation 10: 179.

R79 (609a). ——. 1983. Review of Long, S.P. and C.F. Mason, Saltmarsh Ecology, 1983. Environm. Conservation 10: 369.

R80. ——. 1983. Review of Smith, A.C., Flora Vitiensis Nova, vol. 2, 1981. Taxon 32: 156.

D72 (608a). ——. 1983. A possible new pathogen affecting *Metrosideros* in Hawaii, [abstract.] Pacific Science Association, 15th Congress, Abstracts, p. 75.

D73 (608b). Stoddart, D.R., C.D. Woodroffe, and F.R. Fosberg. 1983. Substrate-specific species distributions on Suwarrow Atoll, Central Pacific: implications for island biogeography theory, [abstract.] Pacific Science Association, 15th Congress, Abstracts, pp. 227-228.

1984

527 (621). Fosberg, F.R. 1984. Henderson Island saved. Environm. Conservation 11: 183-184.

528 (624). ——. 1984. Phytogeographic comparison of Polynesia and Micronesia, pp. 33-44, *in* Radovsky, F.J., P.H. Raven, and S.H. Sohmer, eds., Biogeography of the Tropical Pacific, Proceedings of a Symposium. Special Publ. Bernice Pauahi Bishop Mus., 72. x + 221 pp.

529 (629). Fosberg, F.R. and D. Herbst. 1984 [1983.] A *Nesogenes* (Chloanthaceae) from Micronesia. Micronesica 19: 11-15.

530 (609, 610). Fosberg, F.R. and M.-H. Sachet. 1984. Identity and typification of *Ruellia triflora* Roxb. and *R. difformis* L.f. (Acanthaceae). Baileya: 22: 138-140.

531 (612). —— and ——. 1984 [1982.] Micronesian Poaceae: critical and distributional notes. Micronesica 18(2): 45-102. [*Cynodon, Digitaria, Echinochloa, Imperata, Isachne, Ischaemum, Lepturopetium, Oplismenus, Paspalum, Pennisetum, Pogonatherum, Polytrias, Saccharum, Sorghum.*]

532 (613). —— and ——. 1984. [1982] The identification of *Desmodium purpureum* (Roxburgh) Hooker and Arnott. Micronesica 18(2): 195-196.

533 (620). Fosberg, F.R. and D.R. Stoddart. 1984. Vegetation and floristics of western Indian Ocean coral islands, pp. 221-238, *in* Stoddart, D. R., ed., Biogeography and Ecology of the Seychelles Islands. Dr W. Junk Publishers, The Hague.

R81 (636). Fosberg, F.R. 1984. Review of: Synge, H. The IUCN/WWF Plants Conservation Programme 1984-1985. Environm. Conservation 11: 285-286.

1985

534 (625). Fosberg, F.R. 1985. *Cordyline fruticosa* (L.) Chevalier (Agavaceae). Baileya 22: 180-181.

535 (628). ——. 1985. Origin and early history of Flora Neotropica, pp. 25-27, *in* Cuatrecasas, J., Flora Neotropica Monograph number 2 Supplement, Brunelliaceae.

536 (632). ——. 1985. Range extension of *Diaporthiopsis meterosideri* to Bird Park, Hawaii Volcanoes National Park. Newslett. Hawaiian Bot. Soc. 24: 18.

537 (637). ——. 1985. Coral reef destruction in Ryukyu Islands. Environm. Conservation 12: 270.

538 (638). ——. 1985 [1986?]. Present state of knowledge of the flora and vegetation of emergent reef surfaces. Proceedings of the Fifth International Coral Reef Congress, Tahiti, 5: 107-112.

539 (678). ——. 1985. Classification of emergent reef surfaces. Atoll Res. Bull. 292: 29-36, .

540 (679). ——. 1985. Botanical visits to Krakatau in 1958 and 1963. Atoll Res. Bull. 292: 39-48.

541 (625a). Fosberg, F.R. and M.-H. Sachet. 1985. History of the generic name *Pseuderanthemum* Radlkofer (Acanthaceae). Baileya 22: 178-179.

542 (633). —— and ——. 1985. Rare, endangered, and extinct Society Island plants. Natl. Geogr. Soc. Res. Report 21: 161-165.

543 (634). —— and ——. 1985. *Santalum* in eastern Polynesia. Candollea 40: 459-470.

544 (635). —— and ——. 1985 [1982.] A new *Pavonia* from Ceylon. Ceylon J. Sci., Biol. Sci. 15: 38-40.

545 (623). Fosberg, F.R. and E.E. Terrell. 1985. A recently established exotic in west Florida and Alabama (*Hedyotis salzmannii* or *Oldenlandia salzmannii* Rubiaceae). Castanea 50: 49-51.

546 (638a). Dassanayake, M.D. and F.R. Fosberg, eds. 1985. A Revised Handbook to the Flora of Ceylon. Vol. V. Amerind Publishing Co. Pvt. Ltd., New Delhi, 476 pp.

547 (627). Lourteig, A. and F.R. Fosberg. 1985. Application of the name *Calophyllum calaba* L., Guttiferae (Clusiaceae). Phytologia 57: 153-55.

R82 (630). Fosberg, F.R. 1985 [1983.] Review of Hezel, F.X., The First Taint of Civilization: A History of the Caroline and Marshall Islands in Pre-Colonial Days, 1983. Micronesica 19: 180-181.

*R83 (631). ——. 1985. Review of Cuzent, G., revised and expanded by Florence, J., M. Guerin, F. Margueron, D. Margueron, D. Koenig, and R. Koenig, Archipel de Tahiti: Recherches sur les principales productions vegetales, 1983. Pacific Stud. 8: 125-129.

1986

548 (639). Fosberg, F.R. 1986. Biodiversity. Environm. Aware. 9: 125-129.

549 (639a). ——. 1986. (264) Proposal to abolish conservation of specific names. Taxon 35: 847.

550. ——. 1986. (265) Proposal regarding autonyms. Taxon 35: 847-849.

551. ——. 1986. (266)-(268) Proposals relating to the rejection of names under Article 69. Taxon 35: 849-850.

552. ——. 1986. (269)-(274) Proposals to rationalize and make consistent and understandable Art. 73.8 and Rec. 73g.1 on connecting forms in epithets made up of two elements. Taxon 35: 850-851.

553. ——. 1986. Marie-Hélène Sachet (1922-1986). Taxon 35: 936.

D74 (707). ——. 1986. Vegetation of Bikini Atoll, 1985. Report prepared for Bikini Atoll Rehabilitation Committee, 39 pages, duplicated.

1987

554 (640). Fosberg, F.R. 1987. The genus *Trukia* Kanehira (Rubiaccae). Phytologia 62: 171-176.

555 (641). ——. 1987. A new *Pisonia* (Nyctaginaceae) from thc Hawaiian Islands. Phytologia 62: 177-178.

556 (642). ——. 1987. *Bobea platypes* Fosbcrg, new specics (Rubiaceae) from Maui, Hawaiian Islands. Phytologia 62: 179-180.

557 (643). ——. 1987. New nomenclatural combinations for Galapagos plant spccics. Phytologia 62: 181-183. [*Solanum*, *Spermacoce*.]

558 (646). ——. 1987. Artificial Diversity. Environm. Conservation 14: 74.

559 (647). ——. 1987. A living museum of Ceylon trees. Environm. Conservation 14: 79.

560 (648). ——. 1987. Pāpala Kēpau, *Pisonia umbellifera* (Forster) Seeman. Newslett. Hawaiian Bot. Soc. 26(2): 23-25.

561 (648b). ——. 1987. *Geophila* (Rubiaceae), pp. 320-321, *in* Dassanayake, M.D. and F.R. Fosberg, eds. A Revised Handbook to the Flora of Ceylon. Vol. VI. Amerind Publishing Co. Pvt. Ltd., New Delhi, 424 pp.

562 (650). ——. 1987. Marie Hélène Sachet: islands, atolls and reefs, *in* Introduction to Marie-Hélène Sachet Commemorative Issue. Atoll Res. Bull. 293: 1-7.

563 (651). Fosberg, F.R. and M.-H. Sachet. 1987. Flora of Maupiti, Society Islands. Atoll Res. Bull. 294: 1-70.

564 (652). —— and ——. 1987. Flora of Gilbert Islands, Kiribati, checklist. Atoll Res. Bull. 295: 1-33.

565 (648a). Dassanayake, M.D. and F.R. Fosberg, eds. 1987. A Revised Handbook to the Flora of Ceylon. Vol. VI. Amerind Publishing Co. Pvt. Ltd., New Delhi, 424 pp.

*D75 (644). Fosberg, F.R. 1987. Undisturbed vegetation on Fernandina. 1 p. abstract distributed at workshop on vegetation research and management, Charles Darwin Research Station, 12 April, Santa Cruz Island, Galapagos.

*D76 (645). ——. 1987. Revegetation of Bikini Atoll, 1987. 1 p. abstract distributed at workshop on vegetation research and management, Charles Darwin Research Station, 12 April, Santa Cruz Island, Galapagos.

D77 (653). ——. 1987. Workshop on botanical research and management in Galápagos, held at the Charles Darwin Research Station, Santa Cruz Island, Galápagos, Ecuador, during 13-19 April 1987. Environm. Conservation 14: 277-278.

1988

566 (654). Fosberg, F.R. 1988. New and noteworthy plants from Great Barrier Reef Sand Cays, Australia. Brittonia 40: 52-65. [*Lepturus*, *Boerhavia*, *Euphorbia*, *Spermacoce*, *Diospyros*, *Abutilon*.]

567 (649, 655). ——. 1988. Native Hawaiian flora surveyed. *Naturalist Review*, Winter,. p. 3.

568 (656). ——. 1988. *Fimbristylis juncea* (Forst. f.) R. and S. and its relatives. J. Jap. Bot. 63: 78-85.

569 (656a). ——. 1988. The vegetation of Bikini Atoll, 1985. Atoll Res. Bull. 315: 1-28+ 5 figs.

570 (657). Fosberg, F.R. and M.-H. Sachet. 1988 [1987.] A geographic checklist of the Micronesian Monocotyledonae. Micronesica 20: 19-129.

571 (658). —— and ——. 1988 [1987.] Noteworthy Micronesian plants 5. Micronesica 20: 131-156. [*Crinum*, *Dianella*, *Dioscorea*, *Curcuma*, *Didymoplexis*, *Liparis*, *Habenaria*, *Peristylus*, *Microstylis*, *Malaxis*, *Nervilia*, *Spathoglottis*, *Rhynchophreatia*, *Taeniophyllum*, *Trachoma*.]

572 (659). —— and ——. 1988 [1987.] The genus *Timonius* (Rubiaceae) in the Palau Islands. Micronesica 20: 157-164.

573 (660). —— and ——. 1988 [1987.] Notes on Micronesian Cyperaceae. Micronesica 20: 165-170. [*Cyperus*, *Fimbristylis*, *Machaerina*.]

574 (656b). [Fosberg, F.R., I.G. MacIntyre, K. Rützler, and L.L. Cole, eds.] 1988. Island news and comments. Atoll Res. Bull. 320: 1-12.

*L20 (656c). Fosberg, F.R. 1988. Priorities in Science, [letter to the editor.] The Washington Post, 14 May.

*D78 (656d). ——. 1988. A review of the natural history of the Marshall Islands. Prepared for East-West Center, MacArthur Foundation Project.

1989

575 (662). Fosberg, F.R. 1989. Interest and beauty in the world. Environm. Conservation 16: 4.

576 (663). ——. 1989. Society Island plants 1. *Typha* L. (Typhaceae). Bot. Bull. Acad. Sin. 30: 219-221.

577 (666). ——. 1989. Garbage dump in the Marshall Islands? Environm. Conservation 16: 78-79.

578 (668). ——. 1989. Nuclear garbage proposal for the Marshall Islands. Environm. Conservation 16: 273.

579 (669a). ——. 1989. A skeptic sees a miracle. Environm. Conservation 16: 353-354.

580 (669b). ——. 1989. Success against shifting sands in Uzbekistan. Environm. Conservation 16: 371.

*581 (697). ——. 1989. Foreword, pp. IX-X, *in* Campbell, D.G. and H.D. Hammond, eds., Floristic Inventory of Tropical Countries, New York Botanical Garden.

582 (669c). ——. 1989. Henderson Island: dedicated to S. Dillon Ripley [dedication of issue.] Atoll Res. Bull. 321: 3 unnumbered pages.

583 (669e). ——. 1989. [Tribute to] Truman G. Yuncker. Brittonia 41: 248-249.

584 (661). [Fosberg, F.R.] 1989. In the beginning .... Univ. S. Pacific Bull. 22(15): 1-3. [Condensation of a lecture.]

585 (664). Fosberg, F.R. and M.-H. Sachet. 1989. Three cultivated *Ixora*s (Rubiaceae). Baileya 23: 74-85.

586 (665). —— and ——. 1989. Lectotypification of *Ixora coccinea* L. (Rubiaceae). Taxon 38: 486-489.

587 (669d). Fosberg, F.R., G. Paulay, T. Spencer, and R. Oliver. 1989. New collections and notes on the plants of Henderson, Pitcairn, Oeno, and Ducie Islands. Atoll Res. Bull. 329: 1-18.

1990

588 (669). Fosberg, F.R. 1990. Endangered species? Why worry? Environm. Aware. 13: 69-71.

589 (671). ——. 1990. New and noteworthy Cook Island plants. Micronesica 23: 1-4. [*Polypodium, Terminalia, Nesogenes, Psychotria, Scaevola.*]

590 (676). ——. 1990. Nyctaginaceae, pp. 976-988, *in* Wagner, W.L. et al. Manual of the Flowering Plants of Hawaii. [*Boerhavia, Mirabilis, Pisonia.*]

591 (690). ——. 1990. Undisturbed vegetation on Fernandina, 1964, *in* Lawesson, J.E., O. Hamann, G. Rogers, G. Reck, and H. Ochoa, eds., Botanical Research and Management in Galapagos, Mongr. Syst. Bot. Missouri Bot. Gard. 32: 59-65.

592 (691). ——. 1990. Revegetation on Bikini Atoll, 1985, *in* Lawesson, J.E., O. Hamann, G. Rogers, G. Reck, and H. Ochoa, eds., Botanical Research and Management in Galapagos, Mongr. Syst. Bot. Missouri Bot. Gard. 32: 265-269.

*593 (691a). ——. 1990. Do we want a monotonous world? Environm. Aware. 13: 55-57.

594 (698a). ——. 1990. A review of the natural history of the Marshall Islands. Atoll Res. Bull. 330: 1-100.

595 (677). Fosberg, F.R. and L. Raulerson. 1990. Noteworthy Micronesian plants. 6. Micronesica 23: 139-152. [*Eragrostis, Cyperus, Alpinia, Hernandia, Oxalis, Bombax, Melochia, Coccinia, Melodinus, Cerbera, Paederia, Psychotria.*]

*R84 (668a). Fosberg, F.R. 1990. Review of Wallace, A.R. The Malay Archipelago: the land of the orang-utan, and the bird of paradise, new edition, 1990. Science Books and Films 26: 118-119.

D79 (667). ——. 1990. The vegetation of the Society Islands, [abstract.] Fifth International Congress of Ecology, Yokohama, Japan, Aug. 27-30, 1990, p. 141.

*D80 (673). ——. 1990. Commentary on Westing's keynote address. Duplicated (and corrected) handout distributed at 4th International Conference on Environmental Future, Budapest, April 26.

1991

596 (683). Fosberg, F.R. 1991. *Casuarina* in *Miscanthus* savanna on Guam. Micronesica 24: 163.

597 (685). ——. 1991. After zero-growth? Environm. Conservation 18: 3-4.

598 (689). ——. 1991. A Code or a bureaucracy? pp. 145-149, *in* Hawkesworth, D.L., ed., Improving the Stability of Names: Needs and Options. Regnum Veg. 123.

599 (694). ——. 1991. Hawaii conservation biology initiative. Environm. Conservation 18: 263-264.

*600 (696). ——. 1991. Pacific oceanic island biodiversity in a geohistoric perspective [Appendix D, Plenary address.] Proc. XVII Pacific Sci. Congress 71-73. [(715.) republished 1992. Atoll Res. Bull. 355: 13-17.]

601 (702). ——. 1991. Opening address, p. 1, *in* Chase, R. and R.R. Thaman, eds., Proceedings of the International Conference on Developing Agricultural Research Programs for Atolls.

602 (705). ——. 1991. The atoll environment [condensation of a lecture,] p. 16, *in* Chase, R. and R.R. Thaman, eds., Proceedings of the International Conference on Developing Agricultural Research Programs for Atolls.

603 (681). Fosberg, F.R. and R.L. Oliver. 1991. C.L. Ledermann's collection of flowering plants from the Caroline Islands. Willdenowia 20: 257-314.

1. Fosberg, F.R. Introduction, pp. 257-259.
2. ——. Miscellaneous notes, pp. 259-267. [*Alternanthera, Bridelia, Celtis, Cerbera, Clitandropsis, Glochidion, Gmelina, Homalanthus, Sterculia.*]
3. Fosberg, F.R. and R.L. Oliver. Numerical list of Ledermann Micronesian collections, pp. 267-299. [lectotypes designated in taxa of: *Amaracarpus, Andruris, Badusa, Bikkia, Borreria, Buchanania, Bulbophyllum, Canthium, Cerbera, Clitandropsis, Coffea, Decaspermum, Dendrobium, Diplocaulobium, Discocalyx, Elaeocarpus, Euodia, Fagraea, Fimbristylis, Garcinia, Geniostoma, Gmelina, Habenaria, Hedyotis, Hetaeria, Hippocratea, Ilex, Loeseneriella, Maesa, Malaxis, Melicope, Microstylis, Moerenhoutia, Morinda, Myrsine, Oldenlandia, Phreatia, Plectronia, Premna, Pseuderia, Psychotria, Rapanea, Rhynchophreatia, Salacia, Salacicrates, Spermacoce, Stemonurus, Symplocos, Syzygium, Taeniophyllum, Timonius, Trichoglottis, Urandra, Vandopsis.*]
4. Fosberg, F.R. and R.L. Oliver. Missing Ledermann types, pp. 299-301.
5. Ledermann species listed by family, pp. 301-314.

604 (698). Fosberg, F.R. and M.-H. Sachet. 1991. Studies in Indo-Pacific Rubiaceae. Allertonia 6: 191-278.

1. Fosberg, F. R. Introduction. 191-193.
2. ——. Introductory remarks on *Hedyotis* L. sensu lato. 193-195.
3. Fosberg, F. R. and M.-H. Sachet. Disposition of *Leptopetalum* Hook. & Arnott in *Hedyotis* L. 195-205.
4. Fosberg, F. R. and M.-H. Sachet. Variation in *Hedyotis auriculata* L. and *H. verticillata* Lam. 205-212.
5. Fosberg, F. R. *Hedyotis* L. in Micronesia. 212-244.
6. ——. The Micronesian species of *Psychotria* L. 244-268.
7. Fosberg, F. R. and M.-H. Sachet. Variations in *Tarenna sambucina*. 268-274.

605 (686). Fosberg, F.R. and D.R. Stoddart. 1991. Plants of the reef islands of the northern Great Barrier Reef. Atoll Res. Bull. 348: 1-82.

606 (700a). Dassanayake, M.D. and F.R. Fosberg, eds. 1991. A Revised Handbook to the Flora of Ceylon. Vol. VII. Amerind Publishing Co. Pvt. Ltd., New Delhi, 439 pp.

607 (682). Rinehart, A.F. and F.R. Fosberg. 1991. *Nervilia jacksoniae* nov. sp., a new species of Orchidaceae from Guam and Rota. Micronesica 24: 81-85.

608 (687). Stoddart, D.R. and F.R. Fosberg. 1991. Phytogeography and vegetation of the reef islands of the northern Great Barrier Reef. Atoll Res. Bull. 349: 1-19.

609 (688). —— and ——. 1991. Plants of the Jamaican Cays. Atoll Res. Bull. 352: 1-24.

R85 (684). Fosberg, F.R. 1991. Ravages of Man, review of Cuddihy, L.W. and C.P. Stone, Alteration of Native Hawaiian Vegetation. Effects of Humans, Their Activities and Introductions, 1990. Micronesica 24: 167-168.

R86 (692). ——. 1991. Review of Wagner, D.R. Herbst. and S.H. Sohmer, Manual of the Flowering Plants of Hawaii, 1990. Environm. Conservation 18: 191.

R87 (695). ——. 1991. Review of Mitchell, A., The Fragile South Pacific, an Ecological Odessey, 1991. Environm. Conservation 18: 285.

R88 (708). ——. 1991. Review of Schultes, R.E. and R.F. Raffauf, The healing forest: Medicinal and toxic plants of the northwest Amazonia, 1990. Taxon 40: 157-158.

*D81 (674). ——. 1991. A Code or a bureaucracy? Duplicated and distributed at Kew meeting on Improving the Stability of Names, Needs, and Options, February 20.

*D82 (680). ——. 1991. Captain Cook's Voyages and Pacific Science, [abstract.] Toward the Pacific Century Symposium, Abstracts, p. 39.

D83 (675). Fosberg, F.R. and S. Pearsall. 1991. Classification of ecosystems. Background paper duplicated and distributed by Nature Conservancy and SPRED at Ecosystem Classification Workshop, East-West Center, Honolulu, March 11-15, 1991, 41 pp.

*D84 (700). [Fosberg, F.R. with thirty other workshop members.] 1991. An ecosystem classification and criterion for conservation in the tropical insular Pacific. Honolulu, duplicated [by the Nature Conservancy?], 81 pp.

1992

610 (699). Fosberg, F.R. 1992. Vegetation of the Society Islands. Pacific Science 46: 232-250.

*611 (701). ——. 1992. Sustainability. Environm. Aware. 15: 15-16.

612 (703). ——. 1992. An essay on lectotypification. Taxon 41: 321-323.

613. ——. 1992. (82-87) Six proposals to amend the Code. Taxon 41: 354-355.

614 (706). ——. 1992. The Coral island environment and its relevance to Atoll agriculture, pp. 45-54, *in* Chase, R.G., Review of Agricultural Development in the Atolls. University of the South Pacific, Apia, Western Samoa, 1992.

615 (713). ——. 1992. Pacific Island plants–taxonomic and distributional notes. Micronesica 25: 175-199. [*Polypodium, Lemaphyllum, Nephrolepis, Spathoglottis, Vanilla, Peperomia, Lepidium, Erythrina, Tephrosia, Euphorbia, Phyllanthus, Passiflora, Luffa, Pouteria, Chionanthus, Ochrosia*.]

R89 (670, 709). ——. 1992. Review of Beehler, B., A Naturalist in New Guinea, 1991. Environm. Conservation 19: 190, 1992.

*D85 (704). ——. 1992. Plant evolution in the Pacific region, [abstract.] AIBS meeting, Honolulu, August, 1992.

D86 (710). ——. 1992. Phytogeographic observations in Okinawa and the southern Ryukyu Islands, [abstract.] International symposium on Okinawan Studies Abstract, Natural Science Session, pp. 7-8. [Also published p. 105 of symposium volume.]

1993

616 (716). Fosberg, F.R. 1993. The Forster Pacific Islands collections from Captain Cook's Resolution Voyage. Allertonia 7: 41-86. [precursor account of a project to locate and interpret with examples collections by the Forsters; *Tmesipteris, Lycopodium, Polypodium, Arachniodes, Agrostis, Paspalum, Miscanthus, Dianella, Peperomia, Korthalsella, Balanophora, Ximenia, Acacia, Sesbania, Euphorbia, Allophylus, Grewia, Waltheria, Xylosma, Wikstroemia, Rhizophora, Terminalia, Alyxia, Melodinus, Cyrtandra, Dicliptera, Guettarda, Ixora, Wollastonia*.]

617 (711). Fosberg, F.R. and S.H. Pearsall III. 1993. Classification of non-marine ecosystems. Atoll Res. Bull. 389: 1-38.

618 (712). Fosberg, F.R., M.-H. Sachet and R.L. Oliver. 1993. Flora of Micronesia, 5: Bignoniaceae-Rubiaceae. Smithsonian Contr. Bot. 81: i-iv, 1-135. [*Catalpa, Clytostoma, Crescentia, Cydista, Dolichandrone, Jacaranda, Kigelia, Macfadyena, Mansoa, Parmentiera, Pyrostegia, Saritaea, Spathodea, Tabebuia, Tecoma, Tecomaria, Sesamum, Aeschynanthus, Cyrtandra, Episcia, Saintpaulia, Utricularia, Acanthus, Andrographis, Aphelandra, Asystasia, Barleria, Blechum, Crossandra, Eranthemum, Fittonia, Graptophyllum, Hemigraphis, Hygrophila, Justicia, Odontonema, Pseuderanthemum, Ruellia, Thunbergia, Myoporum, Plantago, Aidia, Badusa, Bikkia, Canthium, Cephaelis, Cinchona, Coffea, Dentella, Gardenia, Geophila, Guettarda, Gynochthodes, Hedyotis, Hydnophytum, Ixora, Mitracarpus, Morinda, Mussaenda, Mycetia, Ophiorrhiza, Paederia, Pentas, Psychotria, Scyphiphora, Spermacoce, Tarenna, Timonius, Trukia, Uncaria*.]

Publications in press:

619. Thaman, R.R., F.R. Fosberg, H.I. Manner, and D.C. Hassall. In press. Flora of Nauru. Atoll Res. Bull. 392. [in this issue.]

620. Fosberg, F.R. and D.R. Stoddart. In press. Flora of Phoenix Islands, Central Pacific. Atoll Res. Bull. 393. [in this issue.]

621. Stoddart, D.R. and F.R. Fosberg. In press. The Hoa of Hull Atoll and the problem of Hoa. Atoll Res. Bull. 394. [in this issue.]

622. Fosberg, F.R. In press. Story of an oceanic archipelago. Atoll Res. Bull. 395. [in this issue.]

623. ——. In press. Comments on Atoll Phosphate rock. Atoll Res. Bull. 396. [in this issue.]
624. ——. In press. *Ixora casei* vs. *Ixora longifolia* (Rubiaceae). Baileya 23(4). [expected 1994.]
625. ——. In press. A new species of *Scleria* (Cyperaceae) from New Caledonia. Adansonia. [expected 1994.]

Submitted publication:

Fosberg, F.R. Biodiversity in India, 1993. Herbaria, plant diversity, and conservation–new challenges ahead. Botanical Survey of India.

SOME PUBLISHED PHOTOGRAPHS, DEDICATIONS, AND BIOGRAPHICAL INFORMATION

Gregory, H.E. et al. 1935. Mangarevan Expedition. Bernice P. Bishop Mus. Bull. 133: 33-71. [Photograph and information about F.R. Fosberg.]

Fosberg, F.R. 1961. Pacific vegetation progress report (1956-1958). Proc. Symposium on Humid Tropics Vegetation, UNESCO, Tjiawe, Indonesia, 1958, 32-33. [Includes biographical sketch of F.R. Fosberg.]

1971. Bull. Pacific Tropical Bot. Gard. 1(3): 8. [Photograph of F.R. Fosberg with other famous tropical botanists.]

Harney, T. 1978. Spreading the News on Atolls. The Smithsonian Torch 78-10: 6. [Description of Atoll Research Bulletin, comments about and photograph of F.R. Fosberg.]

Mason, C.N. 1980. Browning Award to Dr. Fosberg. Environm. Conservation 7: 124. [Appreciation of F.R. Fosberg's work and as recipient of 1979 Edward W. Browning medal for distinguished international services in the cause of environmental conservation.]

[Fosberg, F.R.] 1989. In the beginning .... Univ. S. Pacific Bull. 22(15): 1-3. [condensation of a lecture, accompanied by a photograph of Dr. Fosberg receiving an Honorary degree from the Vice-Chancellor.]

Meurer-Grimes, B. 1989. Itinerary of Truman G. Yuncker's expeditions. Fig. 1, Brittonia 41: 226. [Photograph of Erling Christopersen, E. Y. Hosaka, F. Raymond Fosberg, Harold St. John, and Truman G. Yuncker in Oahu, 1932.]

Stoddart, D.R. 1992. F. Raymond Fosberg and the Atoll Research Bulletin 1951-1991. Atoll Res. Bull. 355: 1-6. [Photographs of F.R. Fosberg and others on pages 8 & 12.]

Anonymous. 1993. News and Comments, 40th Anniversary Reception. Atoll Res. Bull. following 389, 2 unnumbered pages (30-40). [Photographs with F.R. Fosberg and appreciation of his work.]

Mueller-Dombois, D. 1992. F. Raymond Fosberg: An Appreciation. Pacific Science 46: 107-110.

van Balgooy, M.M.J., ed. 1993. Pacific plant areas, volume 5. Rijksherbarium/Hortus Botanicus, Leiden. [Final volume dedicated to F.R. Fosberg.]

Nicolson, D.H. In press. Lists of taxa named for F. Raymond Fosberg and by him. Atoll Res. Bull. 390. [in this issue.]

In addition, several newspapers carried obituaries of F. Raymond Fosberg, including the *Washington Post* and *London Independent*. Obituaries will also appear in scientific journals including *Taxon*. The National Tropical Botanical Garden intends to dedicate an upcoming issue of its Bulletin to F.R. Fosberg. Undoubtedly other scientific journals will include obituaries and other dedications will appear in the coming months.

INDEX TO GENERIC NAMES

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

R

S

T

U

V

W

X

Y

Z

ATOLL RESEARCH BULLETIN

NO. 392

THE FLORA OF NAURU

BY

R.R. THAMAN, F.R. FOSBERG, H.I. MANNER
AND D.C. HASSALL

ISSUED BY
NATIONAL MUSEUM OF NATURAL HISTORY
SMITHSONIAN INSTITUTION
WASHINGTON, D.C., U.S.A.
FEBRUARY 1994

DEDICATION

We dedicate this Flora of Nauru to Joseph Detsimea Audoa, his family and the people of the Republic of Nauru who have had their precious island and its flora destroyed and degraded as a result of wars and exploitation beyond their control.

ACKNOWLEDGEMENTS

The authors would like to acknowledge, in particular, the late Honorable Joseph Detsimea Audoa, the Minister of Health and Education at the time of the commencement of the study and later Minister of Justice in the Government of Nauru, who, because of his vision and commitment to the culture and environment of Nauru, initiated and provided the financial support for the study of the flora of Nauru. He was particularly concerned that the plants of Nauru and their cultural uses be recorded before such knowledge was lost.

We also acknowledge Mr. Lisle Newby, the then Director of Education, who, along with Joe Audoa, were the main supporters of the project, and who provided valuable logistical support throughout. Special thanks are also given to our main local informants and assistants, the Reverend James Aingimea and the late Henry Michael Heine; and to Daphne Fotu, Jacob Gabwinare, Katarina Satto, Kenia Raidinen, Reynold Capelle, Eda Adam and Montiba Star, our main informants in relation to the cultural uses and Nauruan names of plants.

Our thanks also go to the Honorable Lawrence Stephen, Minister of Education during part of the project; Obera Menke, Robert Kaierua, Leo Keke, Delilah Capelle, Eddie Borak, John Healy, Gary Bailey, Dennis and Ria Berdinner, Julie Olsson, Dennis Ketner, Sio Fotu, Pine Harrison, John Brechtefeld, Rene Harris, Porthos Bop, Jacob Aroi, Leon Thompson, Benjamin Morgan, Iosefa Elisala and Teaora Tabanou, all of whom contributed in some way to the success of the study. To others who helped in any way during our study, we also give thanks.

Thanks are also due to those people, who over the past 100 years, have collected and identified plants on Nauru; and to Saula Vodonaivalu of the South Pacific Regional Herbarium of The University of the South Pacific, Suva, Fiji who identified, preserved and is the curator of the herbarium specimens collected by Thaman, Manner and Hassall. Without their efforts, this flora, would have been impossible. Similarly, we would like to thank The University of the South Pacific for the support it has provided throughout the duration of the study, both as the institution where the study was initiated and completed and as Nauru's own university of which it is one of twelve regional member countries.

In addition to the above acknowledgements, Fosberg wants to mention the substantial assistance given him during his week-long visit to Nauru in 1983 This visit was at the invitation of Mr. Richard Wood, accountant for the Nauru government, who made the arrangements for the visit and who served as guide during the first day, reaching areas not otherwise accessible. The success of this visit was also made possible by transport and guidance by Mrs. Joan Nichols of the Australian High Commission's office. In her company much of the interior of the island and some of the local gardens were visited and many plant specimens were gathered. The success of this visit

was largely due to the two people mentioned above, and their company in the field was much enjoyed and appreciated. Many thanks!

Finally, we wish to express our heartfelt thanks to the people of Nauru whose warmth and hospitality made our work on their beautiful but damaged island so enjoyable and worthwhile.

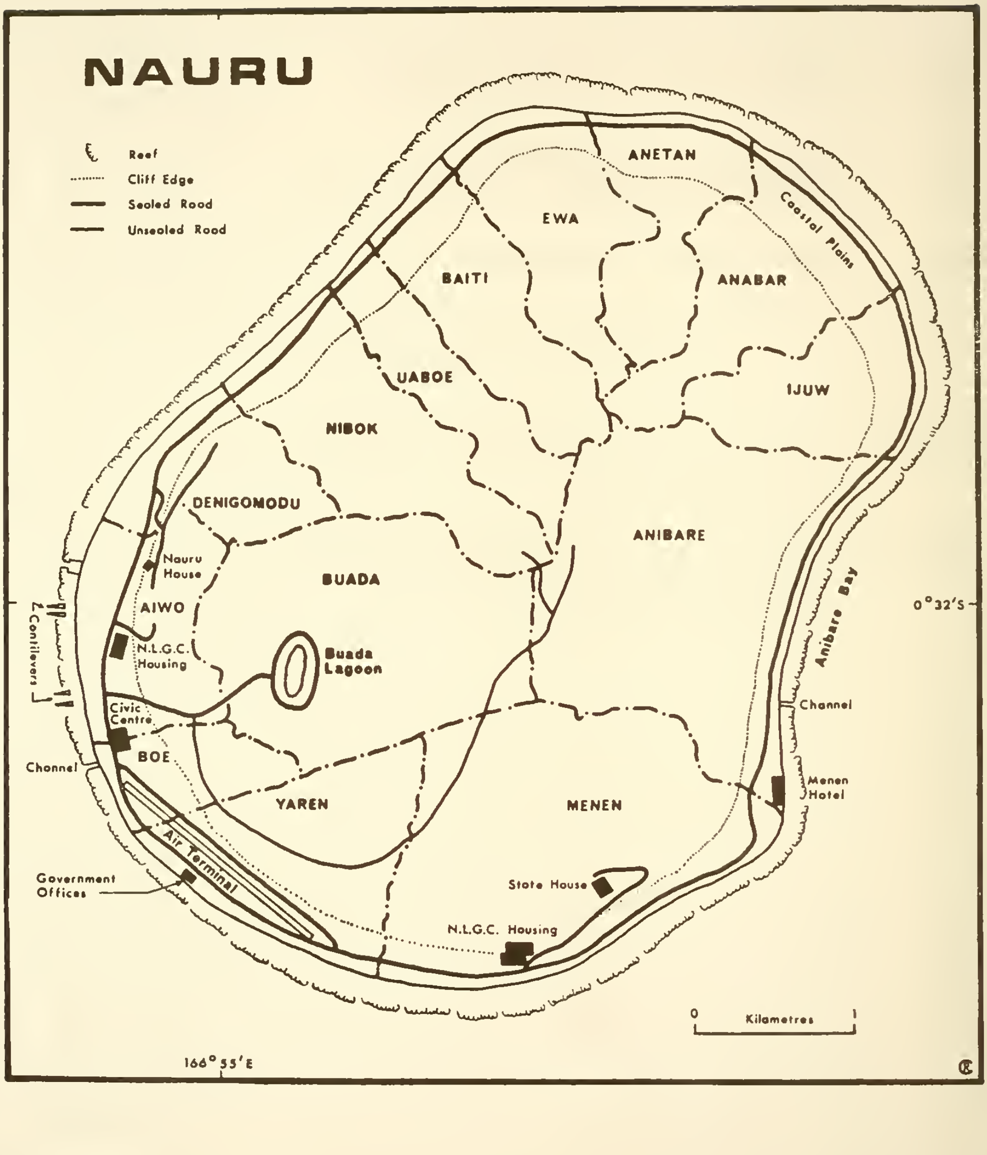
To all of you, ***TUBWA KOR***,

R.R Thaman, F.R. Fosberg, H.I. Manner and D.C. Hassall
Suva, Fiji
June 1993

CONTENTS

LIST OF TABLES

LIST OF APPENDICES



NAURU
Reef
Cliff Edge
Sealed Road
Unsealed Road
ANETAN
EWA
BAITI
ANABAR
Coastal Plains
UABOE
IJUW
NIBOK
DENIGOMODU
ANIBARE
Nauru House
BUADA
AIWO
Cantilevers
N.L.G.C. Housing
Buada Lagoon
Anibare Bay
0°32'S
Channel
Civic Centre
BOE
Channel
Menen Hotel
YAREN
MENEN
Air Terminal
Government Offices
State House
N.L.G.C. Housing
0 Kilometres 1
166°55'E

THE FLORA OF NAURU

A COMPILATION AND ANALYSIS OF THE VEGETATION AND FLORA OF THE EQUATORIAL PACIFIC OCEAN ISLAND OF NAURU

BY

R.R. THAMAN[1], F.R. FOSBERG[2], H.I. MANNER[3] AND D.C. HASSALL[4]

PART I.

INTRODUCTION AND ANALYSIS OF THE VEGETATION AND FLORA

INTRODUCTION

The recorded flora of the raised phosphatic limestone island of Nauru in the equatorial Pacific Ocean consists of approximately 493 species. Only 59 are possibly indigenous, none of which are endemic. The balance is composed of ornamentals, weedy exotics, food plants, and a limited number of other useful cultigens. Twelve of the recorded species are either extinct or were never successfully established on Nauru. Long human settlement, expansion of coconut monoculture during the colonial period, widespread destruction during World War II, and almost a century of open-cast phosphate mining, have led to serious vegetation degradation, disturbance, and displacement

---

[1]. Professor of Pacific Islands Biogeography, Department of Geography, School of Social and Economic Development, The University of the South Pacific, Suva, Fiji.

[2]. Emeritus Professor of Botany, Botany Department, National Museum of Natural History, Smithsonian Institution, Washington D.C.

[3]. Professor of Geography, College of Arts and Sciences, Department of Social Science and Anthropology, University of Guam, Mangilao, Guam.

[4]. Former Senior Lecturer in Biology, University of the South Pacific, Suva, Fiji.

Manuscript received 12 July 1993; revised 6 August 1993.

of the indigenous flora. Although greatly outnumbered by exotics, indigenous species still dominate some of the most disturbed habitats, as well as constituting the most culturally-utilitarian and ecologically-important species.

The flora is in two parts. PART I: INTRODUCTION AND ANALYSIS OF THE VEGETATION AND FLORA, includes a brief discussion of: 1) previous studies and the current study; 2) the physical environment, people, development history and contemporary economy of Nauru; 3) the nature of the existing flora and vegetation associations of Nauru; and, 4) an analysis of the ecological and cultural importance of the flora in the context of modern small-island development.

PART II: A COMPILATION OF THE VASCULAR FLORA OF NAURU, consists of a listing of all vascular plants reported to have been present on Nauru, along with relevant information on each species. Although a number of persons have collected plants on Nauru over the past century, this constitutes the first extensive flora the of vascular plants of the island. The plants are listed in alphabetical order by family and species within families, starting with the ferns and gymnosperms and then angiosperms, with monocotyledons listed first. Information on each species, variety or subspecies includes: 1) scientific (Latin) name and synonyms; 2) common (mainly English) name (s); 3) Nauruan, Kiribati, Tuvaluan, Chinese (Cantonese), Filipino and Solomon Island names, when available; 4) origin; 5) antiquity status (i.e., whether a species is indigenous to Nauru, an aboriginal introduction, an early post-European-contact introduction or a recent post-World War II introduction; 6) its status in terms of abundance (i.e., whether it is abundant, common, rare, extinct, etc); 7) a detailed botanical description; 8) its habitat or distribution on Nauru; and 9) its cultural or ethnobotanical importance.

PREVIOUS STUDIES

Although collections and observations of the flora have been made on Nauru by Finch prior to 1900; Burges in 1933; Fosberg in 1980; Scully in 1980; Thaman, Hassall and Manner in 1980 and 1981; Thaman and Manner in 1987; Swarbrick in 1988; and Raulerson in the early 1980s, little has been published. The only substantial publications on Nauru's vegetation include studies by Manner, Thaman and Hassall (1984 and 1985) on vegetation changes induced by phosphate mining; a list of Nauruan plant names by Thaman, Manner and Hassall (1985); and the "Vegetation of Nauru and the Gilbert Islands" by Thaman (1992). Fosberg, Sachet and Oliver's "A geographical checklist of Micronesian Dicotyledonae" (1979); "Geographical checklist of Micronesian Pteridophyta and gymnosperms" (1982); and "A geographical checklist of the Micronesian Monocotyledonae" (1987), are also important and list most of the species cited and specimens examined prior to 1980.

CURRENT STUDY

The current study is based on an in-depth analysis of the above sources; five-weeks fieldwork, including two visits by R.R. Thaman, H.I. Manner and D.C Hassall of The University of the South Pacific, Suva, Fiji in Nauru in 1980, 1981; one week each by Thaman and Hassall in 1987; and a three-day visit by F.R. Fosberg of the Botany Department of the Smithsonian Institution, Washington, D.C. in 1987. During these visits herbarium specimens were collected and identified and the Latin and vernacular names of all plant species recorded and listed alphabetically. These lists were then cross-checked, consolidated, amended and augmented, both during and after the field studies, using lists and names from previous studies. Information was also collected on the cultural uses (ethnobotany) of the flora.

BACKGROUND ON NAURU

Physical Environment

The Republic of Nauru is an isolated, uplifted limestone island located 41 km south of the equator at 166 deg 56 min E longitude, some 2000 km east-northeast of Papua New Guinea, 4450 km south-southeast of the Philippines and an equal distance to the southwest of Hawaii. The nearest island is Banaba (Ocean Island), 300 km due east, which is part of the Republic of Kiribati. The Gilbert Islands, the main islands of Kiribati, lie a further 400 km to the east.

The island, with an area of only 22 km^2, consists of a narrow coastal plain, ranging from 50 to 300 m wide, encircling a limestone escarpment rising some 30 m to the central plateau (See map of Nauru). The escarpment ranges in gradient from vertical cliffs to gradually-sloping areas of colluvial soil interspersed with limestone outcrops and pinnacles. The plateau, with a maximum elevation of 70 m, consists of a matrix of coral-limestone pinnacles and limestone outcrops, between which lie extensive deposits of soil and high-grade tricalcic phosphate rock (Viviani 1970, Tyrer 1963). Buada Lagoon, a landlocked brackish lake, and its associated fertile depression (about 12 ha in size), is located in the low-lying southwest-central portion of the island.

Apart from Buada Lagoon, there are no surface freshwater resources on Nauru, although there are a few brackish ponds on the northeast of the island and an underground lake in Moqua Cave in the southeast (Viviani 1970:4). The only significant permanent freshwater resource is groundwater in the form of a "lens" of often slightly brackish freshwater, hydrostatically "floating" on higher density saltwater beneath it. The height of the freshwater lens above sea level and the level of salinity vary in relation to the elevation, geology, texture and shape of the island, and with the amount of water use and rainfall. Replenishment or recharge of the lens is dependent on rainfall.

Climatically, Nauru is located in the dry belt of the equatorial oceanic zone, with mean daily temperatures ranging from 26 to 32°C. Annual rainfall is extremely variable, averaging 1500 mm per year with a range of 300 to 4572 mm. Severe prolonged droughts are common and place severe stress on even the most hardy coastal strand species, lead to the death of non-coastal exotics (such as breadfruit), and severely restrict the production of even coconut palms (Catala 1957). For example, in 1917 and 1918, during an unprecedented drought, when only 465 and 483 mm of rain fell, "thousands of coconuts and other fruit trees died" (Griffiths 1923).

The coastal soils of Nauru are among the poorest in the world. They are shallow, alkaline, coarse-textured and have carbonatic mineralogy. They are composed of a variable layer of organic matter and coral sand and fragments, which overlay a limestone platform. The coastal soils are only about 25 cm deep, and contain more coral gravel than sand in the lower horizons. Potassium levels are often extremely low, and pH values of up to 8.2 to 8.9 and high $CaCO_3$ levels make scarce trace elements, particularly iron (Fe), manganese (Mn), copper (Cu) and zinc (Zn), unavailable to plants. Fertility is, therefore, highly dependent on organic matter for the concentration and recycling of plant nutrients, lowering soil pH, and for soil water retention in the excessively well-drained soils. Although levels of organic matter can be relatively high in undisturbed soils under natural vegetation, it can decrease dramatically as a result of clearance by fire or replacement by coconuts and other introduced plants (Morrison 1987ab).

The plateau soils of Nauru vary from shallow soils, on the tops of limestone pinnacles, composed primarily of organic material and sand or dolomite, with very little phosphate, to deep phosphatic soils and sandy phosphatic rock, up to over 2 m deep between the pinnacles. Topsoils range from 10 to 25 or 30 cm in depth, overlaying a deeper material which is frequently reddish yellow and between 25 and 75 cm deep, changing to pinkish grey at greater depth. Undisturbed plateau soils have a high level of organic material and are generally fertile. Calcium dominates the exchange complex and exchangeable magnesium is also high. Exchangeable potassium is low, while extractable phosphate values are generally high and sulphate moderate. The trace elements manganese, copper, cobalt and molybdenum levels are very low, and these, plus iron and zinc, are rendered unavailable to plants under pH values >6.5 (Morrison 1987b).

Around Buada Lagoon and in some poorly drained swampy areas near the base of the escarpment on Nauru, there are poorly developed, but relatively fertile, wet soils.

The People

The indigenous people of Nauru are Micronesians, who have probably inhabited the island for up to 3000 years or more. There is some evidence of Melanesian, and possibly Polynesian, influence. The Nauruan language is quite distinct from all other Pacific languages, reportedly a fusion of elements from the Gilbert, Caroline, Marshall and Solomon Islands. Early this century there was evidence of distinct racial types or groups of mixed origin. The people were divided into twelve distinct, originally totemic, matrilineal clans, most of which spoke different dialects, some of which were still in evidence when trying to obtain vernacular plant names in the early 1980s. However, most dialects have become obsolete, having been replaced by the principle dialect, which was used for Bible translation by European missionaries early this century (Viviani 1970:4-7).

The traditional subsistence economy of Nauru was based on coconut and pandanus as the main staples, a limited range of wild terrestrial food products, sea birds, such as the black noddy tern (*Anous tenuirostris*) and a very wide range of fish and other marine foods. Milkfish or *ibija* (*Chanos chanos*) fry, collected from the reef at low tide, were farmed in family-owned divisions of Buada Lagoon to provide fish for special occasions and when other supplies failed. Their housing, tools, clothing, medicines, fuel, fishing equipment, canoes, dyes, ornamentation, perfumes, toys and other material and many of their non-material needs were satisfied from their environment, especially from plants.

The Nauruan population suffered from introduced diseases against which they had no natural resistance, and from incessant tribal warfare, with Nauruans numbering only 1250 in 1910, a decline of 150 from the total of 1400 in 1840 and 300 less than recorded in the German census in 1905 (Viviani 1970:37).

The estimated population of Nauru in the most recent census in 1983 was 8042, of whom 4964 were Nauruan, with the balance comprised mainly of I-Kiribati (people of Kiribati, formerly the Gilbert Islands of the British Gilbert and Ellice Islands Colony), Tuvaluan, Chinese, Filipino or Solomon Island contract workers in the phosphate industry. There are also European, Indian and Pacific island expatriates working mainly for the Nauruan Government. The Nauruans live on the coastal strip and around Buada Lagoon, the phosphate workers in the Nauru Phosphate Company dormitory accommodation at Location near the phosphate loading cantilevers, and the expatriate civil servants in residential areas on the escarpment. The town center is located between the airport and Location near the cantilevers (Figure 1), with most government offices near the airport.

Development History

After the first recorded European sightings of Nauru by John Fearn of the British Ship *Hunter* in 1798 who named it "Pleasant Island", there was little regular contact with the island until the 1830s when British and American whalers made regular stops for water and food, and beachcombers arrived. The beachcombers, with the introduction of new weaponry, intensified a period of almost incessant clan warfare. At the time of the beginning of formal colonial influence when Nauru was incorporated into Germany's Marshall Islands Protectorate in 1888, the island "had the appearance of a battlefield" (Viviani 1970:22). In 1919, after World War I, Nauru became a League of Nations mandate of Great Britain, Australia and New Zealand, administered by Australia. Nauru became independent in 1968.

Apart from the provisioning of whaling vessels, mainly with fish, pigs and coconuts, the first regular non-traditional economic activity was a sporadic copra trade established in the 1880s. By the late 1880s Nauru produced about one million pounds of copra annually, one of the main reasons that Germany, on the recommendation of resident German traders, annexed the island in 1888. In the 1890s, due to drought and infrequency of ships, the copra trade failed to reach its potential with Nauruans refusing to make more copra than needed to pay their taxes (Viviani 1970; Carter 1984).

The strategic and economic importance of Nauru increased dramatically with the discovery, in 1900, of high grade phosphate rock, containing up to 78 per cent tricalcic phosphate. The mining of phosphate, without approval of the indigenous inhabitants, began in 1907. Caroline Islanders and Chinese contract-laborers were recruited to mine the deposits. Since then, I-Kiribati, Tuvaluan, Filipino and Solomon Islands contract workers have been recruited to work in the phosphate industry. The deposits have been mined continuously since 1907, except for disruptions during World War I and again during World War II. Copra production continued to fluctuate, with over 300 tons having been exported the year before the phosphate trade began in 1906, 277 tons in 1916, and falling to only 10 tons in 1918 due to a prolonged drought (Viviani, 1970: 22-38).

With the beginning of the phosphate trade, the whole pattern of Nauruan life began to change. Although barter continued, money became the medium of exchange, and trade stores with their array of goods, further encouraged the trend. As Viviani (1970:38) argues:

> Old crafts such as mat making began to be forgotten as woven materials become available. Rites and customs were debased. Faced on all sides by the white man's attempt to dominate their environment and the disintegration of their culture, the Nauruans sought a new orientation for their lives. They could no longer follow the old ways completely and so settled for a combination of the basic elements of the old culture, clinging strongly to their family life, and some of the advantages of Western civilisation. They were able to achieve this because, although royalties were low - only about 230 Pounds Sterling per annum at this time for the whole population - this money, together with land rents and some return from copra, freed them from the necessity of working on the phosphate fields to pay their taxes.

The most disruptive period for Nauru was World War II, during which the island was continuously bombed by Japanese and Americans planes. Beginning in 1940, five phosphate vessels were sunk off Nauru and the island shelled by German warships. Nauru was again bombed by Japanese planes in 1941 and 1942 prior to Japanese occupation of the island. After a Japanese military airstrip was completed in 1943, the island was bombed almost continuously by Allied planes. By the end of 1943, due to the importation of at least 3000 Japanese marines, some 1500 Japanese and Korean laborers, and the relocation of 700 Banabans to Nauru, the food situation became so serious that 1201 Nauruans, seven Chinese and two priests were deported to Truk. Malnutrition and dysentery were widespread. Allied bombings increased considerably until the Japanese surrender to an Australian occupation force in 1945. At this time, of nearly 5200 people, only 591 were Nauruan, and the destruction of the phosphate works and buildings on Nauru was almost total. The 737 Nauruans who had not died under the harsh conditions imposed by the Japanese in Truk returned home in 1946 (Viviani 1970; Carter 1984). As argued by Viviani (1970:85):

> The Japanese had destroyed the Nauruan's homes, schools, and churches, placed them on a semi-starvation level and destroyed much of what was left of their old way of life. The deportation of two-thirds of the Nauruans and the death of nearly 500, mostly the old and the young, left the society after the war with a gap in generations and a disruption of family life. Again the Nauruan population had fallen well below the 1,500 level which the Nauruans themselves regarded as a minimum for survival.

Contemporary Economy

Nauru's sole export continues to be phosphate, with the sporadic export of copra having ceased in the 1950s. Phosphate earnings have made Nauru among the wealthiest nations in the world in terms of per capita income, although the distribution of wealth is uneven due to unequal land rights to phosphate deposits. Nauru is considered totally urbanized, with Nauruans having almost completely abandoned subsistence production, except for the harvest of coconuts and pandanus fruit for consumption; pandanus leaves for plaited ware; the acquisition of fish and other seafood; and the hunting of noddy terns, which are considered a delicacy of chiefly status, and the capture and caring for of frigate birds as pets, both traditional pastimes. Most of the limited subsistence agricultural production is in the hands of immigrant communities.

The establishment of its own heavily subsidized international airline, Air Nauru, in 1970, which flies to Asia, Australia, New Zealand and other Pacific islands, and the extension of the runway over the reef have accelerated the processes of urbanization and an increasing dependence on imported products. Of concern is the impact that the destruction of the traditional subsistence food system, rapid urbanisation and the almost total dependence on nutritionally-poor imported food and drink, including extremely high rates of alcohol consumption, have had on the health of Nauruans, which have the among highest or most rapidly increasing rates in the world of obesity, dental disease, alcoholism and nutrition-related non-communicable diseases such as diabetes, cardiovascular disease, gout and hyperuricemia and liver cancer. All are causes of premature mortality (Zimmet *et al.* 1977, 1978; Speake *et al.* 1979; Taylor 1983; Coyne 1984; Thaman 1982, 1983, 1985, 1988a).

In terms of Nauru's economic future, the phosphate deposits on Nauru are projected to be depleted shortly after the turn of the century. Fortunately, a significant proportion of recent phosphate returns have been wisely invested in overseas properties, businesses and investment funds to provide income in post-phosphate-mining Nauru. A further source of income is derived from Nauru's status as a "financial center" or "tax haven" for overseas companies wishing to register there. Finally, negotiations and litigation arising out of a recent Commission of Inquiry into the Rehabilitation of the Worked-out Phosphate Lands in Nauru to determine culpability and the extent of damages to the Nauruan culture and environment are currently in process and could lead to substantial payments to Nauru and the development of plans for the rehabilitation of the island.

Impact on the Flora

Due to environmental factors described above - extreme isolation from major plant source regions, small island size, extremely poor soils, and climatic and physiological drought - the indigenous flora of Nauru is among the poorest and most restricted on earth. Moreover, the long settlement history, widespread destruction during World War II, monocultural expansion of coconut palms as the sole cash crop, increasing urbanization and contact with, and importation of plants from the outside world, and over 75 years of open-cast phosphate mining (in Nauru and Banaba), have all played a role in the serious degradation, disturbance, and displacement of the indigenous flora and vegetation.

VEGETATION TYPES

The terrestrial primary vegetation types of Nauru are limited to:

1. coastal strand vegetation;

2. limited areas of mangroves and coastal marsh vegetation;

3. relict stands of inland forest; and,

4. limestone escarpment or pinnacle vegetation.

Secondary and cultural vegetation types include:

1. coconut-palm-dominated lands under various degrees of maintenance;

2. houseyard gardens and urban vegetation;

3. extensive and variable areas of ruderal vegetation; and,

4. three-quarters of the entire island under severely-modified disclimax vegetation in various stages of succession after some 80 years of open-cast phosphate mining.

These vegetation types will each be described in turn.

Coastal Strand Vegetation

The coastal strand vegetation of Nauru has been severely modified as a result of: 1) thousands of years of human habitation and selective removal of indigenous species for construction, boatbuilding, firewood and other purposes; 2) the expansion of monocultural coconut groves for export production of copra; 3) the expansion of coastal settlements which occupy most of the coastal plain; and, 4) the widespread practice of allowing pigs to forage freely along beach flats (Viviani 1970).

The dominant species in the outer coastal zone in Nauru include the herbaceous species *Lepturus repens*, *Cyperus javanicus*, *Ipomoea pes-caprae* and *Vigna marina*; the woody species, *Scaevola taccada*, *Tournefortia argentea* and *Morinda citrifolia*, plus the aboriginal introduction, *Cocos nucifera*. Species common on rocky limestone outcrops along the coast include the same species plus *Polypodium scolopendria*, *Capparis cordifolia*, *Clerodendrum inerme*, *Terminalia catappa* and *Calophyllum inophyllum*. Species present on non-rocky, somewhat disturbed inland coastal sites between the strand and the base of the escarpment include *Hibiscus tiliaceus*, *Cocos nucifera*, *Premna serratifolia*, *Calophyllum inophyllum*, *Pandanus tectorius*, *Morinda citrifolia*, *Terminalia catappa*, *Ochrosia elliptica*, and isolated specimens of *Barringtonia asiatica*, *Thespesia populnea* and *Hernandia nymphaeifolia*. Shrubby species include *Scaevola taccada*, *Colubrina asiatica*, *Abutilon indicum* and *Phyllanthus societatis*; herbaceous species include *Cyperus javanicus*, *Digitaria setigera*, *Vigna marina*, *Ipomoea macrantha* and the ferns, *Polypodium scolopendria* and *Nephrolepis biserrata*. *Caesalpinia bonduc*, *Euphorbia chamissonis*, *Sida fallax* and *Triumfetta procumbens* are scarce, but were probably more abundant in the past.

Mangroves and Coastal Marsh Vegetation

Shallow-water habitats with muddy bottoms and protected from strong wave action are extremely limited on Nauru. Although reportedly present in the past around Buada Lagoon, Nauru's single mangrove species, *Bruguiera gymnorhiza*, is now restricted to a system of landlocked brackish ponds or small lagoons near the base of the escarpment in Menen, Anabar and Anetan Districts. The largest concentration is found around Araro

Lake in Anetan. Fosberg (c.1972) also reports the occurrence of *B. gymnorhiza* in similar landlocked ponds, sink-holes and small inland swamps in Palau.

Other species commonly associated with mangroves and present in Nauru include *Derris trifolia*, encountered on limestone outcrops, and *Vitex negundo*, which is present in depressions near the base of the escarpment in Menen District.

The swampy areas surrounding Buada lagoon and near the base of the escarpment on Nauru are dominated by *Cyperus javanicus* and *C. compressus*, with one specimen of *Ludwigia octovalvis* collected from a coastal depression.

Relict Stands of Inland Forest

In terms of relict stands of primary inland forest on Nauru, there seem to be two distinct types: 1) plateau forest, which probably covered up to 90 per cent of the island before the onset of phosphate mining, and 2) escarpment forest, including forest on unmined limestone outcrops or pinnacles on the plateau.

The former, four-fifths of which has been removed during phosphate mining, is dominated almost entirely by 16 m-tall *Calophyllum inophyllum*. Infrequent canopy trees include *Guettarda speciosa*, *Premna serratifolia* and *Terminalia catappa*, with the understorey dominated by *Scaevola taccada*, *Morinda citrifolia* and *Dodonea viscosa*, the parasite *Cassytha filiformis*, *Psilotum nudum*, and the ferns, *Polypodium scolopendria* and *Nephrolepis biserrata*. Also occasional in open sites is *Phyllanthus societatis*. Exotic species dominant in disturbed sites include *Psidium guajava*, *Lantana camara* and two herbaceous species, *Euphorbia hirta* and *Desmodium triflorum* (Manner et al. 1984, 1985).

Limestone Escarpment or Pinnacle Vegetation

The dominant species on the limestone cliffs of the escarpment and on emergent pinnacles on Nauru is *Ficus prolixa*, with *Terminalia catappa*, *Ochrosia elliptica* and *Guettarda speciosa* constituting important second stratum species (Manner et al. 1985). Isolated relict stands of *Barringtonia asiatica* and *Pisonia grandis* are also found along the crest of the escarpment above Anibare Bay. The ferns, *Nephrolepis biserrata* and *Polypodium scolopendria*, and the liana, *Ipomoea macrantha*, are locally abundant, and the herb, *Laportea ruderalis*, is found in moist shady habitats at the base of the escarpment. On the more gradually-sloping colluvial portions of the escarpment almost impenetrable thickets of *Hibiscus tiliaceus* are found. Understorey species include *Colubrina asiatica* and *Tacca leontopetaloides*. In Anetan District, in the north (Figure 1), *Clerodendrum inerme* festoons limestone outcrops and cliffs. In some areas the exotic fruit trees, soursop and sweetsop (*Annona muricata* and *A. squamosa*) have become naturalised and constitute the dominant understorey species.

Coconut-Palm- and Pandanus-Dominated Agricultural Lands

As stressed above, coconuts and pandanus were the two most important staple crops in pre-European-contact Nauru. Coconut groves, although far less important today than in the past when copra was the main export, are still found in a number of sites on Nauru's coastal strip. In most cases, the plantations are comprised of randomly scattered trees of varying heights and ages. In poorly-maintained groves, coconut seedlings and fallen leaves and husks dominate the understorey.

Planted groves of edible *Pandanus tectorius* cultivars in forest clearings, both on the plateau and on the more gradually sloping areas of the escarpment, were also once a prominent feature of Nauru's traditional agricultural vegetation. Today, they are restricted to a few relict groves, some of which were found to be present in the unmined areas of Anibar District in 1980.

Houseyard Gardens and Urban Vegetation

Although indigenous and aboriginally introduced species are important components, most houseyard gardens and urban vegetation are dominated by recently introduced exotic species. The high diversity of recently introduced exotics in Nauru is due mainly to the almost complete destruction of the subsistence economy, urbanization and increasing air transport contact with overseas sources of non-quarantined planting materials.

In indigenous Nauruan houseyard gardens the dominance of recently introduced ornamental species is very pronounced, with some 118 of 140 species being classified as recent introductions. Indigenous species include *Abutilon indicum*, *Barringtonia asiatica*, *Calophyllum inophyllum*, *Cerbera manghas*, *Clerodendrum inerme*, *Cordia subcordata*, *Ficus prolixa*, *Guettarda speciosa*, *Morinda citrifolia*, *Ochrosia elliptica*, *Premna serratifolia* and *Terminalia catappa*, which in some cases, such as with *Cerbera manghas* and *Cordia subcordata*, are only present today in Nauru in houseyard gardens. Common food plants include, in order of importance, coconut, breadfruit, bananas, pandanus, papaya, *Citrus* spp. and guava. Common ornamentals, found in at least four of 16 sample gardens, include *Acalypha amentacea* vars., *Bougainvillea* spp., *Caesalpinia pulcherrima*, *Caladium bicolor*, *Casuarina equisetifolia*, *Catharanthus roseus*, *Codiaeum variegatum*, *Cordyline fruticosa*, *Crinum* spp., *Delonix regia*, *Dieffenbachia* spp., *Hibiscus rosa-sinensis*, *Hosta plantaginea*, *Hymenocallis littoralis*, *Ixora* spp., *Jasminum sambac*, *Jatropha integerrima*, *Nerium oleander*, *Pentas* spp., *Plumeria* spp., *Polyscias* spp., *Pseuderanthemum carruthersii*, *Sansevieria trifasciata*, *Tabernaemontana divaricata*, *Tecoma stans* and *Thunbergia erecta*.

The houseyard gardens of I-Kiribati, Tuvaluan, Chinese and Filipino contract workers, and in the European and Indian expatriate communities of Nauru, are very different. Each reflect distinctive preferences in food and ornamental plants, and are commonly dominated by food plants. I-Kiribati and Tuvaluan gardens at Location, where there is very little space for planting, usually consist of a single banana, coconut, papaya or breadfruit tree, or a few cassava, sweet potato, taro, tannia (*Xanthosoma sagittifolium*), pineapple, sugarcane, hibiscus spinach (*Hibiscus manihot*), or chilli (*Capsicum frutescens*) plants. All are often grown in boxed or fenced areas filled with imported soil or mulch. Chinese gardens at Location focus more on short-term vegetable plants, such as Chinese cabbages (*Brassica* spp.), onions and garlic (*Allium* spp.), amaranth spinach (*Amaranthus* spp.), coriander (*Coriandrum sativum*), long beans (*Vigna sesquipedalis*) and a range of cucurbits. Filipino workers plant sweet potato, hyacinth bean (*Dolichos lablab*) and horseradish or drumstick tree (*Moringa oleifera*). European expatriates plant tomatoes, lettuce and parsley, whereas the expanding Indian expatriate community has planted eggplant (*Solanum melongena*), okra (*Hibiscus esculentus*), horseradish tree (*Moringa oleifera*) and bilimbi (*Averrhoa belimbi*). A similar range of food species are cultivated behind the workshops on Topside, although the areas under crops are greater, with some gardeners growing taro, tannia and giant swamp taro, employing the traditional intensive mulching systems of Kiribati and Tuvalu (Thaman 1987a, 1988b).

The balance of the "urban vegetation" is composed of many the same species which are occasionally planted as roadside trees or around government and Nauru Phosphate Corporation buildings and parking lots. The remaining area of extensive urban vegetation is the golf course in Aiwo District which is lined with trees, including *Hibiscus tiliaceus*, *Thespesia populnea*, but dominated by banyan trees (*Ficus* spp.).

Ruderal Vegetation

Extensive areas of highly disturbed ruderal vegetation in settlements, waste places, along roadsides and airstrips, and in areas associated with pre-mining vegetation clearance are found in Nauru. The dominant species in most areas are pioneering grasses, annuals and shrubby weedy species.

Common species include; 1) the grasses, *Cenchrus echinatus*, *Chloris inflata*, *Cynodon dactylon*, *Dactyloctenium aegyptium*, *Digitaria* spp., *Eleusine indica*, *Eragrostis amabilis*, *Lepturus repens* and *Tricholaena rosea*; 2) the sedges, *Cyperus javanicus*, *C. rotundus* and *Fimbristylis cymosa* (which, along with *Digitaria setigera* and *Lepturus repens*, are probably indigenous); and, 3) the herbaceous species, *Ageratum conyzoides*, *Alysicarpus vaginalis*, *Amaranthus dubius*, *A. viridis*, *Bidens pilosa*, *Cassia occidentalis*, *Cleome rutidosperma*, *C. viscosa*, *Crotalaria goreensis*, *C. spectabilis*, *Desmodium tortuosum*, *Euphorbia* spp., *Hedyotis corymbosa*, *Indigofera hirsuta*, *Malvastrum coromandelianum*, *Passiflora foetida*, *Phyllanthus amarus*, *Physalis* spp., *Portulaca oleracea*, *Sida rhombifolia*, *Spermacoce assurgens*, *Stachytarpheta urticifolia*, *Synedrella* *nodiflora*, *Tridax procumbens* and *Vernonia cinerea*, plus the indigenous species, *Phyllanthus societatis* and the parasitic *Cassytha filiformis*.

A few tree or tree-like species have become naturalized in dense stands in Nauru. *Mangifera indica* is dominant in dense forests behind residences in the Buada Lagoon depression; *Annona muricata* and *A. squamosa*, as mentioned above, form dense stands on gradually sloping areas of the escarpment; *Adenanthera pavonina*, *Lantana camara* var. *aculeata*, *Leucaena leucocephala* and *Psidium guajava* form dense stands or thickets between Buada Lagoon and the decalcination plant on the coastal strip in Aiwo District; and *Casuarina equisetifolia* and *Muntingia calabura* have colonized roadside areas and portions of the phosphate-mined area. Of particular interest, is the almost monospecific colonization of the large topsoil stockpile on Topside by the cucurbit, *Luffa cylindrica* var. *insularum*.

Phosphate-Mined Lands

As a result of almost 80 years of open-cast phosphate mining, some three-quarters of Nauru is under severely-modified disclimax vegetation in various stages of succession. Prior to mining the vegetation is removed by bulldozer and the topsoil removed to expose the phosphate deposits which lie between coral-limestone pinnacles. The extraction of phosphate then causes dramatic changes in local relief, which varies between 4 and 8 m from the top of the pinnacles to the pit bottoms, with about three to four pinnacles occurring within each 100 m^2. Because mining is only about 20 per cent efficient, unconsolidated phosphate deposits remain in the pit bottoms and on the saddles and scree slopes between the pinnacles. These deposits (which might be mined at a later date) and the pinnacle surfaces, constitute the main sites for recolonization (Manner et al. 1984, 1985).

Although there is widespread evidence that exotics commonly replace indigenous species in highly disturbed habitats, the Nauru study by Manner, Thaman and Hassall (1984, 1985) supports the conclusion of Mueller-Dombois (1975) that indigenous (pioneer) species are often better adapted to edaphically harsh environments, given the cessation of human disturbance. Their study shows a very rapid colonization of mined areas by indigenous ferns and exotic herbs, followed by a fairly rapid replacement by native, primarily coastal strand, species.

Early pioneer species include the non-woody exotics, *Alysicarpus vaginalis*, *Cleome rutidosperma*, *Crotalaria goreensis*, *Emilia sonchifolia*, *Eragrostis amabilis*, *Euphorbia cyathophora*, *E. hirta*, *E. prostrata*, *Hedyotis corymbosa*, *Synedrella nodiflora*, *Tricholaena rosea*, *Tridax procumbens* and *Vernonia cinerea*, plus the indigenous ferns, *Nephrolepis biserrata* and *Polypodium scolopendria*. Of these, only the two ferns species, and *Euphorbia hirta*, *E. prostrata*, *Tricholaena rosea*, *Tridax procumbens* and *Vernonia cinerea* remain significant components of the flora in the later stages of succession, usually in open disturbed sites.

Species entering the succession early and remaining dominants in the 40- to 80-year-old sites include: the trees, *Calophyllum inophyllum*, *Dodonea viscosa*, *Ficus prolixa*, *Guettarda speciosa*, *Morinda citrifolia* and *Premna serratifolia*; the shrubs, *Phyllanthus societatis* and *Scaevola taccada*; the grasses and sedges, *Lepturus repens*, *Fimbristylis cymosa* and *Cyperus javanicus*; the parasite, *Cassytha filiformis*; and the diminutive fern, *Ophioglossum petiolatum*, All are indigenous. Larger exotics found in the later stages of succession in more open habitats include *Lantana camara*, *Psidium guajava* and *Stachytarpheta urticifolia*.

The study suggests that the potential natural disclimax vegetation of the open-cast mined plateau will probably be dominated by *Calophyllum inophyllum* and *Guettarda speciosa*, with the epiphytic *Ficus prolixa* dominating the more ecologically severe pinnacle habitats. *Morinda citrifolia*, *Premna serratifolia* and the exotics, *Lantana camara* and *Psidium guajava*, could become important components of the subcanopy. The exotics, *Casuarina equisetifolia* (which is native to limestone habitats on other Pacific islands) and *Muntingia calabura*, both now locally abundant in some mined areas, could enter into the succession as well.

As argued by Manner *et al.* (1985), given no deliberate human intervention, the succession to a disclimax vegetation association capable of sustaining human life will probably take "many thousands of years". It is stressed that it is ironic that Nauru's central plateau, from which Nauruans formerly obtained some of the necessities of life, will be a "topographic jungle" stripped of its natural vegetation, before the next century, in order to provide the phosphate needed to revive phosphate-poor soils to fuel the development of Australia and New Zealand.

THE FLORA

Like the extremely limited, degraded and displaced vegetation types, the indigenous terrestrial flora of Nauru exhibits extreme poverty and current numerical domination by exotics. Of a total of 493 species or hybrid cultivars reported to have been present on Nauru, only 59 (12%) are possibly indigenous (Tables 1 and 2). There are no reported endemics, reflecting the lack of habitat diversity and the predominance of ubiquitous, easily-dispersed pantropical or paleotropical coastal species. Two species (*Achyranthes canescens* and *Tarenna sambucina* are presumably now extinct, *Aidia cochinchinensis* possibly now extinct, and half (28) of the remaining 56 species are severely restricted in distribution, endangered or possibly extinct, due to removal and severe habitat modification or limitation (Table 2). The high number of recent introductions in Nauru reflects its increasing contact with the outside world via its national airline, Air Nauru, increasing urbanization and the total absence of quarantine regulations.

Table 1. Antiquity status of the flora of Nauru in terms of whether species are presumed to be indigenous to Nauru; aboriginal or recent post-European-contact introductions; or now extinct.

Class/Genera	Indigenous	Aboriginal	Recent	Extinct	Total
Pteridophytes	8	-	3	-	11
Gymnosperms	-	-	2	-	2
Monocotyledons	6	2	137	-	145
Dicotyledons	45	3	278	9	335
Total	59	5	420	9	493

In terms of diversity at the family level, only 97 vascular plant families are represented on Nauru (Appendix I). Of these, only 33 are represented by indigenous species.

The pteridophytes and gymnosperms are represented by six families, all of which are represented by an indigenous species. The Gymnosperms are represented by only two families, none of which are indigenous.

The 145 monocotyledons fall into 18 families, only three of which, Cyperaceae, Pandanaceae and Poaceae, are indigenous. Araceae, Liliaceae and Poaceae are the only families with over ten separate species (26, 34 and 26 respectively). Other monocotyledon families represented by five of more species include Arecaceae, Commelinaceae, Cyperaceae, Marantaceae, Orchidaceae and Zingiberaceae. The majority of species from these families are cultivated ornamentals, or in the case of Poaceae, weedy grasses.

The dicotyledons are represented by 71 families, 25 of which are possibly indigenous. Families represented by two or more indigenous species each are Apocynaceae, Boraginaceae, Capparidaceae, Convolvulaceae, Euphorbiaceae, Fabaceae, Malvaceae, Rubiaceae and Verbenaceae (see Part II and Appendix I).

Table 2. Species indigenous or possibly indigenous to Nauru (? = status uncertain, possibly an aboriginal or recent introduction; E = possibly extinct; e = endangered or rare).

Type/Species	Status
PTERIDOPHYTES	
Asplenium nidus	+e?
Nephrolepis biserrata	+
Nephrolepis hirsutula	+
Ophioglossum petiolatum	+
Polypodium scolopendria	+
Psilotum nudum	+
Pteris tripartita	+
Pyrrosia adnascens	+e
Subtotal	8
HERBS	
Achyranthes canescens	E?
Heliotropium procumbens	+e
Laportea ruderalis	+*e*
Triumfetta procumbens	+
Subtotal	3 (1E)
GRASSES AND SEDGES	
Cyperus javanicus	+?
Digitaria setigera	+?
Fimbristylis cymosa	+
Lepturus repens	+
Stenotaphrum micranthrum	+e
Subtotal	5

VINES AND LIANAS

Canavalia cathartica	+e
Canavalia rosea	+e
Capparis quiniflora	+e
Cassytha filiformis	+
Derris trifoliata	+e
Ipomoea littoralis	+e
Ipomoea macrantha	+
Ipomoea pes-caprae	+
Vigna marina	+
Subtotal	9

SHRUBS

Abutilon asiaticum var. *albescens*	+e
Caesalpinia bonduc	+e
Capparis cordifolia	+
Clerodendrum inerme	+
Colubrina asiatica	+
Dodonaea viscosa	+
Euphorbia chamissonis	+e
Phyllanthus societatis	+
Scaevola taccada	+
Sida fallax	+e
Suriana maritima	+e
Subtotal	11

TREES

Aidia cochinchinensis	+e
Barringtonia asiatica	+e
Bruguiera gymnorhiza	+e
Calophyllum inophyllum	+
Cerbera manghas	+e
Cordia subcordata	+e
Erythrina variegata	+e
Fagraea berteriana	E?
Ficus prolixa	+
Guettarda speciosa	+

Hernandia nymphaeifolia	+e
Hibiscus tiliaceus	+
Morinda citrifolia	+
Ochrosia elliptica	+e
Pandanus tectorius	+
Pisonia grandis	+e
Premna serratifolia	+
Tarenna sambucina	E?
Terminalia catappa	+?
Thespesia populnea	+e
Tournefortia argentea	+
Vitex negundo	+e
Subtotal	20 (2E)
TOTAL SPECIES	56 (3E)

Sources: An extensive review of the available literature and personal records and observations by the authors; see in particular Thaman 1992; Manner, Thaman and Hassall 1984, 1985.

Nature of Indigenous Species

Of the indigenous species, eight are widespread pantropical or paleotropical pteridophytes, including *Psilotum nudum*, *Polypodium scolopendria*, *Ophioglossum petiolatum*, *Pteris tripartita* and *Nephrolepis* spp., with *Pyrrosia adnascens*, a common epiphyte, also present on Nauru (Table 2). *Asplenium nidus*, although almost certainly indigenous, was found only as an ornamental in houseyard gardens during the current study.

There are no indigenous gymnosperms, although the widespread *Cycas circinalis* is found in cultivation.

Indigenous monocotyledons are restricted to *Pandanus tectorius*, some cultivars of which are undoubtedly aboriginal introductions, and a small range of sedges and grasses (Cyperaceae and Poaceae), some of which might be aboriginal or recent introductions. The coconut palm (*Cocos nucifera*) is classified as an aboriginal introduction. The grass *Stenotaphrum micranthrum* (reported present by Fosberg *et al.* 1987) is considered to be endangered or now absent.

The dicotyledons are comprised almost exclusively of salt-tolerant, widely-dispersed, pantropical coastal species. Of the 42 herbaceous and woody dicotyledons, half (21) are endangered or rare (Table 1). Species such as *Heliotropium procumbens*, *Laportia ruderalis*, *Triumfetta procumbens*, *Abutilon asiaticum*, *Caesalpinia bonduc*, *Euphorbia chamissonis*, *Sida fallax*, *Suriana maritima*, *Aidia cochinchinensis*, *Barringtonia asiatica*, *Cerbera manghas*, *Erythrina variegata*, *Hernandia nymphaeifolia*, *Pisonia grandis*, *Thespesia populnea* and *Vitex negundo* are represented by only a few remaining individuals, often in houseyard gardens, or by localized relict communities. Prior to widespread disturbance, Nauru would have undoubtedly had more species than it has at present.

Comparison with Other Island Floras

The extreme poverty of the indigenous flora of Nauru becomes more obvious when compared with estimates of the indigenous floras of island groups which are larger or closer to the Asian plant source region. The estimated number of indigenous species for the following island groups are: Malaya (c. 20,000), Philippines (10,000), Bismarck Archipelago (700), Vanuatu (750), Fiji (more than 1,100), Tonga (257), Samoa (548) and French Polynesia (600). Only extremely isolated small islands such as Easter Island and the three small atolls of Tokelau, with indigenous floras of 32 and 33 species respectively, have poorer floras than Nauru (Good 1947 in Manner 1987, Parham 1971). When taken individually, the floras of Pacific atolls range from as few as three to perhaps 150 indigenous species, compared to some Indian Ocean atolls, nearer to continental areas, which have close to 300 indigenous species (Fosberg 1952).

The floristic poverty of Nauru becomes even more pronounced based on a comparison of the frequency occurrence of 142 widespread coastal species in eleven Pacific island groups (see Appendix II and Thaman 1992). All of the species considered have the ability to cope successfully in environments characterized by loose shifting sands, wave action, soil-less limestone and volcanic terraces and rock outcrops, high salinity, strong sunlight, strong winds, seaspray and associated physiological drought (Fosberg 1952, 1960) and, in some cases, periodic inundation and waterlogging, all conditions common in Nauru.

The island groups analyzed ranged from large, geographically-older high island groups such as Fiji, composed of over 300 islands with a total area of 18,376 km^2, to the three small isolated atolls of Tokelau with a total land area of only 12.2 km^2. Also included in the comparison were high island groups with diverse habitats, such as Guam, a volcanic island with extensive areas of limestone and an area of 549 km^2; Samoa and Hawaii, recent basaltic volcanic island groups, with little or no limestone; Palau, a group of some 340 volcanic and uplifted limestone islands, including an atoll, Kayangel, and the raised phosphate island of Angaur, located only 850 km to the east of the Philippines; Tonga, a group of about 150 uplifted limestone and some volcanic islands, with a total area of 697 km^2; Niue, an isolated uplifted limestone island, like Nauru, but with an area of 258 km^2, and few beaches; and Makatea, an uplifted phosphatic island about the same area as Nauru, and like Nauru, with no protective barrier reefs or coastal lagoons (Thaman 1992).

Although these comparisons are strongly biased by the size and geologic age of the islands, their distance from plant source areas and the unavailability of information on other analogous islands such as Banaba (Ocean Island), the poverty of the coastal floras of the two small phosphate islands of Nauru and Makatea (in the Tuamotu Archipelago of French Polynesia) is clearly apparent, both with only 55 of the 142 widespread coastal species each. The Gilberts and Tokelau, both groups of low-lying atolls, have only 74 and 34 species each. All other island groups, including Hawaii and Niue, have at least two-thirds of the 142 species present as indigenous or long-established introductions, an indication of greater habitat diversity and/or less habitat degradation (Thaman 1992). Of interest is that 55 of Nauru's 59 indigenous species are among the 142 widespread coastal or mangrove species listed in Appendix I.

As atoll groups, the Gilbert and the Tokelau Islands, have the fewest ferns, although Nauru has the fewest widespread coastal herbs. It could be assumed that the fern, *Davallia solida*, and widespread herbaceous species, such as *Boerhavia*, *Hedyotis* and *Portulaca* spp. and *Sesuvium portalucastrum*, were all originally present on Nauru, but eliminated due to widespread destruction of coastal habitats. In terms of coastal grasses and sedges, Nauru, the small atolls of Tokelau, and Makatea have the fewest species, possibly due to the combination of widespread habitat destruction and a relative absence of marsh or wetland environments. The widespread destruction of the areas around Buada Lagoon for cultivation by the Japanese during World War II may have destroyed many natural wetland environments. Species which might have been present include the grasses *Paspalum distichum* and *Thuarea involuta*. Whether a given sedge species arrived naturally or was introduced deliberately due to its cultural utility is uncertain.

Coastal vines and lianas are noticeably fewer on Makatea and Nauru, with only three and eight out of the 14 widespread species. Noticeably absent on Nauru are *Abrus precatorius*, *Entada phaseoloides* and *Mucuna gigantea*.

With the exception of the Tokelau Islands (with only three species), Nauru and Makatea have the poorest shrub flora, with only 10 and 11 species respectively, out of a possible 27 species. Similarly, the Tokelaus have only 16 of 62 common coastal tree species, with Nauru and Makatea having only 23 and 21 species respectively. Conspicuously absent on Nauru are the shrubs, *Allophylus timoriensis*, *Pemphis acidula*, *Sophora tomentosa* and *Wollastonia biflora*; and the trees, *Ficus tinctoria*, *Neisosperma oppositifolia*, *Pipturus argenteus* and *Terminalia samoensis*, most of which are present on the smaller elevated phosphate-rich island of Fais and the coral-limestone island of Satawal in the western Caroline islands (Fosberg and Evans 1969).

There are other widespread non-coastal species which might have been present in the past on Nauru, which were present in 1932 (before mining, which ceased in 1966, almost completely destroyed the island's inland vegetation) on the analogous phosphate island of Makatea, which is located much further from the centers of plant diversity than Nauru. These include: the fern, *Ophioglossum pendulum*; orchids, such as *Oberonia* and *Taeniophyllum* spp.; the herb, *Procris pedunculata*; the vines, *Abrus precatorius* (mentioned above) and *Dioscorea bulbifera* (the most widespread of all yam species and present, in many cases probably as an aboriginal introduction, from East Africa to Micronesia and eastern Polynesia)(Stone 1970); and the shrubs and trees, *Alyxia* sp., *Canthium barbatum*, *Celtis paniculata*, *Glochidion ramiflorum*, *Ixora* sp., *Melochia odorata*, *Planchonella* (*Pouteria*) sp., and *Timonius* sp. (Wilder 1934). *Tarenna sambucina*, also present on Makatea, was reported present on Nauru by Burges in 1933, but is now considered to be extinct.

Makatea has one presumably endemic species, *Euprichardia vuylstekeana*, and it might be expected, given the diversity of pre-mining microhabitats and the isolation of Nauru, that there could have been endemic species there also. Interestingly, the one plant that was thought to be possibly endemic on Nauru turned out to be *Phyllanthus societatis*, "a common plant among coral rocks" on Makatea in 1933 (Wilder 1934).

A similar comparison with the relatively undisturbed flora of Henderson Island, a remote raised limestone island with a similar limestone plateau and pinnacle topography, provides further insight into some of the plant species that might have existed in the past on Nauru. Because it was unsuitable for permanent habitation and had no economic phosphate deposits, Henderson has survived successive Polynesian and European impacts, with only five known introduced plant species. Species of widespread genera found on Henderson, but not on Nauru include: the fern, *Davallia solida*; the herbs, *Boerhavia tetrandra*, *Euphorbia sparrmannii*, *Lepidium bidentatum*, *Peperomia hendersonensis*, *Portulaca lutea*, *Procris pedunculata* and *Sesuvium portalucastrum*; the shrubs, *Allophylus* sp., *Alyxia* sp., *Canthium barbatum* and *C. odoratum*, *Glochidion pitcairnense*, *Ixora fragrans*, *Jasminum didymum*, *Eugenia reinwardtiana* (*Eugenia rariflora*), *Morinda umbellata* var. *forsteri*, *Pemphis acidula*, *Timonius polygamus* and *Xylosma suaveolens* var. *haroldii*; and the trees, *Celtis paniculata* var. *viridis*, *Geniostoma hendersonense*, *Meryta brachypoda*, *Pittosporum arborescens*, *Sesbania coccinea* and *Santalum hendersonense*. Nine species or varieties are presently recognized as endemic, all of which are found in the interior. These are the very areas on Nauru that have been so devastated by phosphate mining, long settlement and devastation and scavenging for food and firewood during the Second World War. Not present on Henderson, but present on Nauru are *Calophyllum inophyllum* and *Barringtonia asiatica* (Paulay and Spencer 1989, Fosberg et al. 1983, Fosberg et al. 1989).

Nature of Exotic Species

Exotic species, which constitute 88 per cent (434 out of a total of 493 reported species) of the flora of Nauru, dominate ruderal, houseyard and urban vegetation. Exotic species include a wide range of ornamentals, weedy species, food plants and a number of other useful species.

Ornamentals, which are normally confined to houseyard and village gardens, comprise some 59 per cent (257) of the 434 exotic species. On Nauru, introductions by travellers from Australia, Fiji and other areas with highly developed ornamental gardening traditions; the absence of quarantine restrictions; and the almost total breakdown in the subsistence economy, seem to be the main reasons for the disproportionate importance of ornamental plants. Some of these ornamental, of course, have other uses such as living fencing or for the preparation of medicines or garlands.

The proportions of the exotic flora composed of weedy species is 18 per cent (80 of 434 species), an indication of both the poverty of the competitive indigenous flora and the highly disturbed nature of the vegetation.

Although food plants represent 16 per cent of the exotic flora, due to the harsh environment, limited land area and limited focus on food production in Nauru, many of these species are restricted in numbers or utility and are often represented by experimental attempts to diversify food production or by individual, often immature specimens of a given species. Exotic food plants of particular importance on Nauru include numerous edible pandanus cultivars (*Pandanus tectorius*), some of which are undoubtedly aboriginal introductions, and the coconut (*Cocos nucifera*), also an aboriginal introduction. Recent introductions of more localized importance, or of particular importance to contract worker communities on Nauru include: the vegetables, hibiscus spinach (*Hibiscus manihot*), Chinese cabbage cultivars (*Brassica* spp.), long beans (*Vigna sesquipedalis*), amaranthus spinach (*Amaranthus* spp.) and pumpkin (*Cucurbita pepo*); the staple root crops, taro (*Colocasia esculenta*), tannia (*Xanthosoma sagittifolium*), sweet potato (*Ipomoea batatas*) and cassava (*Manihot esculenta*); a range of banana and plantain cultivars (*Musa* cultivars); and the tree crops, lime (*Citrus aurantifolia*), guava (*Psidium guajava*), mango (*Mangifera indica*), soursop (*Annona muricata*) and the horseradish or drumstick tree (*Moringa oleifera*), all of which seem to do well in Nauru's harsh environment. Important emergency or pig foods include Polynesian arrowroot (*Tacca leontopetaloides*) and purslane (*Portulaca* spp.), both of which are found as naturalised plants in the coastal vegetation of in ruderal sites.

Other useful exotic species include kapok (*Ceiba pentandra*), cotton (*Gossypium barbadense*), tobacco (*Nicotiana tabacum*), and bamboo (*Bambusa vulgaris*), which were all reportedly more abundant in the past. As suggested above, some larger weedy exotics, such as *Adenanthera pavonina*, *Annona* spp., *Casuarina equisetifolia*, *Lantana camara*, *Leucaena leucocephala*, *Mangifera indica*, *Muntingia calabura* and *Psidium guajava*, some which are classified as ornamentals, food plants or other useful plants, have become naturalized and competitive with the indigenous species in some disturbed and relatively undisturbed sites.

ECOLOGICAL AND CULTURAL UTILITY OF EXISTING FLORAS

Although highly disturbed, outnumbered and, in some ways, "enriched" by introduced exotics, the vegetation and flora of Nauru still constitute a critical ecological and cultural resource to the people of Nauru. This is particularly true for the indigenous species, virtually all of which had wide cultural utility within the traditional subsistence economy.

In terms of the more specific ecological attributes of Nauru's plant resources, the most important functions include the provision of shade and animal and plant habitats, protection from wind, erosion, flood and saltwater incursion, land stabilization, protection from the desiccating effects of salt spray, soil improvement and mulching.

In terms of more strictly cultural utility, preliminary analyses indicate 169 purposes or use categories for 39 indigenous species, an average of 4.3 uses per species. There are 434 uses for 354 exotic species, an average of 1.2 uses per species (Table 3). This gives a combined total of 603 use/purpose categories for 393 species (1.5 uses per species). Twenty (20) indigenous and 80 exotic species had no reported uses. The relative importance of the indigenous flora would undoubtedly be much more pronounced if: 1) a more systematic in-depth survey of the cultural utility of each indigenous species had been conducted; 2) Nauru had not experienced such widespread devastation of its population, traditional economy, traditional education system and its indigenous flora (and associated ethnobotanical knowledge) over the past 100 years; and 3) planted ornamentals, by far the most widespread use of exotic species, were excluded from the analysis of indigenous species.

Table 3. Frequency of use for specified purposes of plant species present in Nauru (Note: Introduced includes both aboriginal introductions such as coconut and recent post-European-contact introductions).

Purpose/Use	Indigenous x/59	Introduced x/434	Total x/493
Cultivated Ornamentals	9	257	266
Food Plants	2	64	66
Body Ornamentation	16	23	39
Medicinal/Health	17	13	30
Staple Foods	1	13	14

General Construction	11	2	13
Scenting Oil/Perfumery	6	7	13
Firewood/Fuel	6	4	10
Emergency/Famine Foods	3	6	9
Tools/Utensils	7	1	8
Boat/Canoe Building	8	-	8
Handicrafts	7	1	8
Games/Toys	6	1	7
Food Parcelization	5	2	7
Living Fences/Hedges	1	6	7
Cordage/Fibre	3	3	6
Hair Conditioner	6	-	6
Woodcarving	5	-	5
Adhesive/Glue/Caulking	1	4	5
Earth Oven Cover	5	-	5
Magic/Sorcery	4	-	4
Drinks/Beverage	-	4	4
Fishing Equipment	2	2	4
Clothing	3	1	4
Animal Feed	2	2	4
Plaited Ware	3	1	4
Legends/Mythology	2	1	3
Furniture	3	-	3
Animal Cages/Roosts	1	2	3
Fish Poisons	2	-	2
Fire by Friction	1	1	2
Strainers/Filters	1	1	2
Thatching/Roofing	1	1	2
Dyes/Pigments	2	-	2
Nets/Traps	2	-	2
Fans		1	1 2
Chewing Gum/Masticants	-	2	2
Oils/Lubricants	1	1	2
Corks/Stoppers	1	1	2
Other Uses*	12	6	18
TOTAL	169	434	603
NO USES	20	80	100

* Other uses include aphrodisiacs, appetite stimulants, brushes, toilet paper, illumination, soap/shampoo, containers, deodorants/air fresheners, fishnet floats, green

manure, groundcover, meat tenderizer, insect repellents/fumigants, love potions, wild animal food, fishing bait, cigarette wrappers and tobacco.

Moreover, if distinct uses within use/purpose categories (e.g., tools with distinct functions, different types of fishing equipment, foods or ornamentation for different occasions or purposes, medicines for different ailments, or plants used for specific parts of boats or houses) are counted (see individual uses for each species as detailed in Part II), the economic and cultural utility of plants becomes even more pronounced. The coconut (*Cocos nucifera*) palm, for example, has 33 reported uses in Nauru (Table 4), almost undoubtedly a gross underestimate, in light of at least 128 reported uses (many of which are almost ubiquitous) for the coconut palm throughout the Pacific Islands (Thaman 1992). Next in order of importance, are 19 species, all with 5 or more reported uses. These include, in order of importance, *Hibiscus tiliaceus*, *Pandanus tectorius*, *Scaevola taccada*, *Morinda citrifolia*, *Guettarda speciosa*, *Calophyllum inophyllum*, *Cordia subcordata*, *Terminalia catappa*, *Artocarpus altilis*, *Thespesia populnea*, *Tournefortia argentea*, *Premna serratifolia*, *Triumfetta procumbens*, *Vitex negundo*, *Ochrosia elliptica*, *Cassytha filiformis*, *Musa* ABB Group, *Bambusa vulgaris* and *Carica papaya*. Of these 20 species, only *Cocos nucifera*, *Artocarpus altilis*, *Musa* ABB Group, *Bambusa vulgaris* and *Carica papaya*, are aboriginal or recent introductions. The rest are probably indigenous or very early aboriginal introductions (e.g., some authorities suggest that species such as *Hibiscus tiliaceus*, *Morinda citrifolia*, *Cordia subcordata* and *Terminalia catappa* might have been aboriginal introductions into some Pacific islands because of their cultural utility.

Another 13 species, 7 of which are indigenous (*Dodonea viscosa*, *Hernandia nymphaeifolia*, *Plumeria rubra*, *Psidium guajava*, *Erythrina variegata*, *Bruguiera gymnorhiza*, *Barringtonia asiatica*, *Vigna marina*, *Clerodendrum inerme*, *Gardenia taitensis*, *Jasminum sambac*, *Crinum asiaticum* and *Hibiscus rosa-sinensis*), have at least 3 uses each. Another 22 species have at least two reported uses each (Table 4). There is some usage overlap between categories, such as supplementary and emergency foods, medicinal, magical, ceremonial and body ornamentation plants, or plants used for handicrafts, woodcarving, cordage and clothing. Conversely, the categories could be further broken down to yield an even greater list of uses. Moreover, the list does not include the more strictly ecological functions of coastal plants, such as shade, protection from wind, sand and salt spray, erosion and flood control, coastal reclamation, animal and plant habitats, and soil improvement, all of importance, particularly on an ecologically devastated post-mining Nauru.

Table 4. Species of particular cultural utility on Nauru based on an analysis of different individual uses listed under each species in Part II (Notes: 1) uses do not include a wide range of ecological functions or uses; A = probably an aboriginal introduction; R = recent post-European-contact introduction; all undesignated species are possibly indigenous).

Latin Name	Uses
Cocos nucifera (A)	33
Hibiscus tiliaceus	12
Pandanus tectorius	12
Scaevola taccada	11
Morinda citrifolia	10
Guettarda speciosa	9
Calophyllum inophyllum	8
Cordia subcordata	6
Terminalia catappa	6
Artocarpus altilis	6
Thespesia populnea	5
Tournefortia argentea	5
Premna serratifolia	5
Triumfetta procumbens	5
Vitex spp.	5
Ochrosia elliptica	5
Cassytha filiformis	5
Musa ABB Group (R)	5
Bambusa vulgaris (R)	5
Carica papaya (R)	5
Dodonea viscosa	4
Hernandia nymphaeifolia	4
Plumeria rubra (R)	4
Psidium guajava (R)	4
Erythrina variegata	3
Bruguiera gymnorhiza	3
Barringtonia asiatica	3
Vigna marina	3
Clerodendrum inerme	3
Gardenia taitensis (R)	3
Jasminum sambac (R)	3
Crinum asiaticum (R)	3
Hibiscus rosa-sinensis (R)	3

Note: Species with two (2) recorded uses each: *Polypodium scolopendria*, *Cyperus javanicus*, *Abutilon asiaticum*, *Ficus prolixa*, *Pisonia grandis*, *Sida fallax*, *Ipomoea pes-caprae*, *Spondias dulcis* (A), *Ageratum conyzoides* (R), *Asclepias curassavica* (R), *Bougainvillea* spp. (R), *Cassia occidentalis* (R), *Catharanthus roseus* (R), *Citrus aurantifolia* (R), *Delonix regia* (R), *Ixora casei* (R), *Lantana camara* (R), *Mangifera indica* (R), *Mirabilis jalapa* (R), *Ocimum basilicum* and *O. sanctum* (R).

In terms of specific uses, cultivated ornamentals and food plants are by far the most common. If, however, only indigenous plants are considered, the most widely reported uses are for medicine, body ornamentation, general construction, cultivated ornamentation, boat or canoe building, tools or utensils, handicrafts, scenting coconut oil or perfumery, firewood or fuel, games and toys, hair conditioners, food parcelization, woodcarving, covering or insulating the earthen oven, magic or sorcery, emergency or famine foods, cordage or fibre, clothing, plaited ware and furniture.

It must be stressed that the analyses are based on traditional uses, many of which have lapsed or are only employed in emergency, because modern technology has pre-empted them. Modern medicine, clothing, fishing lines, matches, crockery, plastic bags, soap, and emergency food rations (food aid) have, for example, replaced traditional plant-derived products in Nauru. Moreover, many of the current generation, schooled in the modern educational system and living in the cash economy, often know few of the traditional uses of plants, let alone their vernacular names . . . a state which could be referred to as "devegetation of the mind" . . . and which has undoubtedly contributed to the degradation of the indigenous and long-established aboriginal vegetation in Nauru.

Of particular note is the importance of traditional food and beverage crops, the abandonment of which, for highly imported foods such as sugar, white rice and flour, cabin biscuits, noodles canned fish, soft drinks, alcohol and tea, has led, as stressed above, to dangerous levels of food dependency and some of the highest, or most rapidly increasing, incidences in the world of vitamin and mineral deficiency and nutrition related diseases. Diseases such as iron-deficiency anemia, vitamin-A-deficiency-induced night blindness, diabetes, cardiovascular disease, hypertension and stroke, gout and hyper-uricemia, some forms of cancer and dental disease, which were rarely encountered in the past are now serious causes of morbidity and mortality in Nauru, and among other Pacific island populations (Speake et al. 1979; Coyne 1984; Taylor 1983; Zimmet et al. 1977, 1978; Thaman 1982, 1983, 1988a).

CONCLUSION

The vegetation and flora of Nauru are among the most impoverished, degraded, disturbed and displaced in the Pacific islands. Long habitation, almost a century of open-cast phosphate mining, continuous bombing, destruction and displacement of the people during World War II, rapid urbanization and the abandonment of agriculture and subsistence activities have arguably produced one of the most severely modified natural and cultural floras on earth.

Although both the vegetation and limited indigenous flora of Nauru has been severely degraded and outnumbered by exotic species, many of the native species are still present, unfortunately often in an endangered state. The indigenous flora also still dominates most habitats, including the later stages of the phosphate-mined pit and pinnacle topography of Nauru. Even in ruderal habitats and in houseyard gardens and villages, where they are outnumbered by exotics, indigenous species constitute important components.

It is argued that, while floristic degradation in Nauru appears to be among the most severe in the Pacific, the current flora still constitutes an important ecological and cultural resource that must be protected as part of the development process, and NOT as an afterthought. Even in the case of Nauru, it may not be too late.

PART II
A COMPILATION OF THE VASCULAR FLORA OF NAURU

Part II, "A Compilation of the Vascular Flora of Nauru", consists of a listing of, and relevant information on, the 493 vascular plant species or distinct cultivars and six widely recognised varieties of common species reported to have been present at some time on Nauru.

It begins with Pteridophyta (ferns and fern allies), followed by Gymnosperms and then Angiosperms. Within Angiosperms, Monocotyledons precede Dicotyledons. Under these headings individual families are listed in alphabetical order (e.g. Acanthaceae, Amaranthaceae, Anacardiaceae . . .), with individual species being listed in alphabetical order by genus within each family (e.g. *Asystasia gangetica*, *Barleria cristata*, *Barleria prionitis*, *Blechum brownei* . . .).

KEY

Under each species/entry the types of information and order of presentation is as follows: 1) Latin or scientific name; 2) common name (s); 3) local vernacular names used by the main ethnic groups in Nauru; 4) synonyms for the Latin or scientific name; 5) antiquity status of the species, i.e., whether it is indigenous to Nauru, an aboriginal introduction or a recent introduction to Nauru; 5) geographical origin of the species; 6) abundance or frequency of occurrence; 7) description of the species; 8) habitat or distribution in Nauru; 9) uses or cultural utility; and 10) an indication of the persons who have recorded or collected a given species, including numbers corresponding to herbarium specimens. This information, its organization and the symbols used under each category are explained below.

Latin/Scientific Names

1. The first name listed in **bold print** is what the authors consider to be the currently most widely accepted published Latin binomial for a given species (usually the earliest published name or basionym). All names follow the *International Code of Botanical Nomenclature*.

2. The Latin names provided in italics after the common and the vernacular names include Latin binomial synonyms (syns.) or older names no longer in use for the species, and, in some cases, incorrect names commonly applied to the species, which are indicated by *sensu auct. non*.

4. The name (s) or the abbreviation of the name (s) of the authority or authorities (persons responsible for describing and publishing a given species name) are provided after each species name, e.g., (L.) Anders.

Family

1. Family names (e.g., **POLYPODIACEAE, ACANTHACEAE** or **RUBIACEAE**) are centered in bold capitals immediately before the first species entry in each family.

2. Where a family is known by two different names or a species placed in either of two families, both are listed (e.g., **FABACEAE OR LEGUMINOSAE, POACEAE OR GRAMINAE** or **CLUSIACEAE OR GUTTIFERAE**)

Common Names

1. English or common names for a species, and other widely-used names, are included in quotation marks, e.g., "coconut", immediately to the far right of the Latin name.

Vernacular Names

1. The vernacular names include the Nauruan names and other names used by the dominant ethnic communities of Nauru. These are found on the second line, after the common English names.

2. The letter (B) after a Nauruan name indicates names listed by Burges (1933). All other names were collected by Thaman, Manner and Hassall as part of the current study.

3. N, K, T, C, SI, Philippines and Hindi, are used in parentheses to indicate the Nauruan, Kiribati, Tuvaluan, Chinese (Cantonese), Solomon Island, Filipino and Hindi names, respectively.

4. The question mark (?) designates unverified or doubtful names.

5. In terms of pronunciation, the Nauruan phonetics are difficult to match with the accepted sounds and orthography of the Latin alphabet. The closet approximations of the correct Nauruan pronunciation of a given name are provided instead of resorting to the use of strange combinations of letters or special phonetic symbols.

6. In the cases of other vernacular languages used in Nauru, the ‘g’ in Tuvaluan is pronounced as if it were like ‘ng’ as in the word ‘sing’; in Kiribati the t, when

followed by an i, is pronounced like an s, and when ti falls at the end of a word, the i remains silent, e.g., 'roti' is pronounced as if it were 'rose'.

Antiquity Status

Antiquity status indicates whether a given species is presumed to be indigenous to Nauru; an aboriginal introduction by Nauruans or other indigenous Pacific Islanders before European contact; or a post-European-contact introduction. In some cases it is suggested that a species may have been successfully introduced prior to European contact, but either not successfully established or brought to extinction before botanical collections or observations of the flora were made. In the case of recent introductions, some species are categorized as to whether they are assumed to be pre- or post-World War II introductions. This is based on information received from informants and/or whether a species was reported present before World War II by Burges in 1933. The ? indicates that the true status of a species is in doubt (e.g., whether it is really indigenous or an aboriginal introduction).

Geographical Origin

Geographical origin refers to what seems to be the original natural distribution of a given species before humans began to acts as dispersal agents for plants. In many cases it is difficult to be sure what the original pre-human or pre-European-contact range of a given species was because species introduced either deliberately or accidentally by the Pacific Island colonizers of the islands have often become naturalized and integral components of what now seems to be indigenous vegetation.

With respect to terminology, Malesia (sometimes spelled Malayasia) is a biogeographical term referring to an area encompassing insular southeast Asia, the Indonesia, Philippines and the island of New Guinea; Indomalaysia refers to an area encompassing the Indian Ocean and Malesia; Indopacific refers to an area extending from the Indian Ocean to the Pacific Islands; Paleotropics refers to the Old World tropics including tropical Africa, Asia and the tropical Pacific Islands; pantropical indicates that a species is found throughout the Old and New World tropics; and cosmopolitan indicates that a species is found almost worldwide. In some cases (usually in the cases of easily dispersed weedy pioneer species) information is provided on both the assumed original distribution and whether a species is now more widespread (e.g., pantropical).

Abundance or Frequency Occurrence

The estimates of abundance or frequency occurrence or whether a given species is now endangered or extinct are based on in-the field observations by Thaman, Manner and Hassall from 1979 through 1987, plus information included in herbarium vouchers of other collectors. In-the field data included in-depth analysis of all vegetation associations, transects at ten locations around the coastal plain, transects across the entire island and extensive sampling using 100 m^2 quadrats in areas where open-cast phosphate mining had occurred.

Species Description

Descriptions of individual species (and selection of the most widely accepted scientific names and authorities) were based on the analysis of living plants in Nauru, herbarium specimens and a synthesis of the best existing descriptions in the works listed in the Bibliography. Works of particular value included Fosberg, Sachet and Oliver 1979, 1982, 1987; Haselwood and Motter 1976; Hay, McQuown, Beckett and Beckett 1974; Henderson and Hancock 1989; Henty and Pritchard 1973; Herklots 1972; Macoboy 1969, 1979; Neal 1965; B.E.V. Parham 1972; J.W. Parham 1972; Purseglove 1972, 1974; Rotar 1968; St. John 1973; Smith 1979, 1981, 1985, 1988, 1991; Stemmermann 1981; Stone 1970; Sykes 1970; Whistler 1980, 1983, 1992; Wilder 1934; Wright, Minter and Carter 1984; and Yuncker 1959.

Uses and Cultural Utility

Ethnobotanical information (including vernacular names) on uses or cultural utility of the individual plant species was obtained through in-depth interviews with elderly person known for their knowledge of the traditional uses of Nauru's plants; other respondents, whenever possible; and from information in available documents and publications. Main informants included Joseph D. Audoa, James Aingimea, Henry Michael Heine, Daphne Fotu, Jacob Gabwinare, Katarina Satto, Kenia Raidinen, Reynold Capelle, Eda Adam and Montiba Star.

Collectors and Herbarium Specimens

The numbers listed at the end of the information on each species indicate which collectors or observers collected or recorded that species as being present on Nauru; the numbers in parentheses identify the numbers of the herbarium vouchers or specimens collected by each collector (s), e.g., 2, 3(58802), 4(168N), 5(92), 6, 7(27812).

The numbers and the collectors/observers are as follows:

1 refers to citations by persons such as Finch prior to 1900, about which there is very little information;

2 refers to citations by Alan Burges of Sydney University who collected in 1933 and most of whose specimens are lodged at Kew Botanical Gardens, London;

3 refers to citations by F.R. Fosberg of the National Museum of Natural History of the Smithsonian Institution, Washington D.C. in 1980, whose specimens are lodged with the Smithsonian Institution;

4 refers to Brian Scully of the University of California at Riverside who also collected in 1980 and most of whose specimens are also lodged with the Smithsonian Institution;

5 and 6 refer R. R. Thaman, H.I. Manner and D.C Hassall of The University of the South Pacific, Suva, Fiji who collected over two 2-week periods in November 1980 and July 1981, respectively, and whose specimens are lodged with the South Pacific Regional Herbarium at The University of the South Pacific, Suva;

7 refers to Thaman and Manner (then with the University of Guam) who collected again in July-August 1987 and whose specimens are also lodged at the South Pacific Regional Herbarium; and,

8 refers to John Swarbrick, of the University of Queensland, Gatton College who collected weedy species on Nauru in June 1988, and whose specimens are lodged in Queensland with duplicates at the South Pacific Regional Herbarium..

When possible, F.R. Fosberg of the Smithsonian Institution examined and verified the identifications of all herbarium specimens. These include some specimens collected in the early 1980s by Dr. Lynn Raulerson of the University of Guam.

VASCULAR PLANTS OF NAURU

PTERIDOPHYTA (Ferns and Fern Allies)

ASPLENIACEAE

Asplenium nidus L. "bird's-nest fern"

laulu, laukatafa, laukatapa (T)

syns. *Neottopteris nidus* (L.) Sm.; *N. curtisorus* (Christ) Hosok.; *Asplenium curtisorum* Christ; *A. phyllitidis* D. Don; *Neottopteris phyllitidis* (D. Don) J. Sm.

Indigenous? Paleotropical. Rare. Large epiphytic fern with a short creeping rhizome; fronds, up to 1 m or more long and 15 cm wide, simple, bright green, elongated, swordlike, with prominent midribs, forming a rosette-like cluster; sori numerous, linear, borne on distal parts of fronds, reaching nearly to the margin. Reported by Burgess as an epiphyte on *Calophyllum inophyllum* in 1935, but seen only as a ornamental by Thaman, Hassall, and Manner in 1980 and 1981. 2, 5, 6, 7(27813).

DAVALLIACEAE

Nephrolepis biserrata (Sw.) Schott "sword fern"

dakeang, dageang (N); te keang, te keang ni Makin (K); sulufe (T)

syns. *Aspidium biserratum* (Sw.); *Nephrodium biserratum* (Sw.) Gaud.; *N. splendens* (Willd.) Gaud.; *Aspidium splendens* Willd.

Indigenous. Pantropical. Abundant. Terrestrial tufted fern with short scaly creeping to erect rhizome; stipes, up to 30 cm or longer, clustered; fronds, up to 2 m or longer and 30 cm wide, oblong-elliptic in outline, pinnate; pinnae up to 15 cm or longer and 2 cm wide, margins usually serrate, apex acuminate; sori, large, in a row at a distance from the margin (submarginal). Found in colonies and dense populations in unmined areas and in pits between pinnacles in mined areas; one of first plants to colonize mined areas; occasional as an ornamental. Leaves used occasionally in garlands. 3(58600), 4(136N), 5(44), 6, 7.

Nephrolepis exaltata (L.) Schott "Boston fern"
syn. *Polypodium exaltatum* L.

Recent introduction. Pantropical. Occasional. Fern with graceful spreading fronds. Ornamental pot plant. 3, 5(86), 6(181).

Nephrolepis hirsutula (Forst.f.) Presl "sword fern", "fishtail fern"
dakeang, dageang (N); te keang (K); sulufe (T)
syns. *Polypodium hirsutulum* Forst.f.; *Nephrodium gibbosum* (Willd.) Gaud.; *Aspidium gibbosum* Willd.

Indigenous. Indopacific. Occasional. Terrestrial fern with a creeping rhizome; stipes, clustered, scaly; fronds, up to 50 cm or more long, pinnate; pinnae, up to 10 cm or more long and 1 cm wide, sessile, oblong-lanceolate, serrullate, obtuse or acutish, pubescent; sori, large, round, submarginal. "Abundant amongst moist rocks." 8 (9586).

OPHIOGLOSSACEAE (Adder's Tongue Fern Family)

Ophioglossum petiolatum Hook. "adder's tongue fern"

Indigenous. Pantropical. Occasional. Diminutive erect terrestrial fern, about 6 cm high, with creeping rhizomes; fronds, ovate to rhombic, 2.5 to 6 cm long. Found as scattered individuals in sandy open and partly shaded areas, primarily in older strip-mined areas on floors of pits between pinnacles. No reported use. 5(151), 6.

POLYPODIACEAE

Polypodium scolopendria Burm.f. "lawai fern" (Hawaii)
dakeang, dageang (N); te keang (K); maile (T)
syns. *Phymatodes scolopendria* (Burm.) Ching; *Polypodium phymatodes* L.; *Phymatodes phymatodes* (L.) Maxon; *Tectaria phymatodes* (L.) Cav.; *Polypodium grossum* Langsd. & Fisch.; *P. hemionitis* Cav.; *Microsorum scolopendria* (Burm.f.) Copel.

Indigenous. Paleotropical. Very abundant. Terrestrial and epiphytic fern with a stout creeping rhizome; stipes, up to 30 cm or longer; fronds, up to 40 cm or more long, broadly triangular-ovate in outline, simple but deeply and broadly divided into lanceolate acute lobes; sori, large, commonly in two rows on lower surface of lobes. Found in colonies and dense populations in unmined areas, in pits between pinnacles in mined areas, and on escarpment and cliffs below the plateau. Fragrant fronds used for making garlands, leis, and other ornamentation and boiled in coconut oil to scent it. 3(58594), 4(121N), 5(43), 6, 7(27811), 8(9578A).

Pyrrosia lanceolata (L.) Farw.

syns. *Arostichum lanceolatum* L.; *Pyrrosia adnascens* (Sw.) Ching; *Cyclophorus lanceolatus* (L.) Alst.; *C. adnascens* (Sw.) Desv.; *Polypodium adnascens* Sw.; *Niphobolus varius* Kaulf.; *Cyclophorus varius* (Kaulf.) Gaud.; *Pyrrosia varia* (Kaulf.) Farw.

Indigenous. Trop. Asia to Polynesia. Rare. Small inconspicuous epiphytic dimorphic fern with a long creeping slender rhizome; fronds at intervals along slender rhizomes; sterile fronds, 4 to 10 cm long and 1 to 1.5 cm wide, simple, oblong-elliptic or oblanceolate; fertile fronds, up to 15 cm or longer and about 7 mm to 1 cm wide; sori, small, densely packed together on lower surface. Growing on tree. 6(173).

PSILOTACEAE

Psilotum nudum (L.) Beauv. "psilotum", "reed fern"

ibiribir (N); te kimarawa (K)

Indigenous. Tropics and subtropics. Occasional. Small erect terrestrial perennial herb, up to about 30 cm or higher, arising from a stout rhizome, with many successively two-forked green 3-angled, longitudinally-ribbed branches, about 2 mm in diameter; leaves, minute, scale-like; sporangia, about 1 mm in diameter. axillary, subglobose, three-lobed. Found as scattered individuals and small clusters in shady areas under unmined vegetation on the central plateau and uncommon under trees and shrubs on escarpment. No reported use. 2(53.5), 3(58764, 58596), 5(102), 6, 7(22314).

PTERIDACEAE

Adiantum sp. "maiden-hair fern"

Recent introduction. Occasional. Fern with finely-dissected fronds and wiry black stalks. Small ornamental fern grown as a pot plant. 5, 6.

Pteris ensiformis Burm.f. "sword brake"

Recent introduction. Tropical and subtropical Asia to Polynesia. Small dimorphic fern, 15 to 50 cm high, with a brown scaly rhizome; stipes, up to 30 cm or longer straw-colored; sterile fronds, 6 to 10 cm long, blades lanceolate, smooth, bipinnate, pinnules variable in size and shape, mostly oblong to linear-lanceolate, sharply serrate; fertile fronds, 15 to 25 cm long, pinnate or bipinnate, pinnules, up to 15 cm long and 7 to 10 mm wide, widely-spaced, linear; sori, marginal, near serrate. Rare. Ornamental pot plant. 6(172).

Pteris tripartita Sw. "sword brake"
dakeang, dageang (N)
syn. *P. marginata* Bory

Indigenous. Paleotropical. Occasional. Large terrestrial fern with a short rhizome; stipes, up to 60 cm or longer, smooth, brown; fronds, up to 1 m or longer, tripartite, deltoid, each part divided into lanceolate pinnae; sori forming a continuous row along margins of pinnae. Found as individuals or isolated clusters at base of limestone cliffs of escarpment and in waste places near cliff base; occasionally a planted ornamental. 4(135N), 5(55), 6, 7(27815).

GYMNOSPERMAE (Gymnosperms)

ARAUCARIACEAE (Araucaria Family)

Araucaria heterophylla (Salisb.) Franco "Norfolk Island pine"
syn. *A. excelsa* (Lamb.) R. Br.

Recent introduction. Norfolk Island. Infrequent. Stately symmetrical tree with about 5 horizontal or drooping branches, each with many branchlets, radiating from each tier; leaves, up to about 1.2 cm or longer, evergreen, stiff awl- or scale-shaped, narrowly-triangular, overlapping, borne on branchlets; cones, 7.5 to 10 cm in diameter, ovoid, woody; pollen borne in catkins, about 5 cm long, which develop singly at the ends of branchlets. Planted immature ornamental trees in home gardens near airport. 5, 6, 7.

CYCADACEAE (Cycad Family)

Cycas circinalis L. "cycad", "sago palm"

te bam (K); laupama, laukimoa (T)

syn. *C. rumphii* Miq.; *C. seemannii* (A. Br.) Schuster; *C. undulata* Desf.

Recent introduction. Trop. Asia, Australia, and the Pacific islands. Occasional. Small dioecious palm-like rarely-branching plant, up to 2 m or taller, with a sturdy brown-ringed trunk; leaves, up to 1 m or longer and 30 cm or more wide, clustered in a rosette at the crown, frondlike, smooth, pinnate; pinnae, up to 30 cm long and 1 to 2 cm wide, narrowly lanceolate, with prominant midribs; male inflorescence, up to about 50 cm by 10 cm or more, borne in center of leaves, brown, cone-shaped, consisting of pollen-bearing scales; female inflorescence and fruit borne on edges of modified brown, woolly leaves, up to 30 cm long; fruit, up to 5 cm long, ovoid, somewhat compressed, with a thin fleshy orange-brown covering and nutlike seeds, with poisonous kernels. Planted ornamental. No reported use in Nauru; seed kernels processed into flour as a famine or ceremonial food in areas of Melanesia, Polynesia and Micronesia. 3, 5(46), 6, 7.

ANGIOSPERMAE (Angiosperms or Flowering Plants)

MONOCOTYLEDONAE

ARACEAE (Arum or Taro Family)

Aglaonema commutatum Schott "aglaonema"

Recent introduction. Indonesia to Pacific Is. Rare. Perennial herb, up to 1.5 m; leaf blades, 8 to 20 cm long and 3 to 10 cm wide, elliptic- to oblong-lanceolate, dark green with silver markings and 4 to 5 pairs of primary side veins; petioles, 5 to 15 cm long. Ornamental pot plant. 5, 6(274), 7.

Aglaonema costatum N.E. Br. "aglaonema"

Recent introduction. S. E. Asia. Rare. Perennial herb, up to 1 m; leaf blade, about 12.5 by 7.5 cm, stiff, ovate to heart-shaped, dark green with white markings and 5 to 10 pairs of primary side veins. Ornamental pot plant. 6(273), 7.

Aglaonema marantifolium Bl. "aglaonema"

Recent introduction. S. E. Asia. Occasional. Perennial herb, up to 1 m; leaf blade, 15 to 35 cm long and 7.5 to 12.5 cm wide, oblong, pointed, dark green with light green markings along main and side veins. Ornamental pot plant. 5, 6(271), 7.

Aglaonema cv. "Pseudobracteata" "Chinese evergreen", "aglaonema"

Recent introduction. S. E. Asia? Occasional. Perennial herb, up to 80 cm; leaf blades, 15 to 35 cm long and 7.5 to 12.5 cm wide, dark green with large white and light and dark green markings; petioles white. Ornamental pot plant cultivar. 5, 6(272).

Alocasia cucullata (Lour.) G. Don "Chinese taro"
syn. *Arum cucullatum* Lour.

Recent introduction. India. Occasional. Perennial herb, up to 1.5 m; leaves, up to 30 cm or more in diameter, dark green, long-stalked, rounded heart-shaped; petiole, long. Ornamental pot plant. 5, 6.

Alocasia lowii Hook.f.

Recent introduction. Malaysia. Rare. Perennial herb, up to 2 m; leaves, 30 cm or longer, metallic green, heart- or arrow-shaped, with silver-white veins and edges, edges entire or somewhat wavy; petioles rose colored, up to 30 cm or longer. Ornamental pot plant. 6.

Alocasia macrorrhiza (L.) Schott "giant taro", "elephant ears"
te kabe (K); taamu (Tuvalu)
syns. *Arum macrorrhizon* L.; *Alocasia indica* (Roxb.) Spach; *Colocasia gigantea* Hook.f.; *Colocasia macrorrhiza* (L.) Schott

Recent introduction. Trop. Asia. Occasional. Tall thick-stemmed (up to 15 cm in diameter) herbaceous plant, up to 2 m tall; leaves, up to 1 m long and 60 cm wide, broadly arrow-shaped, leathery, entire or wavy margins; petiole, up to 1 m long. Possibly an aboriginal introduction into Nauru, which was either never adopted as a food plant or was not used at the time of European contact. No reported Nauruan name. Planted ornamental and rare Tuvaluan food plant at Location and in food gardens near Topside Workshops, where a large specimen had been planted and mulched in a plaited pandanus-leaf basket set in the ground. Important staple food plant in Samoa and Tonga and an important supplementary staple food plant in Fiji, eastern Polynesia and on some atolls in Tuvalu and the Tuamotu and Caroline Islands. Swollen tuberous stem cooked as a staple vegetable. Wild or naturalized, ornamental (often variegated), and edible varieties or cultivars exist in many countries, some of which are used only as a famine or emergency food. 5, 6, 7.

Alocasia sanderiana Bull. "alocasia", "kris plant"

Recent introduction. Philippines. Occasional. Perennial herb, up to 1.5 m; leaves, 30 cm or longer, heart- or arrow-shaped, dark green with silver-white veins and edges, reddish below, deeply-lobed edges; petioles up, to 25 to 30 cm long. Ornamental pot plant. 5, 6, 7.

Alocasia cv. "Amazonica"

Recent introduction. Rare. Potplant. Hybrid cross with A. sanderiana. 6(185).

Anthurium andraeanum Lind. "anthurium"

Recent introduction. Trop. America. Rare. Erect perennial, up to 1 m tall; leaves, 15 to 20 cm long and 7.5 to 12 cm wide, oblong, heart-shaped; petiole, longer than blade; flowers subtended by a plastic-like, bright red or orange-pink, heart-shaped spathe, 10 to 12 cm long, flowers borne on a yellow or white spadix, up to 15 cm long. Ornamental pot plant. 6.

Caladium bicolor (Ait.) Vent "artist's pallet", "caladium"
syn. *Arum bicolor* Ait.

Recent introduction. Brazil. Occasional. Perennial herb, up to 35 cm tall; leaf blade, 10 to 30 cm long, attractive, heart-shaped, variegated, patterned with green pink, red or white spots; leaf stalks, 3 to 6 times longer than blade. Ornamental pot plant. 3(58717, 58793), 5, 6, 7.

Colocasia esculenta (L.) Schott "taro", "dasheen"
detaro (N); te taroro (K); talo (T)
syns. *C. antiquorum* Schott; *Caladium esculentum* Vent.

Pre-World War I introduction; possibly originally an unsuccessful aboriginal introduction. Trop. Asia. Occasional. Large perennial herb rising on petioles, up to 1 m, from an underground tuber; leaves, 25 to 50 cm long and 15 to 30 cm wide, clustered, green, heart-shaped or ovate-cordate, peltate, tips pointing down; petioles, up to 1 m;

inflorescence shorter than leaves, spathe yellow, spadix shorter, cylindrical; tuber or corm, up to 30 cm long and 15 cm in diameter, often with up to 2 to 15 side tubers or cormels. Possibly an aboriginal introduction into Nauru, which was either never adopted as a food plant or was not used at the time of European contact. Food plant in Tuvaluan, I-Kiribati, and Chinese gardens at Location and Topside workshops; occasionally planted and mulched in plaited pandanus-leaf baskets. Very important, often dominant staple in other Pacific countries, although recently becoming less important in western Melanesia because of widespread infestations of taro leaf blight (*Phytophthora colocasiae*) and Alomae and Bobone viruses. Corms cooked as a staple food and the tender green leaves, and sometime the petioles, as a spinach or green vegetable. 5, 6, 7(27825).

Cyrtosperma chamissonis (Schott) Merr. "giant swamp taro"

dababai (N); te babai (K); pulaka (T)

syns. *Arisacontis chamissonis* Schott; *Cyrtosperma edule* Schott; *C. merkusii* (Hassk.) Schott; *Caladium cordifolium* Hartzer

Pre-World War I introduction from other areas of Micronesia; possibly originally an unsuccessful aboriginal introduction. New Guinea and western Pacific Is. Uncommon. Large massive perennial tuber-forming herb, up to 3 m high, rising from a large corm; leaf blades, up to 2 m long, but usually less, dark olive-green, erect, ovate-sagittate (arrow-shaped), only very slightly peltate, tip pointing upward, basal lobes rather pointed, sinus deep; petiole, up to 2.5 m or more, but usually less, erect, spiny on the lower part. Immature food plant at Location; small patch in poorly-drained area surrounding Buada Lagoon and six plants cultivated in moist area in mulched plaited pandanus-leaf baskets in Topside Workshop food gardens in 1987. Very important staple root crop and ceremonial food in Tuvalu and Kiribati and other low-lying atoll countries of Micronesia, but evidently not traditionally important in Nauru. Corms cooked as a staple vegetable. 5, 6, 7(27826).

Dieffenbachia leonii Hort. "dumb cane"

Recent introduction. Colombia. Rare. Perennial herb, up to about 70 cm high; leaves, variable in shape, green with more or less regular white areas; probably a horticultural hybrid between *D. maculata* and *D. seguine*. Ornamental pot plant. 6.

Dieffenbachia maculata (Lodd.) Bunt. "dumb cane"

syn. *D. picta* Schott

Recent introduction. Brazil. Common. Thick-stemmed erect perennial herb, less than 1 m tall, with a ringed, cane-like stem; leaves, up to 30 cm long and 15 cm wide, narrowly ovate-oblong but variable, green with many irregular ivory-white flecked markings, midrib strong with 15 to 20 pairs of curved-ascending lateral veins; petiole, about 12 cm long, broadly grooved. Ornamental pot plant; occasionally planted in gardens. Sap causes dermatitis when applied externally and causes mouth paralysis and severe pain when taken in mouth. 3(58677, 58774), 5, 6, 7.

Dieffenbachia seguine (Jacq.) Schott "dumb cane"

Recent introduction. N. S. America and Caribbean. Occasional. Thick-stemmed erect perennial herb, up to 1 m, with a ringed, cane-like stem; leaves variable, narrowly oblong or ovate-oblong but variable, dark-green with irregular white spots and 9 to 15 side veins; petiole, not, or only narrowly grooved. Ornamental pot plant. Exhibits same properties as described for *D. maculata*. 3(58677), 6, 7.

Epipremnum aureum (Lind. ex Andre) Bunt. "taro vine", "pothos aureus"
syns. *Rhaphidophora aurea* (Lind. ex Andre) Birds.; *Scindapsus aureus* (Lind. ex Andre) Engl.; *Pothos aureus* Lind. ex Andre; *Epipremnum pinnatum* cv. "*Aureum*".

Recent introduction. Solomon Is. Occasional. Branched high climbing vine with thick rope-like stems with adventitious rootlets; leaf blades, up to 50 cm long and 35 cm wide, ovate-subcordate, deeply-lobed, petiolate, variegated green and cream or pale-yellow with irregularly-spaced bands on each side of the midrib, lateral veins slightly ascending. Planted ornamental. 3(58724), 5, 6, 7.

Monstera deliciosa Liebm. "monstera", "fruit salad plant", "taro vine", "ceriman"

Pre-World War II introduction. C. America and Mexico. Rare. Perennial epiphytic stout-stemmed herbaceous vine, nodes often with long hanging aerial roots; leaf blades, up to 80 m long, thick, dark-green, heart-shaped, pinnately-lobed or parted, grooved, often conspicuously perforated; petioles, up to 90 cm long; inflorescence with stalk, up to 15 cm long, spathe rather thick, up to 24 cm long, pale-yellowish, spadix up to 20 cm long and 5 cm wide, cone-shaped; fruit, edible berries, up to 1 cm long, numerous, yellowish-green to purplish, edible, borne on spadix. Pot plant and planted ornamental. 3(58727), 5, 6, 7.

Philodendron hastatum C. Koch & Sellow "philodendron"

Recent introduction. Brazil. Rare. Perennial herbaceous climbing vine; leaf blades, up to 25 cm long, oblong heart-shaped to sagittate or hastate, medium-green, shiny; petiole, 15 cm or longer. Ornamental pot plant. 6, 7.

Philodendron scandens C. Koch & Sellow ssp. **oxicardium** (Schott) Bunt."philodendron"
syn. *P. oxycardium* Schott

Recent introduction. Trop. America. Rare. Perennial herbaceous climbing, twining vine; leaf blades, up to 30 long and 20 cm wide, shiny green, heart-shaped, tapering to a fine point; petioles 10 to 20 cm long. Ornamental pot plant. 6(238), 7.

Philodendron sp. "philodendron"

Recent introduction. Trop. America. Rare. Ornamental pot plant. 5 (238), 7.

Scindapsus pictus Hassk. var. **argyraeus** (Engl.) Engl. "silver vine"

Recent introduction. Indomalaya. Rare. Tall fleshy perennial herbaceous vine; leaves, up to 30 cm or longer, thick, leathery, oval to heart-shaped, pointed tips curved to one side, dark green with silver dots or marbling. Ornamental pot plant. 6(225).

Spathiphyllum cv. "Clevelandii" "spathiphyllum", "white sails"

Recent introduction. Rare. Hybrid perennial herb, up to 80 cm; leaf blade, up to 25 cm by 10 cm, dark green, narrow ovate or oblong; flowers, arising on long slender flower stems from the base to above the leaf tops, bearing attractive white flower bracts or spathes and white spikes or spadices, 5 to 10 cm long. Ornamental pot plant. 6, 7.

Syngonium angustatum Schott "syngonium"
syn. *S. podophyllum* sensu Souder non Schott

Recent introduction. Mexico. Occasional to common. Climbing or creeping perennial herb; leaf blades, up to 20 cm long, shining green, palmate, deeply three- to nine-parted, held erect on rigid stems. Pot plant and planted ornamental. 3(58722), 5, 6, 7.

Xanthosoma lindenii (Andre) Engl.

Recent introduction. Colombia. Rare. Perennial erect herb; leaf blades, up to 30 cm long and 7.5 cm wide, spear-shaped, green, principal midrib and side veins white, under surface green; petioles green, up to 30 cm long. Ornamental pot plant. 6.

Xanthosoma sagittifolium (L.) Schott "tannia", "yautia", "cocoyam", "American taro"
detaro (N); te taororo (K); talo Palagi (T)
syn. *Arum sagittifolium* L.

Pre-World War II introduction. W. Indies. Occasional. Large taro-like tuberous perennial herb, up to 2 m or higher; leaf blades, up to 50 cm or longer and 40 cm wide, thick, sagittate (arrow-shaped), glaucous, green to purple-green; petioles, up to 1 m long, arising from a central tuber or corm with up to 10 or more lateral tubers or cormels, each 15 to 25 cm long. Food plant in home gardens at Location and near Nauruan home at Buada; occasionally planted and mulched in pandanus-leaf baskets at Topside work-shops; found primarily in Tuvaluan gardens. Important staple food crop throughout Melanesia and Polynesia. Possibly introduced into Nauru in the late 19th or early 20th century, but never becoming as important as in other areas of the Pacific. Side cormels cooked as a staple and tender young leaves cooked as a green vegetable or spinach. 5, 6, 7.

ARECACEAE/PALMAE (Palm Family)

Caryota urens L. "fishtail palm", "wine palm", "toddy palm"

Recent introduction. Trop. Asia. Rare. Erect single-stemmed palm, up to 10 m; fronds, up to 5 to 6 m long, drooping, bipinnate, with wedge-shaped fishtail-like leaflets, irregularly and jaggedly toothed; flowers, numerous, grouped in threes, one female between two male flowers, hanging in clustered panicles, each produced successively lower on the trunk from the leaf (frond) nodes, until the lowest node flowers and produces seed, after which the plant dies; fruit, ovoid, red, juicy, surrounding a kidney shaped seed. Planted ornamental. 6.

Chrysalidocarpus lutescens H. Wendl. "golden cane palm", "golden-fruited palm"

Recent introduction. Madagascar. Rare. Small erect many-trunked clump-forming palm, up to 5 m or more high, with smooth bamboo-like ringed trunks; fronds, arching, light green, turning yellow-orange with age, deeply divided into long narrow forked segments, each about 2.5 cm wide; flowers, borne in clusters among the leaves, male and female flowers separate in the same cluster; fruit, yellow, date-like. Planted ornamental. 5, 6.

Cocos nucifera L. "coconut palm"
ini (N); te ni (K); niu (T)

Aboriginal introduction. S. Asia and Indian Ocean Islands. Abundant. Tall erect single-stemmed palm with a slender, more or less curved or inclined, trunk, up to 30 m tall; leaves, up to 4 m or longer, clustered at top of trunk, frond-like, pinnate, with numerous narrow oblong-lanceolate leaflets (pinnae), 25 to 90 cm long; flowers, in clusters on a simple-branched spadix, up to 1.2 m or longer, which originates in the axils between the leaves, with female flowers at the base of the branchlets and small male flowers near the tips and over the remainder of the branchlets; each spadix subtended by a stout woody, boat-shaped, beaked bract or spathe; fruit, 15 to 30 cm long, subglobose to ovoid or ellipsoid, one-seeded, with a thick fibrous husk surrounding a hard nut filled with hard white oily edible pulp and, when young, with sweet water. Planted extensively on coastal strip, around Buada Lagoon, near roads in strip-mined areas; occasional on plateau and escarpment; common along strand; common in Nauruan home gardens and occasionally planted around contract workers quarters at Location and Topside workshops. Cultivars include *inur*, *ito*, *ita*, *inamaro* and *ini*. Formerly important for copra production for export; trunks used in house construction and for animal pens; midrib of frond used for flooring and walls of houses; young fronds used for weaving baskets, food containers and parcels, mats, housing thatch, fans, hats, dividers for communal fish farming in Buada Lagoon, and other plaited ware and for making skirts (*ridi*); old and young fronds used for roofing; coir and dry leaves important as tinder in making fire by friction and carrying fire; midrib of leaflets or pinnules used in brooms and in weaving; soft endosperm (meat) and water (milk) of young, green nuts (*ini*) consumed; meat of mature nuts (*eanikiwi*) grated and eaten in a variety of ways and squeezed and boiled, usually with flowers or leaves, to make perfumed coconut oil; coconut endosperm ("meat") has been an important staple throughout the small-island Pacific and in coastal areas of larger islands, with some people receiving up to 70% of their dietary calories from this source; it was also undoubtedly the main staple plant food of Nauruans in the past and a major food for chickens and pigs; coir or husk of both green and mature nuts used to make strong fibre and cordage (sennit) for strainers, affixing tool handles, boat and house lashings, fishnets and lines, belts, canoe caulking, corks or stoppers, slings; dried fronds, husks, and shells used as fuel for cooking; shells used for making charcoal, one of the main uses being to fuel hand irons in the past; shells used to make drinking cups in the past; sap from flower spathe tapped to make toddy (*karawai*) and then often boiled down to make a molasses-like syrup (*kamaimai*); toddy often allowed to ferment to become alcoholic "sour" toddy; loose burlap-like tissue (*inini*) at the base of the fronds used to strain coconut milk; dust or pollen collected on lower ends of fronds used as a blood coagulant and disinfectant; coconut oil use to treat tinea; inside of very small immature nuts used in post-natal medicine; very young leaves, without the midrib, chewed and used as a medicine for fever and infantile beriberi. 2, 3, 5, 6, 7.

Livistonia chinensis (Jacq.) R. Br. "Chinese fan palm", "fountain palm"
syn. *Latania chinensis* Jacq.

Recent introduction. China, Ryukyu and Bonin Islands. Rare. Attractive single-stemmed erect palm, up to 10 m tall, but normally less than 5 m, with a ringed gray trunk; fronds, rounded or palmate, fan-like, about 1.5 m or more in diameter, pleated in middle and divided radially into 70 to 90 leaflets, about 4 cm wide, each with yellow-green midribs and split (bifid) drooping tips; petioles, up to 2 m long and 15 cm wide, with stout tooth-like spines, up to about 1.5 cm long, on the lower part; flowers, borne in large numbers in clusters on branchlets of long branched inflorescences; fruit, up to 2 cm long, dull bluish-green, olive-like. Ornamental pot plant and planted ornamental. 6, 7.

Phoenix sp. "date palm"

Recent introduction. Rare. Erect single-stemmed palm with feather-like pinnate fronds. Planted ornamental on Command Ridge. 5, 6(61).

Pritchardia pacifica Seem. & Wendl. "Pacific fan palm", "Fiji fan palm"
dabam (N); te bam (K)
syn. *Eupritchardia pacifica* (Seem. & Wendl.) O. Ktze.

Recent introduction. Fiji, Tonga, and Samoa. Rare to occasional. Erect single-stemmed spineless palm up to 10 m tall; fronds, 1 m long and 1.2 m wide, spreading from the crown, wedge- or fan-shaped, pleated or folded in middle, when young, and divided radially into numerous leaflets with forked, scarcely drooping tips; petioles, about 1.5 m long, stout; flowers, numerous brownish, borne in clusters on branched axillary panicles; fruit, about 1.2 cm in diameter, ovoid, green to blackish, 1 seeded. Planted ornamental at the Meneng Hotel. Small edible fruit consumed in Fiji, Tonga and elsewhere in the Pacific but reportedly not eaten in Nauru. 3, 5, 6, 7.

Roystonea elata (Bartr.) Harper "royal palm"
dabam (N)
syns. *Palma elata* Bartr.; *Roystonea regia* (HBK.) O.F. Cook; *Oreodoxa regia* HBK.

Recent introduction. Cuba and Florida. Rare. Erect single-stemmed symmetrical palm, up to 15 m or taller, with a smooth greenish-grey to whitish trunk; fronds, up to 3 m long, pinnate, arching from crown and radiating from a long green cylinder of leaf sheaths which looks like an extension of the trunk; leaflets, nearly 1 m long, diverging at various angles; inflorescence, up to 1 m long, borne below the leaves, many-branched, with a long, slender boat-shaped spathe; flowers, usually in groups of 3, of which 2 are staminate and 1 pistillate, cream-colored with violet stamens; fruit, less than 2 cm long, ovoid, purplish, one-seeded. Planted ornamental. 5(137), 6, 7.

BROMELIACEAE (Pineapple Family)

Ananas comosus (L.) Merrill "pineapple"
te bainaboro (K); fara, painapolo (T)
syns. *Bromelia comosa* L.; *B. ananas* L.; *Ananas sativus* Schult.f.; *A. ananas* (L.) Karst.

Pre-World War I post-European contact introduction. Brazil. Rare. Green to bluish-grey short-stemmed perennial herb, up to 1 m high; leaves, sword-shaped, succulent, pointed and sometimes armed (spiny), arranged in a bushy rosette; inflorescence, terminal, many-flowered head with small blue flowers; fruit, a pinecone-shaped or globose syncarp, 15 to 30 cm long, yellow-brown to green, surmounted by a crown of small leaves, which is composed of many 6-sided berries arranged spirally and embedded in yellow pulp. Food plant in home gardens at Location and Topside Workshops and occasionally in expatriate home gardens. Fruit edible. 3, 5, 6.

Nidularium innocenti Lem.

Recent introduction. Brazil. Rare. Perennial rosette-forming herb, up to 50 cm of higher; leaves, strap-shaped, finely-toothed, radiating from a rosette, overlapping bases forming water-holding reservoirs; flowers, central, small, white with showy red-orange bracts. Ornamental pot plant. 6.

Tillandsia usneoides L. "Spanish moss", "Florida moss", "long moss"

Recent introduction. Trop. America. Rare. Pendulous, rootless epiphyte with slender, wiry stems, up to 4 m or longer; leaves, 2.5 to 7.5 cm long, grey, narrow, curved, threadlike, scattered at regular intervals along stem; flowers, nearly 12 mm long, axillary, inconspicuous, single, yellowish. Planted ornamental. 6.

Vriesia sp. "vriesia"

Recent introduction. Trop. America. Rare. Perennial herb with stiff smooth-edged variegated leaves arranged in a rosette. Ornamental pot plant. 6.

CANNACEAE (Canna Family)

Canna indica L. "Indian shot", "canna"

Recent introduction. W. Indies. Rare. Perennial herb, to over 1 m high; leaves, 15 to 50 cm long and 10 to 25 cm wide, oval to narrow, rather fleshy, borne on long slender erect green stems, up to 1 to 1.5 m long; flowers, orchid-like, red, yellow or speckled (variegated), in loose erect clusters; fruit, warty, black, capsular, nearly globose, containing a variable number of round black seeds. Planted ornamental. Most ornamental specimens are showy hybrids or selections. 6(189), 7.

COMMELINACEAE (Dayflower Family)

Dichorisandra thyrisiflora Mikan "blue ginger"

Recent introduction. Brazil. Rare. Perennial herb up to 1 m tall; leaves, shiny-green, spirally arranged; flowers, terminal, blue to violet-blue and white, borne on a stalk in a cone-shaped flower panicle. Planted ornamental. 6.

Rhoeo spathacea (Sw.) Stearn "tradescantia", "oyster plant", "Moses in a boat"
syns. *Tradescantia spathacea* Sw.; *T. discolor* L.'Her.; *R. discolor* (L'Her.) Hance

Recent introduction. Mexico and W. Indies. Occasional. Perennial short-stemmed herb, up to 40 cm high; leaves, up to 20 to 30 cm long and 4 to 6 cm wide, lance- or sword-shaped, stiff, succulent, shining green above, purplish beneath, borne in crowded rosettes; flowers, small, white, in axillary clusters within boat-shaped purple bracts; fruit, capsular, 3-valved. Pot plant and planted ornamental; planted along borders in ornamental gardens. 3(58703), 5, 6, 7.

Setcreasia purpurea B. K. Boom "purple tradescantia", "purple heart"

Recent introduction. Mexico. Rare. Perennial smooth-stemmed trailing herb, up to 30 cm high; leaves, up to 15 cm long and 3.5 cm wide, ovate-acuminate, black-purple above and purple beneath, with woolly hairs along margins; long purple flowering stems, up to 30 cm, bearing purple bracts and rose-pink flowers in dense clusters. Ornamental pot plant. 3(56779), 6, 7.

Tradescantia fluminensis Vell. "wandering Jew"

Recent introduction. S. America. Rare. A trailing perennial herb with green or purplish wiry stems; leaves, 2.5 to 7.5 cm long, oblong, bright green or white-striped, sometimes purplish beneath; flowers, small rose-purple to whitish, each with two leafy bracts. Ornamental pot plant. 6.

Zebrina pendula Schnizl. "purple wandering Jew"

Recent introduction. Mexico. Occasional. A fleshy trailing perennial herb; leaves, up to 6 cm long, ovate, reddish-purple beneath and silver-green with purple bands down the middle and around the edges above; flowers, 3-petaled, pink to rose-purple, borne in bract-like leaves near stem tips. Ornamental pot plant. 3(56780), 5, 6, 7.

CYPERACEAE (Sedge Family)

Cyperus alternifolius L. "umbrella plant", "umbrella sedge"

Recent introduction. Madagascar. Rare. Tufted sedge with many stout dark green flowering stems, up to 120 cm or higher; basal leaves reduced to lanceolate, acuminate sheaths, 10 to 20 cm long; flower heads, terminal, umbel-like, composed of arching leaf-like bracts, up to 25 cm long and 1 cm wide, borne at the end of stems, and umbel-like inflorescences, 7 cm across, on rays, up to 10 cm long, with numerous spikelets, up to 3 cm long, crowded at the tips; fruit, 3-angled achene, less than 1 mm long. Planted ornamental. 6, 7.

Cyperus compressus L. "sedge"

Recent introduction? Pantropical. Occasional. Tufted sedge with erect to spreading thin triangular stems, up to 40 cm long; leaves, 1.5 to 3 mm wide, threadlike, shorter than sheathing stems, which are up to 3 cm long, and often reddish; spikelets, 1 to 2.5 cm long and 3 to 5 mm wide, green, 12 or more borne in umbellate clusters subtended by 3 or more leaf-like bracts, each about 3 mm long; fruit, a 3-angled, obovoid achene, sides slightly concave, brown to almost black. Weed growing in rather dense populations in low ground near Buada Lagoon and swampy area near bottom of escarpment. 3(58644), 6.

Cyperus iria L. "sedge"

Recent introduction. Sedge up to 40 cm high; leaves, few, shorter than culms; inflorescence, branched spikes, about 2.5 cm long, 12- to 20-flowered, spikelets about 6 mm long, bracts longer than inflorescences; fruit, a 3-angled, narrowly ovoid, yellow-brown achene. Rare weed. 5(90a).

Cyperus javanicus Houtt "sedge", "marsh cypress"

reyenbangabanga (N); te ritanin (K); mouku (T)

syns. *C. canescens* Vahl; *C. pennatus* Lam.; *C. stuppeus* Forst.f.; *Mariscus javanicus* (Houtt.) Merr.; *M. albescens* Gaud.; *M. pennatus* (Lam.) Domin; *M. stuppeus* (Forst.f.) Merr.

Indigenous? Paleotropical. Abundant. Large perennial tufted sedge, up to 1 m high, with triangular stems; leaves, 7 mm or more wide, are often longer than flowering stems, firm, rough, serrulate; inflorescence, compound umbrella-like flower clusters, to about 15 cm across, with branched rays, up to 10 cm long, bearing spikes, to nearly 2.5 cm to 3.5 cm long, and crowded green to brownish spikelets, about 4 to 8 mm long; fruit, 1.5 mm long, 3-angled, ellipsoid, dark-brown or black achene. Found growing wild in isolated clusters and tufts and in colonies or dense populations in moist habitats on the coastal strip, surrounding Buada Lagoon, on the inner border of the coastal strand, and occasionally in mined areas. Stems used as stringers for garlands and for stringing fish; swollen bottoms eaten occasionally in the past. The name "reyenbangabanga" means literally the "surrounding border", referring to the way in which *C. javanicus* surrounds parts of Buada Lagoon. 3(53634), 4(160N), 5(90), 6(218), 7(27824), 8(9576).

Cyperus papyrus L. "papyrus", "Egyptian paper"

Recent introduction. Africa and Mediterranean. Rare. Tall perennial clump-forming green-stemmed sedge, 1 to 4 m high; leaves, basal ones reduced to bladeless sheaths, the involucral leaves much shorter than inflorescence; inflorescence, umbel-like flower cluster of tufted yellow-green flower heads on drooping threadlike rays, 10 to 40 cm long, with linear spikelets, 6 to 10 mm long and 1 mm across, bearing 6 to 20 scales; fruit, an oblong, 3-angled achene. Planted ornamental. 5, 6.

Cyperus rotundus L. "nut sedge", "nut grass"

ibugibugi (N); te mutemute (K); mouku (T)

syn. *C. hexastachyos* Rottb.

Pre-World War II introduction? Cosmopolitan. Common. Perennial tufted erect sedge, 10 to 50 cm high, with hard, scaly brown-black tubers borne on underground runners or rhizomes; leaves, 5 to 15 cm long and 2 to 5 mm wide, grass-like, folded along the midrib; inflorescence, reddish-brown flower spikelets, 1 to 2 cm long, and 2 to 4 leaf-like bracts, 1 to 12 cm long, borne on unequal rays, to 6 cm long, in loose terminal umbels borne at the top of three-angled flowering stems (culms), 10 to 40 cm tall; fruit, about 1.5 mm long, brown, oblong, 3-sided achene. Weed in gardens; growing in extensive stands as lawns; in swamps in Meneng. 3(58686), 4(149N), 5(89), 6, 7, 8.

Eleocharis ochrostachys Steud. "sedge"

syn. *E. laxiflora* (Thw.) H. Pfeiff.

Recent introduction. Asia. Rare. Erect perennial sedge, 35 to 70 cm tall, with pithy stems; leaves, reduced to basal sheaths; inflorescence, a cylindrical spikelet, 10 to 20 cm long and 3 to 4 mm across, with numerous green to yellowish-brown scales, 4 to 5 mm long, and 5 to 7 bristles; fruit, 1.5 to 2 mm long, 2-sided, obovate, shiny brown to gray achene. Planted ornamental. 6(210).

Fimbrystylis cymosa R. Br. "sedge", "beach sedge"

ibugibugi, ibiugbiugi; te uteute ni mane (K); mouku (T)

syns. *F. spathacea* Roth; *F. pyncnocephala* Hillebr.; *F. glomerata* (Retz.) Nees ex K. Schum. non (Schrad.) Nees; *F. atollensis* St. John; *F. wightiana* Nees

Indigenous. Pantropical. Abundant. Perennial tufted sedge, 10 to 50 cm high, with erect 3-angled stems; leaves, 5 to 30 cm long and 1.5 to 4 mm wide, numerous, stiff, linear, densely-clumped; inflorescence, a head or simple umbel with 3 to 8 primary rays, 1 to 4 cm long, and single or clustered brown spikelets, 1 to 4 mm long, in globose heads, 5 to 10 mm in diameter, borne on 3-angled flowering stems (culms), 10 to 60 cm high; fruit, less than 1 mm long, 2- to 3-sided, obovate, brown-black achene. Found growing in clusters or tufts in open and semi-open places on the coastal strip and in mined areas on the plateau. No reported use on Nauru. 2, 3(58613, 58670), 5, 6(210), 7.

DIOSCOREACEAE (Yam Family)

Dioscorea alata L. "yam", "greater yam", "winged yam"

te iam (K); ‘ufi (T)

Pre-World War II introduction. S. E. Asia. Rare. Herbaceous or shrubby, twining, high-climbing tuberous vine with square, more or less winged, unarmed, four-angled stems; leaves, up to 12 to 25 cm or longer and 8 to 15 cm wide, opposite, ovate or heart-shaped (cordate), palmately 5- to 11-nerved; petiole, nearly half, to nearly as long as blade; flowers, rarely-seen, small, greenish, in narrow terminal axillary panicles, up to 30 cm or more long; tubers, large, up to 10 kg or more in weight, variable-sized, globose, cylindrical or lobed, black- to brown-skinned, with white to purplish flesh. Food plant in home gardens at Location and Denigomodu. Important staple food crop in many parts of Melanesia, Polynesia and Pohnpei (Ponape), Yap and other high islands in Micronesia, where numerous named cultivars are recognized, but insignificant in Nauru. Tuber cooked as a staple vegetable. 5, 6.

Dioscorea esculenta (Lour.) Burkill "lesser yam", "sweet yam", "Goa yam"
syns. *Oncus esculentus* Lour.; *Dioscorea fasciculata* Roxb.

Pre-World War II introduction. S. E. Asia. Rare. Herbaceous or woody, twining, high-climbing tuberous vine with cylindrical thorny or armed stems; leaves, 10 to 15 cm long and wide, alternate, heart-shaped or orbicular, woolly-pubescent; petioles as long as the blades; flowers, 4 to 5 mm wide, rarely-seen, small, green, borne in slender axillary panicles, up to 40 cm long; tubers, 15 to 20 cm long, clustered, ovoid, potato-like, with thin brownish skin and white, slightly sweet flesh. Food plant in home gardens at Location and Meneng. Important staple in parts of Papua New Guinea and Solomon Islands and a supplementary staple crop in many areas of Melanesia, Polynesia and Micronesia. Tuber cooked as a staple vegetable. 5, 6.

IRIDACEAE (Iris Family)

Gladiolus sp. "gladiolus"

Recent introduction. S. Africa. Rare. Erect herbaceous bulbed annual, up to 1 m or higher, of which many hybrid cultivars exist; leaves, up to over 60 cm long and 2 to 3 cm wide, erect, strap- or sword-shaped; flowers, 5 cm or more in diameter, few to many, showy, white, yellow, red or purplish, often variegated, with curved funnel-shaped tubes and oblong segments, born in 1-sided spikes on flowering stems which are longer than the leaves. Planted ornamental. 5, 6, 7.

Iris sp. "iris"

Recent introduction. Origin? Rare. Erect herbaceous rhizomatous perennial, up to 60 cm or higher, of which many hybrid cultivars exist; leaves, several, flat, narrow, forming a fan-shaped cluster at the base of an erect flower stem; flowers, blue to purplish-blue. Planted ornamental. 5, 6(100).

Tigrida pavonina (L.f.) Ker-Gawl. "tiger flower"

Recent introduction. Mexico and Guatemala. Rare. Erect herbaceous bulbed perennial, up to 75 cm tall; leaves, about 30 cm long, stiff, narrow, almost pleated; inflorescence, a branched or unbranched flower stem, up to 60 cm or more, bearing three-lobed, red, orange, yellow or white, often spotted, flowers, 7 to 15 cm in diameter, which appear one after another from bracts, 7 to 12 cm long. Planted ornamental. 6.

LILIACEAE (Including Agavaceae and Amaryllidaceae)(Lily Family)

Agapanthus africanus (L.) Hoffmannsegg "African lily", "lily of the Nile"

Recent introduction. S. Africa. Rare. Erect perennial herb, up to 60 cm tall; leaves, strap-shaped, evergreen; inflorescence, tall flowering stems bearing showy flower heads with many blue, violet-blue or white funnel-shaped flowers, each about 5 cm long. Planted ornamental. 6.

Agave americana L. "century plant", "malina"

Recent introduction. Mexico. Rare. Large stemless erect perennial succulent herb, up to 2 m or higher; leaves, 80 to 160 cm long and 15 to 20 cm wide, thick, fleshy, pointed and spined, variegated with yellow to white margins, borne in a massive rosette of 30 to 60 leaves; flowers, 7.5 cm long, yellow-green, borne in clusters on a tall pole-like branching stem, up to 6 to 10 m high, arising from the center of the rosette. Planted ornamental. 5(68), 6.

Agave rigida Mill. "sisal", "sisal hemp", "malina", "agave"
te robu (K)
syn. *A. sisalana* Perr.

Pre-World War II introduction? Mexico. Occasional. Large stemless perennial succulent herb, up to 2 m or higher; leaves, up to 150 cm long and 10 to 15 cm wide, thick, stiff, fleshy, spine-tipped, bluish, arranged in a large rosette; flowers, up to 5 cm long, shortly-tubular, yellow-green, borne in panicles on a tall branching stem, up to 8 m high, arising from the center of the rosette. Established locally, especially along edges of old strip-mined area. Grown for export in some tropical areas for the fibre from its leaves which is made into rope and other products. 3(58739), 5, 6(215), 7.

Allium ascalonicum L. "shallot"
te anian (K); ts'ung (C)

Pre-World War II introduction. Palestine. Occasional. Small erect green herb, up to 35 cm; leaves, 20 to 35 cm long and 5 to 15 mm wide, narrow, strap-shaped, growing from many clustered individual white to reddish bulbs, surrounding a single planted bulb, which separate into segments or "cloves". Cultivated in Chinese food gardens in beds and containers at Location and Topside workshops. Pungent bulbs and tender leaves eaten raw or cooked as a spice or vegetable. 5, 6, 7.

Allium cepa L. "bulb onion", "common onion"
te anian (K)

Recent introduction. Persia. Rare. Herb with hollow flattened tubular leaves and a well-developed white or light-green, generally single, bulb with white to yellow-brown skin. Single immature plant in Chinese food garden at Location. 6.

Allium fistulosum L. "green onion", "spring onion", "Welsh onion", "Japanese bunching onion"
te anian (K); ts'ung (C)

Pre-World War II introduction. E. Asia. Occasional. Erect green herb, up to 50 cm tall; leaves, 25 to 50 cm long and 1 to 2 cm wide, green, round, tubular, clustered, with white, slightly swollen stems which produce no bulbs. Cultivated food plant in Chinese gardens at Location. Pungent tender leaves and stems eaten raw or cooked as a spice or vegetable. 5, 6.

Allium porrum L. "leek"

Recent introduction. Eurasia. Rare. Herb with long flattened and folded leaves, up to 70 cm long, a long white neck below the leaves, and a small white bulb. Single plant growing in food garden at Location. 6.

Allium sativum L. "garlic"
suen, suen t'au (C)

Pre-World War II introduction. S. Asia. Occasional. Erect green herb, up to 30 cm high; leaves, 10 to 30 cm long and 1 to 2 cm wide, flat, strap-shaped, with a well-developed segmented bulb with a strong persistent odor, which separates into several segments or "cloves". Plant in Chinese gardens at Location. Grown from bulbs, mainly for its pungent edible green leaves which are used as a spice or green vegetable in Chinese cooking. 5, 6.

Allium schoenoprasum L. "chives"

Recent introduction. N. hemisphere. Rare. Erect herb, up to 25 cm high, forming grass-like clumps; leaves, 10 to 25 cm long and 1.5 to 3 mm wide, fine, tubular, with a poorly developed bulb. Pot herb cultivated in container at Cliff Lodge. Tender green leaves used as a spice by European residents. 5, 6.

Allium tuberosum Rottler ex Sprengle "Chinese chives"
sai ts'ung (C)

Pre-World War II introduction. E. Asia. Common. Erect herb, up to 30 cm high; leaves, 20 to 30 cm long and 3 to 4 mm wide, flat, ribbon-like, with a poorly developed bulb. Cultivated in Chinese food gardens at Location and Topside workshops for its edible green leaves. 5, 6, 7.

Asparagus aethiopicus L. "asparagus fern", "Sprenger asparagus"
syns. *A. densiflorus* (Kunth) Jessup; *A. sprengeri* Reg.

Recent introduction. S. Africa. Occasional. A much-branched arching wiry-stemmed perennial, up to 1 m, bearing open whorled fern-like leaf clusters; "leaves", up to 2 to 2.5 cm long, shiny, flat, narrow, pale-green, lanceolate; flowers, small, fragrant, pinkish; fruit, small, red, 1- to 3-seeded berries, about 8 mm in diameter. Ornamental pot plant. 3(58711), 5, 6(167, 180).

Asparagus setaceus (Kunth) Jessup "asparagus fern"
syns. *Asparagopsis setacea* Kunth; *Asparagus plumosus* Baker

Recent introduction. S. Africa. Rare. Slightly woody and spiny climbing, many-branched perennial, up to 1 m, forming flat horizontal fern-like sprays; "leaves", up to 8 mm long, fine, fern-like or needle-like; flowers, minute, white; fruit, small, blackish, 1- to 3-seeded berries. Ornamental pot plant. 6(169), 7.

Chlorophytum capense (L.) Voss "spider plant", "ribbon plant", "bracket plant"
syns. *C. comosum* (Thunb.) Jacq.; *C. elatum* R. Br.

Recent introduction. Africa. Rare. Evergreen perennial herb, up to 30 cm or higher, with tuberous rhizomes; leaves, 15 to 30 cm long and 1.5 to 2.5 cm wide, rosetted or tufted, grass-like, arching, variegated with mid-green and white or yellow longitudinal bands; flowers, small, starry-white, 6-parted, borne in loose clusters on flower stems, up to 1.5 m long, and tipped with leafy offshoots or plantlets; fruit, a leathery 3-angled capsule with flat seeds. Ornamental pot plant. 3(58690), 6.

Cordyline fruticosa (L.) A. Chev. "cordyline", "ti-plant" (Hawaii)
te rauti (K); ti (T)
syns. *Convallaria fruticosa* L.; *Cordyline terminalis* (L.) Kunth; *Taetsia fruticosa* (L.) Merr.; *T. terminalis* (L.) W. F. Wight

Recent introduction. Trop. Asia or Australasia? Occasional. Woody erect shrub or tree-like branched or unbranched perennial, up to 2 m or taller; leaves, up to 60 cm long and 15 cm wide, lanceolate or oblong, smooth, tough, shiny dark-green to rust or red, borne in rosettes clustered in spirals near the tips of the branches; petioles, 5 to 15 cm long; flowers, numerous, white to lilac-tinted, borne on large branching terminal panicles, about 30 cm long; fruit, globose, about 5 mm in diameter, thinly fleshy, red, purplish, or yellowish; seeds,, obovoid, black, glossy; some cultivars with a large edible tuberous root. Planted ornamental and pot plant. Very important ceremonial and magico-religious plant, a traditionally important supplementary food plant and famine food, and important decorative plant, with numerous other cultural uses in Melanesia and Polynesia, where numerous named cultivars and hybrids exist. The large sweet white tubers of some cultivars are baked for days in earthen ovens to be consumed as food, sweets or confectionery, or, in Hawaii, made into an alcoholic beverage known as *okolehao*; leaves important for parcelling food and dancing skirts and body ornamentation. Apparently a recent introduction into Nauru with no reported non-ornamental local uses. 3(58676), 5, 6(186), 7.

Crinum asiaticum L. "spider lily", "crinum lily", "grand crinum"
dagiebu, dagibu (N); te kiebu (K); tapua, talotalo (T)
syns. *C. pedunculatum* R. Br.; *C. procerum* Bak.

Recent introduction. Trop. Asia. Occasional. Perennial erect bulbous herb, up to 1.5 m or taller; leaves, up to 1.5 m long and 20 cm wide, many, arching, fleshy, strap-shaped, green to yellow, rising from a whitish stalk; inflorescence, an umbel-like flowerhead bearing 10 or more spider-like, 6-parted, fragrant, white flowers, with flowering tubes, up to 10 cm long, white filaments and purplish styles, borne on a flattened fleshy flowering stem (scape); fruit, subglobose, beaked, 1- to 2-seeded; seeds, large, fleshy. Planted ornamental. Flowers used in garlands; roots crushed for the treatment of filariasis. 3, 5(122), 6(216), 7.

Crinum augustum Roxb. "crinum lily", "Queen Emma lily"
dagiebu, dagibu (N); te kiebu (K)

Pre-world War II Introduction? Mauritius and Seychelles. Large perennial erect bulbous herb, up to over 1 m tall; leaves, up to 1.5 m long and 12 cm wide, stemless, strap-shaped, tapering; flowers, white with dark reddish-purple markings, segments, 15 to 16 cm long by 2 to 2.5 cm wide, filaments and style purple, borne on a flower stalk which divides into numerous short cluster-bearing stalks. Occasional. Planted ornamental; flowers used in garlands. 5, 6, 7(22319).

Crinum macrantherum Engl.
dagiebu, dagibu (N)?
syn. *C rumphii* Merr.

Pre-World War II introduction. Listed as C. macrantherum on Burgesses'(1935) list. Rare? Planted ornamental. 2.

Crinum moorei Hook.f. "veld lily"

Recent introduction. S. Africa. Rare. Perennial bulbous herb, up to 1 m high; leaves, 60 to 90 cm long and 7.5 to 10 cm wide, lanceolate, smooth; flowers, fragrant, rose, pink or white, funnel-shaped with curved tubes, up to 10 cm long and 2.5 cm wide, and segments, up to 10 cm long. Planted ornamental. 5(63).

Dracaena deremensis Engler "dracaena"
syn. *Pleomele deremensis* (Engler) N.E. Br.

Recent introduction. Trop. Africa. Rare. Woody palm-like erect shrub, up to 1.5 m or taller; leaves, up to 45 cm by 5 cm, sword-shaped, longitudinally green and white-striped, apetiolate. Ornamental pot plant. 6, 7.

Dracaena fragrans (L.) Ker-Gawl. "dracaena", "dragon flower", "pleomele"
syns. *Alectris fragrans* L.; *Pleomele fragrans* (L.) Salisb.

Recent introduction. Trop. Africa. Rare. Woody palm-like erect shrub, up to 3 m or higher; leaves, up to 90 cm long by 10 cm wide, arching, green or longitudinally green and yellow-striped, apetiolate; flowers, fragrant, greenish-yellow, borne in panicles; fruit, orange-colored, unpleasant-smelling berry. Ornamental pot plant. 5, 6, 7(112).

Dracaena sanderiana Sander "dracaena", "ribbon plant"
syn. *Pleomele sanderiana* (Sander) N.E. Br.

Recent introduction. Trop. Africa. Rare. Erect woody shrub, up 1 m or taller; leaves, to about 17 cm long and 3 cm wide, petiolate, arching, dark green, with white edges, set at intervals along the stem; petioles, 7.5 to 10 cm long. Ornamental pot plant. 7.

Furcraea foetida (L.) Haw. "Mauritius hemp"
syns. *F. gigantea* Vent.; *Agave foetida* L.

Recent introduction. Trop. S. America. Rare. Stemless perennial herb, up to 1.5 m or higher; leaves, 1 to 1.8 m long and 10 to 15 cm wide, stiff, fleshy, sword-shaped, spine-tipped, arranged in a rosette; flowers, strong-scented, greenish-white, borne in terminal panicles on a tall branching stem, up to 7 m high. Found in ruderal sites. May have been confused with *Agave rigida* by Swarbrick. 8.

Gloriosa superba L. "climbing lily", "gloriosa", "glory lily"

Recent introduction. Trop. Africa. Occasional. Climbing perennial lily, reaching up to 1.5 m in length; leaves, glossy, twisted, narrow, tapering into tendrils; flowers, up to 7.5 cm long, striking, 6-parted, bright red and yellow, with curled petals which turn inside out and point upwards when fully open. Planted ornamental and pot plant. 5, 6(177).

Hippaestrum puniceum (Lam.) Urban "Barbados lily", "amaryllis"
syns. *Amaryllyis punicea* Lam.; *Hippaestrum equestre* (Ait.) Herb.; *Amaryllis equestris* Ait.

Recent introduction. Trop. America. Bulbous herb, up to 60 cm or higher; leaves, 30 to 48 cm by 4 cm, 6 to 8 in number, strap-shaped, dark green, developing after the flowers have died; flowers, 10 to 12 cm across, funnel-shaped, red or salmon-colored with green centers, borne in groups of 2 to 4 on a stout flowering stem, 30 to 60 cm high. Planted ornamental. 3(58718), 6, 7.

Hosta plantaginea (Lam.) Asch. "plantain lily", "funkia"

Recent introduction. China and Japan. Rare. Clump-forming herb, up to 50 cm high; leaves, ovate with many oblique grooves or ribs spreading from the midrib; flowers, funnel- or bell-shaped, small, white or blue-lilac, borne in narrow spikes on a flower stalk. Planted ornamental. 5(62), 6.

Hymenocallis littoralis (Jacq.) Salisb. "spider lily"
lili (N); te ruru ni mane (K); lili (T)
syn. *Pancratium littorale* Jacq.

Recent introduction. Trop. America. Occasional. Erect bulbous perennial herb, up to 75 cm or higher; leaves, 45 to 75 cm long and 2 to 7 cm wide, strap-shaped, fleshy; inflorescence, an umbel of 3 to 8 striking, white, funnel-shaped, spider-like, fragrant flowers with narrow tubes, 10 to 17 cm long, and long slender spreading petals, connected at the base by a thin web, borne at the top of a thick, flattened flowering stem, 30 to 75 cm long; fruit, green, smooth, 3-celled. Planted ornamental. 3(58782), 5(129), 6, 7.

Littonia modesta Hook "climbing lily"

Recent introduction. S. Africa. Rare. Unusual climbing herb, reaching 60 to 90 cm in length; leaves, narrow, shining, green, spaced along an unbranched stem, each ending in a small tendril; flowers, rich-orange, wide, spreading, bell-shaped, borne singly in the axils of the leaves. Planted ornamental. 6.

Narcissus sp. "daffodil", "narcissus"

Recent introduction. Europe. Rare. Bulbous herb, up to about 25 cm; leaves, flat; flowers, fragrant, white to yellow, on individual stalks borne at the top of a flattened stem. Ornamental pot plant. 6.

Sandersonia aurantiaca Hook.f. "golden lily of the valley", "Chinese lanterns"

Recent introduction. Natal. Rare. Tuberous perennial herb, up to 45 cm; leaves, stalkless, spear-shaped, tapering to a fine point, borne up the slender stem in decreasing size; flowers, showy, orange, lantern-shaped, borne on long pendant stalks from the axils of the leaves on the upper half of the main stem. Ornamental pot plant. 6.

Sansevieria trifasciata Prain "bowstring hemp", "mother-in-law's tongue"

Recent introduction. Trop. W. Africa. Occasional. Erect evergreen perennial, up to 1 m high, with orange turmeric-like rhizomes; leaves, 30 to 90 cm long and 2.5 to 7.5 cm wide, fleshy, erect, sword-shaped, tapering to a sharp subulate point, decorative and cross-banded on both sides with shades of dark green to yellowish to greyish-green, some varieties with creamy-yellow vertical margins; flowers, whitish to yellowish or greenish, tubular, borne in clusters on a flowering stem (scape) which is slightly shorter or as long as the leaves; fruit, globose, orange with fleshy seeds. Planted ornamental and pot plant. 3(58637), 5, 6, 7.

Sprekelia formosissima (L.) Herb. "Jacobean lily", "Aztec lily"

Recent introduction. C. America. Rare. Bulbous plant, about 30 cm high; leaves, strap-shaped, developing after the flowers; flowers, 7.5 to 10 cm across, striking crimson-red, single, irregularly funnel-shaped, 6-segmented, 3 together forming a lip, 2 curled back at the sides and the sixth held upright at the top of the bloom, borne on a long hollow stem. Ornamental pot plant. 6.

Yucca gloriosa L. "yucca", "Spanish bayonet"

Recent introduction. Trop. America and S.E. United States. Rare. Tree-like perennial shrub, up to 2 m or taller; leaves, about 60 cm long and 5 cm wide, sharp-pointed, green to grey-blue, borne in rosettes on a branched or unbranched stem; flowers, up to 7.5 cm across, many, white to creamy, short-stalked, cup- or bell-shaped, borne in clusters on a much-branched flower stem extending above the leaf rosette. Planted ornamental. 3(58683), 5, 6, 7.

Zephyranthes candida (Lindl.) Herb. "zephyr flower", "white star of Bethlehem", "westwind flower", "storm lily"

Recent introduction. Argentina and Uruguay. Rare. Bulbous herb, up to 25 cm high; leaves, seldom over 25 cm, green, fleshy; flowers, 3.5 to 5 cm long, solitary, 6-segmented, white inside, rose-tinged or not outside, borne on erect or bent flowering stems, 10 to 20 cm long; fruit, a 3-valved capsule with flat black seeds. Planted ornamental. 6.

Zephyranthes rosea Lindl. "pink lady", "pink star of Bethlehem", "pink zephyr flower"
susana (T)
syn. *Atamosco rosea* (Lindl.) Green

Recent introduction. Guatemala and W. Indies. Rare. Bulbous herb, rarely up to 10 cm; leaves, up to 25 cm long, narrow, strap-shaped, downward-curved; flowers, about 2.5 to 3 cm long, solitary, pink to rosy-red, borne on erect or bent flower stems, up to 15 cm long. Planted ornamental. 3(58692), 5, 6, 7.

MARANTACEAE (Arrowroot Family)

Calathea ornata (Lem.) Koern. "calathea"
syn. *Maranta ornata* Lem.

Recent introduction. Northern S. America. Occasional. Perennial herb, up to 45 cm or higher; leaves, up to 65 cm long and 22 cm wide, 1 to 7 in number, narrowly oval, green with varied striped markings above, which range from rose to white when young, but to entirely green above and purplish-red below when mature. Ornamental pot plant. 3(58688), 5, 6, 7.

Calathea wiotiana Makoy "calathea", "rattlesnake plant"
syns. *C. insignis* Bull; *C. lanceolata* Boom

Recent introduction. Brazil. Rare. Perennial, low, bushy herb, up to 30 cm or taller; leaves, about 30 cm long, wavy-edged, parallel-sided, velvety green, marked with oblique, dark olive-green blotches above and reddish-purple below. Ornamental pot plant. 6.

Calathea zebrina (Sims) Lindl. "calathea"
syn. *Maranta zebrina* Sims

Recent introduction. Brazil. Rare. Perennial unbranched short-stemmed herb, up to more than 45 cm high; leaves, 30 to 60 cm long and 15 cm wide, oblong, with somewhat wavy edges, as many as 20 in number, spirally-arranged, tufted, velvety, dark-green and light- or yellow-green bands above and purple beneath. Ornamental pot plant. 6.

Ctenanthe lubbersiana (Morr.) Eichl. "ctenanthe", "bamburanta"

Recent introduction. Brazil. Rare. Tufted perennial, up to 50 cm high, with slender forking stems; leaves, 15 to 20 cm long, narrowly oblong, long-stalked, variegated, deep green above, lined and mottled with yellow, and paler beneath. Ornamental pot plant. 6.

Ctenanthe oppenheimiana (Morr.) K. Schum. "ctenanthe", "never-never plant"

Recent introduction. Brazil. Rare. Clump-forming perennial, up to 75 cm high; leaves, up to 25 cm or longer, lance-shaped, green with silver-grey bands on the upper surface and purple-red beneath. Ornamental pot plant. 6.

Maranta leuconeura Morr. "maranta", "prayer plant", "rabbit tracks"

Recent introduction. Brazil. Rare. Perennial herb, up to 30 cm high; leaves, up to 15 cm long, oblong, stalked, light emerald green with brown-purple patches both sides of the mid-vein, lying almost horizontal by day becoming more vertical at night like hands in prayer; flowers, about 2.7 cm long, white to violet, accompanied by two narrow bracts. Ornamental pot plant. 6, 7.

MUSACEAE (Banana Family)*

*The nomenclature for the genus *Musa* is confused, with most of the common seedless cultivars or clones being triploid crosses of the fertile species *Musa acuminata* Colla and *M. balbisiana* Colla. The Latin binomials *M. nana* Loureiro, *M. sapientum* L., and *M. paradisiaca* L. are commonly used as follows: *M. nana* for the "dwarf Cavendish", and *M. sapientum* for the taller bananas, which are generally eaten ripe, but which are also cooked throughout the Pacific as starchy staples, and *M. paradisiaca* for the starchier bananas or plantains, which are usually eaten cooked as a staple starch, but occasionally eaten ripe as fruit. The nomenclature most widely used by agronomists is that developed by Simmonds, which classifies all cultivars or clones on the basis of their assumed genetic background, eg. *Musa* ABB Group would be a triploid cross of one *M. acuminata* group and two *M. balbisiana* groups. Both nomenclature systems are presented here to more precisely identify the clones that are currently present in Nauru.

Musa (AAA Group) Simmonds "banana", "Robusta", "poyo", "Mons Marie"
dabanana (N); te banana (K); fuamaoluga (T)
syns. *M. sapientum* L.; *M. paradisiaca* L. var. *sapientum* (L.) Kuntze; *M. paradisiaca* L. ssp. *sapientum* (L.) Kuntze; *M. acuminata* Colla cvs

Pre-World War II introduction. S. E. Asia. Occasional. Clump- or stand-forming giant perennial herb, up to 6 m tall, with green pseudostems (trunks) composed of leaf sheaths; leaves, up to 2.5 m long and 75 cm wide, broad-bladed, broadly feather-shaped, bright green, smooth, at first entire, but soon splitting like a feather along parallel side veins, spirally arranged in a terminal crown through which the inflorescence emerges, leaf stems and midribs thick; inflorescence, thick, stalk-like, terminal, and bearing male flowers, in a large budlike tip with dark purplish-red scales, and female flowers along the stalk which turn into large hanging fruit bunches; fruit, seedless, blunt-tipped, medium-thick-skinned, greenish-yellow, turning bright yellow on ripening; new pseudostems sprout from base of old pseudostems which die or are cut after bearing fruit. Food plant in Tuvaluan and I-Kiribati food gardens at Location and Topside workshops; occasional in Nauruan and expatriate home gardens. Important food and export crop in many areas of the Pacific, especially in Tonga and Western Samoa, where bananas are a major export crop, and in Tuvalu, where bananas are a major staple food. Not a traditional food plant, and of only limited importance on Nauru. 2, 3, 5, 6, 7.

Musa (AAB Group) Simmonds "lady's finger banana", "pisang rajah" (Indonesia)
dabanana (N); te banana, te oraora (K); tamatamailima, inisi (T)
syns. *Musa* × *paradisiaca* L. var. *hort.* "Pisang raja" (*M. acuminata* Colla × *M. balbisiana* Colla)

Pre-World War II introduction. S. India. Occasional. Clump- or stand-forming giant perennial herb, up to 7 m tall, with bronze-green pseudostems (trunks) composed of leaf sheaths; leaves, up to 3 m long and 80 cm wide, broad-bladed, broadly feather-shaped, bright green, smooth, at first entire, but soon splitting like a feather along parallel side veins, spirally arranged in a terminal crown through which the inflorescence emerges, leaf stems and midribs thick; inflorescence, thick, stalk-like, terminal, and bearing male flowers, in a large budlike tip with dark purplish-red scales, and female flowers along the stalk which turn into large hanging fruit bunches; fruit, tightly-packed, light-yellow, short, slightly rounded, plump, very thin-skinned, seedless; new pseudostems sprout from base of old pseudostems which die or are cut after bearing fruit. Food plant in Tuvaluan and I-Kiribati gardens at Location and Topside workshops. Eaten ripe as a fruit throughout much of the Pacific and a very important staple in Samoa, where it is cooked green. Not usually found in Nauruan gardens. 3, 5, 6, 7.

Musa (ABB Group) Simmonds "cooking banana", "plantain", "bluggoe"
dabanana (N); te banana, te umuumu (K); pata (T)
syns. *Musa* × *paradisiaca* L. var. *hort.* "Bluggoe" (*M. acuminata* Colla × *M. balbisiana* Colla)

Pre-World War II introduction? S. E. Asia and Pacific. Common. Clump- or stand-forming giant perennial herb, up to 6 m tall, with pale green pseudostem (trunks) composed of leaf sheaths; leaves, up to 2.5 m long and 75 cm wide, broad-bladed, broadly feather-shaped, bright green, smooth, at first entire, but soon splitting like a feather along parallel side veins, spirally arranged in a terminal crown through which the inflorescence emerges, leaf stems and midribs thick; inflorescence, thick, stalk-like, terminal, and bearing male flowers, in a large budlike tip with dark purplish-red scales, and female flowers along the stalk which turn into large hanging fruit bunches; fruit, light-green, waxy, thick-skinned, angular, with a tapering blunt-tip; new pseudostems sprout from base of old pseudostems which die or are cut after bearing fruit. Food plant in well mulched areas and planting boxes at Location and near Topside workshops in Tuvaluan and I-Kiribati gardens. Important traditional supplementary staple in many areas of the Pacific, where it seems to be an aboriginally introduced cultivar and known as bata or pata in Fiji and Polynesia respectively. The most common banana cultivar in Kiribati, from where it may have been introduced into Nauru. Leaves and pseudostem used medicinally to wrap sick persons to lower fevers; leaves used to parcel food and to cover earthen oven; green fruit cooked as a staple food and ripe fruit eaten raw. Evidently not a successful aboriginal introduction to Nauru, where Musa cultivars do not seem to have been a traditional food crop. 5, 6, 7.

ORCHIDACEAE (Orchid Family)

Cattleya sp. "cattleya orchid"

Recent introduction. Trop. America. Rare. Bulbous or slender-stemmed orchid with thick, slightly-folded leaves and large showy flowers. Ornamental pot plant. 6.

Dendrobium undulatum R. Br. "dendrobium orchid"

Recent introduction. Australia. Rare. Orchid with short thick leaves and many showy flowers borne along a flowering stem. Ornamental pot plant. 6.

Dendrobium sp. "dendrobium orchid"

Recent introduction. Rare. Orchid with short thick leaves and many showy flowers borne along a flowering stem. Planted ornamental at H.M. De Robert's home. 6.

Spathoglottis plicata Bl. "Malayan ground orchid"

Recent introduction. Indomalaysia. Rare. Terrestrial erect perennial herb, up to 60 cm or taller; leaves, 50 cm to 120 cm long and 5 to 20 cm wide, oblong-lanceolate or elliptic-lanceolate, plicate, with numerous parallel veins; flowers, 2 to 3 cm wide, pink to rose-lavender, with some magenta and bright yellow in the center, borne in clusters on a long flowers stalk (scape), up to 150 cm or higher; fruit, a narrow oblong seed-bearing capsule, about 3.7 cm long. Planted ornamental. 5, 6.

Vanda teres Lindl. "vanda orchid"

Recent introduction. Burma. Rare. Evergreen orchid with tall climbing stems, up to 2 m; leaves, about 15 cm long, dark green, cylindrical; flowers, 2 to 5 flowers, each 10 cm across, with rounded creamy white to rose-tinted sepals, rounded rose-colored petals, orange or yellow throats with red markings, and the middle lobe purple or rose, borne in clusters on the climbing stems. Planted ornamental. 6.

Vanda sp. "vanda orchid"

Recent introduction. S. E. Asia. Rare. Evergreen orchid with showy flowers. Planted ornamental. 6.

PANDANACEAE (Pandanus Family)*

*The nomenclature for the genus *Pandanus* is, like *Musa*, confused, with some taxonomists classifying many of the common cultivars and wild clones or species, both edible and non-edible, as forms or varieties of *P. tectorius*. Other taxonomists consider them distinct species, often listing numerous species or varieties for a given area. For example, *P. odoratissimus* L.f. has long been thought to be synonymous with *P. tectorius*, but is not considered, by many authorities, to occur east of Malaysia. Similarly, *P. odoratissimus* L.f. var. *pyriformis* Mart. has been used as a synonym for a wild and doubtful variety of *P. tectorius*, whereas Stone (1970) considers *P. fragrans* Gaud. to be the common wild species on Guam, and does not consider *P. tectorius* to be present. Thus, because the fruit of many of the named cultivars or varieties found on Nauru were not collected and identified, the identifications here must be considered provisional, with most named cultivars being grouped under *P. tectorius*. Other widespread forms, such as *P. dubius* Spreng., a widespread edible species; and *P. spurius* Miq. cv. "PUTAT" (syns. *P. tectorius* Warb. var. *laevis* Warb.; *P. odoratissimus* L.f. var. *laevis* (Warb.) Mart., which are widely cultivated for their leaves for use in plated ware, are also possibly present, but not listed here. *P. dubius*, if present, however, is a very different plant, not likely to be confused with *P. tectorius*. It has no edible fleshy tissue, but a large globose fruit, 30 to 40 cm in diameter, composed of many drupes, 8 to 18 cm long, each containing a single seed with edible white endosperm.

Pandanus tectorius Warb. var. **pulposus** Warb. "pandanus", "screw pine"
epo, epuh (N); te kaina (K); fala (T)
syn. *P. pyriformis* Gaud.

Indigenous and probably an aboriginal introduction in the case of some cultivars. Pacific Is. Common. Stout, branching tree, up to 5 m or more tall, with numerous aerial roots and thick forking stems; leaves, seldom over 10 cm wide and 1 to 3 m long, spirally-arranged, pointed, with armed or spiny margins and midribs; male inflorescence, fragrant, pendant, with cream-yellow bracts and white spikes; female inflorescence, similar but smaller, on separate trees; fruit, pineapple-like, ovoid, 20 to 30 cm long and 10 to 20 cm wide, with 50 or more wedge-shaped, yellow to red-orange, 1 to 12-celled woody drupes, each about 4 to 8 cm long. Commonly planted on the coastal strip in home gardens and in open areas and in stands on the unmined portions of the plateau

(Topside); women were formerly responsible for the care and cultivation of pandanus, although men helped in the initial clearing of land. An important staple to the Nauruans and to the I-Kiribati and Tuvaluans on their home islands. Very important fresh fruit and staple in Nauru and other atoll and Micronesian countries. Named cultivars which still exist on Nauru include *enaben* (*enabun*), *erabaite* (*erabwaite*), *eragadibyaw*, *eragomogom* (*eragumugum*), *inaparabei* (*inaporabei*), *inimenoiya*, *irireiab*, and *iriribe*; other named cultivars, which are reportedly now extinct due to mining, bombing during World War II, and failure to replant, include *eraburabur* (*eraburbur*), *eramwimwi*, *erarapaiwa* (*erarapeiwa*, *erarapwiewa*), *erkibwir*, *erokwoi*, *eronubwe*, *erwuro*, *inibiterin*, and *itoidi* (*etoidi*). Some of these cultivars may be *P. dubius* (see above). Ripe fruit of all cultivars eaten in Nauru as a vitamin-A-rich snack food and also cooked or fermented and put on pandanus mats or leaves in the sun to dry to make a "rich man's" food known as *edongo*, which is also a traditional food for the sick; leaves, which are commonly soaked in fresh water or boiled, are plaited into mats (*itubare*), baskets, and other plaited ware, and make the best traditional thatching and roofing; main trunk and stilt roots used in house construction; wood and dried fruit sometimes burned as fuel; thin outside bark of the stilt roots scraped and mixed with coconut juice to cure constipation and poor appetite; I-Kiribati use leaves as cigarette wrappers. According to Wedgewood (1936), during the yearly pandanus harvest (*ineded*), which usually occurred around August or September, people used to leave their homes on the coast to stay in temporary bush huts on the pandanus lands in the interior. 2, 3(58760), 5(64), 6, 7(27814?).

Pandanus sanderi Hort. ex Masters "variegated pandanus"

Recent introduction. Indomalaysia to the Pacific Is. Rare. Perennial shrub with long pointed variegated green leaves with yellow-white margins. Planted ornamental. 6.

POACEAE OR GRAMINAE (Grass Family)

Andropogon sp.

Recent Introduction. Rare. Small perennial grass. Local on strip-mined land. 3(58736).

Arundo donax L. "giant reed"

Recent introduction. Old World. Occasional. Large perennial grass or reed with strong, bamboo-like, erect hollow stems, 2 to 4 cm in diameter, rising in clumps, up to 4 m high; leaves, 50 to 70 cm long and 2 to 6 cm wide, flat, pale bluish-green, smooth; inflorescence, a large feathery flowering panicle, up to 70 cm long, with whitish to purplish spikelets, 8 to 12 mm long. Planted ornamental and spontaneous in some areas. 3(58742), 3(171N), 5(95), 6, 7(22318).

Bambusa vulgaris Schrad. ex Wendl. "common bamboo", "feathery bamboo"
ebarabaratu, embarabaraba (B)(N); te kaibaba (K)
syns. *Arundo bambos* L.; *Bambos arundinacea* Retz.; *Bambusa arundinaria* Willd. ex Merr. (Sphalm.); *B. arundinacea* (Retz.) Willd.

Pre-World War II post-European contact introduction. Trop. Asia. Rare. Giant perennial clump-forming woody grass with segmented green to yellowish stems (culms), up to 15 m tall and 8 cm wide; leaves, 9 to 30 cm long and 1 to 4 cm wide, feathery, lanceolate, rough below and on the margins; flowers, spikelets, 2 to 3.5 cm long, borne in large leafy clusters at the nodes. Planted on coastal strip. Woody stems used in the construction of perches for pet frigate birds, for fishing rods, net handles for noddy-bird nets and reef and flying-fish nets; splinters used in the past to mend fishing nets; parts used medicinally. 2, 5, 6(217), 7.

Cenchrus brownii R. & S. "Brown's burgrass", "Brown's sandbur"
eakung, iyakong (N)
syn. *C. viridis* Spreng.

Recent introduction. Trop. America. Occasional. Annual grass, up to 50 cm or higher; leaves, 5 to 12 cm long, narrow, slightly hairy; inflorescence, a cylindrical flowering spike bearing many crowded somewhat delicate globose spiny burrs. Weed in open places and ruderal habitats on the coastal strip. 5(35), 6, 7.

Cenchrus echinatus L. "burgrass", "sand bur"
eakung, iyakong (N); te kateketeke (K); mouku talatala (T)

Pre-World War I introduction. Trop. America. Common. Annual grass, 10 to 60 cm tall, lower parts often prostrate, rooting at the nodes; leaves, 3 to 10 cm long and 3 to 10 mm wide, narrow, slightly hairy on the upper surface near base, smooth on lower surface; inflorescence, a dense cylindrical spike-like raceme, 3 to 8 cm long, bearing 5 to 15 well-spaced (not crowded) spiny burs, usually bearing 2 to 4 spikelets, 5 to 7 mm long; fruit, a globose bur, 3 to 6 mm in diameter, purplish or straw-colored with age, with numerous irregularly arranged spines, up to 5 mm long. Weed occurring in clusters or tufts in open and ruderal habitats on the coastal strip. 2, 3(58607), 4(146N), 5(34), 6, 7, 8.

Chloris inflata Link "finger grass"
syn. *C. barbata* sensu auct. non (L.) Sw.

Recent introduction. Trop. America. Occasional. Tufted perennial grass, up to 90 cm tall, erect or somewhat bent at the base, rooting at the lower nodes, which are often purplish; leaves, up to 3 to 20 cm long and 2 to 6 mm wide, flat, usually bluish-green, rough on the edges, often hairy near the base on the upper side; inflorescence, flower heads of 2 to 11 conspicuous, purplish, finger-like, feathery terminal flower spikes, 2.5 to 7.5 cm long, with spikelets, about 3 mm long, with 3 slender bristles, borne at the tips of flowering stems (culms), up to 60 to 90 cm high. Weed occurring locally in isolated clusters or tufts in open and ruderal places on the coastal strip. 3(58519), 4(151N), 5(40), 6, 7, 8(9549).

Chrysopogon aciculatus (Retz.) Trin. "needle grass", "seed grass", "golden beard grass"
syns. *Andropogon aciculatus* Retz.; *Rhaphis aciculatus* (Retz.) Desv.

Recent introduction. S. E. Asia and Pacific Is. Occasional. Perennial grass, up to 60 cm high, usually with prostrate or creeping stems; leaves, 2 to 5 cm long and 3 to 6 mm wide, flat or folded, linear-lanceolate, rough on the edges; inflorescence, a finely-branched flower stem, up to 25 cm long, bent at the base, bearing slender erect clustered purplish panicles, 2.5 to 6 cm long, with awned or barbed, spikelets, 3 to 6 mm long. Weed occurring locally on bare soil, roadsides, waste places, and occasionally in lawns. 3(58625, 58709), 5(82), 6, 7.

Cynodon dactylon (L.) Pers. "Bermuda grass"
ibugibugi (N); te uteute (K); mouku (T)
syns. *Panicum dactylon* L.; *Capriola dactylon* (L.) O. Ktze.

Recent introduction. Old World. Common. Small, low creeping perennial sod-forming grass, rooting at the lower nodes; leaves, 2.5 to 10 cm long and 3 to 6 mm wide, rough on the edges; inflorescence, a somewhat ascending or erect flowering stem (culm), up to 10 to 15 cm, bearing 2 to 6, often 4 to 5, slender, radiating purplish finger-like terminal flower spikes, 2.5 to 7 cm long, and spikelets, up to 3 mm long. Common in open places forming mat or sod and in lawns. 3(58625), 5, 6(270), 7.

Dactyloctenium aegyptium (L.) Beauv. "four-finger grass", "beach wire grass", "crowfoot grass"
syns. *Cynosurus aegyptius* L.; *Dactyloctenium aegyptiacum* (L.) Willd. (orth. mut.); *Eleusine aegyptiaca* (L.) Desf.

Recent introduction. Paleotropics. Occasional. More or less prostrate annual grass, 15 to 60 cm high, rooting from the lower nodes; leaves, up to 15 cm to 30 cm long, but mostly shorter, and up to 6.2 mm wide, flat, the edges lined with hairs; inflorescence, an erect flowering stem (culm), up to 50 cm tall, bearing 2 to 6 radiating thick, somewhat purplish, dark-colored terminal flower spikes, each up to nearly 3 to 6 cm long, the rachis pointed and extending beyond the spikelets, the spikelets awned, up to 3 mm long. Weed in clusters or tufts in open and ruderal habitats on the coastal strip. 3(58603, 58606), 4, 5, 6(209), 7, 8(9550).

Dactyloctenium cteniodes (Steud.) Besser?

Recent introduction. Africa. Annual grass. Occasional locally in disturbed places. 4(153N).

Dichanthium sp. "blue grass"

Recent introduction. Occasional. Perennial grass with bluish stems (stolons). Occurs locally in open weedy places. 3(58518), 5(85).

Digitaria bicornis (Lam.) R. & S. "crab grass", "large crab grass"
syns. *Panicum bicorne* Lam.

Recent introduction. Trop. Asia. Occasional? Perennial creeping grass. Weed in open and ruderal sites on the coastal strip. 4(152N).

Digitaria ciliaris (Retz.) Koel. "crab grass", "large crab grass"
syns. *Panicum ciliare* Retz.; *Digitaria adscendens* (HBK) Henr.; *Syntherisma ciliaris* (Retz.) Schrader

Recent introduction. Trop. Asia. Occasional? Perennial creeping and ascending grass, rooting by runners at the lower nodes and forming dense mats, with smooth, usually flattened, ascending stems; leaves, 2 to 13 cm long and 3 to 6 mm wide, flat, green to blue-green, sometimes purplish, slightly hairy on upper surface; inflorescence, a branched raceme, 4 to 9 in number, up to about 17 cm long, with 2 to 4 slender finger-like branches, 2.5 to 8 cm long, remaining close together, forming compact delicate heads; rachis, winged; spikelets, about 3 mm long, narrow, ellipsoid. Weed in garden. 3(59604).

Digitaria radicosa (Presl) Miq. "crab grass"
syns. *Panicum radicosa* Presl.; *Digitaria borbonica* Desv.; *D. timorensis* (Kunth) Balansa

Recent introduction. Old World tropics. Occasional? Annual erect or ascending grass, up to 60 cm high; leaves, 2 to 10 cm long and 3 to 7 mm wide, sheaths puberulent; inflorescence, a branched raceme, 4 to 10 cm long, usually 2 to 3, rarely 6 to 8, in number, smooth, but puberulent at the axils, with fingerlike, very narrow spikelets, 3 by 0.6 to 0.75 mm, linear-lanceolate, on pedicels, 2.5 to 3.5 mm long. Roadside weed. 3(58608)

Digitaria setigera Roth "crab grass", "slender crab grass"

ibugibugi, ibiugibiugi (N); te uteute (K)

syns. *Panicum pruriens* Fisch. ex Trin.; *Digitaria pruriens* (Fisher ex Trin.) Buse (in Burgess' list 1935); *D. microbachne* (J. S. Presl) Henr.

Indigenous. S.E. Asia to Polynesia. Occasional. Densely-tufted creeping or ascending grass, up to 60 cm high, with smooth slender stems; leaves, 6 to 20 cm long and 3 to 8 mm wide, smooth hairy, with leaf sheaths at the base; inflorescence, an erect slender raceme, 5 to 15 cm long, 3 or 4, rarely more, somewhat pubescent, with numerous spikelets, about 2.5 to 3 mm long. Weed occurring in clusters or tufts in open and ruderal habitats on the coastal strip. 2, 3, 5(83), 6(156), 7, 8(9551?).

Digitaria violascens Link. "smooth crab grass", "violet crab grass"

syns. *D. argyrostachya* (Steud.) Fern.

Recent introduction. Trop. Asia. Rare. Erect to spreading annual, sometimes perennial, smooth-stemmed grass, up to 60 cm tall, forming dense clumps; leaves, 2 to 9 cm long and 3 to 6 mm wide, flat, slightly reddish, usually smooth, but often slightly rough on the edges and sometimes with a few hairs near the base on the upper side; inflorescence, composed of 2 to 9 slender finger-like branches, 2.5 to 10 cm long, at the tip or along the upper 2.5 to 5 cm of the flowering stem, and very small dark-brown spikelets, up to 2 mm. Weed occurring locally near Buada Lagoon. 3(58786).

Echinochloa colona (L.) Link. "jungle rice"

syns. *Panicum colonum* L.; *Oplismenus colonus* (L.) HBK.

Recent introduction. India. Occasional. Tufted erect to ascendant annual grass, 20 to 80 cm high, often decumbent at the base and rooting at the lower nodes, with flattened often reddish-purple stems; leaves, 2.5 to 15 cm long and 3 to 10 mm wide, flat, tapering, margins smooth or sometimes scabrous; inflorescence, a flowering stem (culm), 20 to 60 cm high, bearing a panicle, 4 to 12 cm long, with very short green or purple-tinged alternating racemes, 1 to 3 cm long, with ovate spikelets, 1 to 3 mm long, crowded in 4 rows on short pedicels. Weed in gardens around buildings. 4(150N), 5 (155).

Eleusine indica (L.) Gaertn. "wiregrass", "goosegrass"
ibugibugi (N); te uteute (K); mouku (T)
syn. *Cynosurus indicus* L.

Pre-World War II introduction. India; long naturalized in Old and New Worlds. Abundant. Ascending tufted annual or perennial grass, usually growing in tufts, with flattened pale green stems, with hairy nodes; leaves, 6 to 30 cm long and 3 to 8 mm wide, mostly glabrous, scabrous on the midvein and upper margins; inflorescence, 2 to 7, flattened, fingerlike terminal branches or spikes, 4 to 12 cm long and 3 to 7 mm wide, radiating from the tip of a flowering stem (culm), up to 30 cm tall, with one or two spikes slightly below the tip; spikelets 3 to 6 mm long; seeds, about 1.5 mm long, dark green to dark-reddish-brown, ridged, crowded in two rows on one side of the spike. Growing in rather dense concentrations or colonies in gardens and waste places. 2, 3(58660), 4(147N, 154N), 5(65), 6, 7, 8(9544).

Eragrostis amabilis (L.) Wight & Arn. ex Hook. & Arn."love grass", "Japanese lovegrass"
ibugibugi, ibiugibiug, bahibahi (N); te uteute n' aine (K); mouku (T)
syn. *Poa amabilis* L.; *Eragrostis tenella* (L.) Beauv. ex R. & S.

Recent introduction? Old World. Common. Small, rather delicate, annual grass, usually branched or spreading at the base but sometimes erect, up to 30 cm tall, with delicate wiry stems, 15 to 45 cm long; leaves, 3.5 to 10 cm long and 1.5 to 4 mm wide, slightly rough on the upper surface, smooth on the lower, with tufts of long hairs at the summits of the sheaths; inflorescence, a flowering stem (culm), 5 to 15 cm long, bearing short, rather delicate, branches and numerous, often reddish-purple, 4- to 6-flowered spikelets, about 1 to 1.5 mm long, in open panicles. Weed occurring in scattered clusters around buildings, paths, and other ruderal places. 2(28.5), 3(58626), 4(148N), 5(66), 6, 7, 8(9539).

Lepturus repens (Forst.f.) R. Br. var. **subulatus** Fosb."bunchgrass", "beach bunchgrass"
ibugibugi, ibiugibiugi (N); te uteute (K); mouku (T)
syns. *Rottboellia repens* Forst.f.; *Monoerma repens* (Forst.f.) Beauv.

Indigenous. Pacific Is. Occasional. Freely-branching, creeping grass with stems, up to 40 cm long, rooting at the nodes; leaves, 7 to 20 cm long and 3 to 7 mm wide, narrowly lanceolate to linear, often with inrolled margins; inflorescence, protruding, solitary, long-awned spikelets embedded in a narrow, jointed, cylindrical flowering spike, 6 to 15 cm long and 1 to 2 mm in diameter, which disarticulates at maturity. Occurring in clusters among strand vegetation. 3(58605, 58750), 5(84), 5, 7.

Oplismenus hirtellus (L.) Beauv. var. "basket grass"

syns. *Panicum hirtellum* L.; *Orthopogon imbecillus* R. Br.; *Oplismenus imbecillus* (R. Br.) R & S.; *O. undulatifolius* (Ard.) Beauv.

Recent introduction. Pantropical. Rare. Slender, much-branched creeping or ascending perennial grass, up to 30 cm or higher; leaves, 5 to 10 cm long and 8 to 12 mm wide, lanceolate, with an acute tip and an asymmetrical base, pubescent, especially below, blade wavy; inflorescence, small flower clusters, with purplish bristles, borne on the upper 7 to 15 cm of a erect unbranching flower stem. In open area in Topside forest. 7(22322).

Panicum subquadriparum Trin.

syn. *Brachiaria subquadripara* (Trin.) Hitch.

Recent introduction. Trop. Asia. Rare. Perennial creeping grass with stems (culms) 20 to 60 cm long, rooting at the lower nodes; leaves, 2.5 to 12 cm long and up to 4 to 10 mm wide, acuminate, nerves pubescent, with a hairy leaf sheath; inflorescence, an open, slender, elongated panicle, 5 to 15 cm long, with 2 to 10 spike-like, solitary, horizontally spreading racemes, 2 to 10 cm long, bearing lanceolate, sharp-tipped spikelets, 2 to 5 mm long, in 2 rows on one side. Rare around Buada Lagoon. 5(83), 6(155).

Saccharum officinarum L. "sugar cane"

tugage (N)("sugarcane"); te kai tioka, te kai soka ("the sugar tree")(K); kaleve gau, tolo (T)

syn. *S. chinense* Roxb. ex Nees in H & A.

Pre-World War I introduction? New Guinea and Trop. Asia. Occasional. Large clump-forming erect perennial grass with strong thick unbranched stems, 2 to 4 m tall and 2.5 cm or more in diameter, with short conspicuous internodes filled with solid juicy pulp; leaves, 45 cm or more long and 3 cm or more wide, smooth, overlapping, finely-saw-toothed, loosely clustered near the top of stems, with hairy overlapping leaf sheaths; inflorescence, straight wandlike terminal stalk, panicle about 20 to 50 cm or more long, borne at the top of each stem, with numerous densely-branched, feathery, pinkish to silvery-white, many-jointed racemes or flower tassels, with spikelets, 4 to 5 mm long, although most chewing cultivars rarely flower. Food plant in I-Kiribati and Tuvaluan gardens at Location and Topside workshops. An important supplementary food plant throughout most of the Pacific, with the sweet juicy pulp a source of sugar and an important snack food, the leaves widely used for high quality house thatching, and the chewing of the fibrous stems reportedly a main factor in good dental hygiene, which is ironic, given the role of processed sugar in tooth decay. Interspecific hybrids of *S. officinarum* and more fibrous wild canes, such as *S. spontaneum* and *S. robustum*, form the basis for the export sugar industries of Fiji and Hawaii. Apparently not traditionally important on Nauru. 5, 6, 7.

Sporobolus diander (Retz.) Beauv. "Indian dropseed"
syn. *Agrostis diander* Retz.

Recent introduction. Southern Asia. Rare. Tufted, smooth, slender, erect perennial grass, 30 to 70 cm high, arising from an abruptly bent base; leaves, 7.5 to 30 cm long and 2 to 6 mm wide; inflorescence, a smooth and sometimes drooping, spike-like, flowering stem or panicle, 10 to 30 cm long and 5 cm wide, bearing numerous open feathery branches, 1.5 to 4 cm long, with dull grey spikelets, 1 to 2 mm long, and brown seeds, less tha 1 mm long. Weed in waste place on coastal strip. 6(154).

Stenotaphrum micranthum (Desv.) Hubb.
syns. *Ophiurinella micrantha* Desv.; *Stenotaphrum subulatum* Trin.

Indigenous. Mascarene Is. in the Indian Ocean through Malesia to eastern Polynesia and the Marshall Islands in Micronesia. Erect to ascending, tufted, freely branching grass, up to 45 cm high, with prominent nodes and slightly compressed sheaths, rooting at the lower nodes; leaves, 2.5 to 12 cm long and 5 to 12 cm wide, lanceolate, finely pointed, glabrous; inflorescence, 3 to 15 cm long, a slender to rather stout, corky cylindrical raceme; spikelets, 2 to 4 on short branchlets, 1.5 to 3 mm long, oblong to oblong-lanceolate, obtuse, embedded in the rachis. Rare grass, cited by Fosberg *et al. 1987, but not seen or collected in 1979 or 1980.*

Tricholaena rosea Nees "Natal grass", "Natal red top"
syns. *Rhynchelytrum roseum* (Nees) Stapf. & Hubb.; *Rhynchelytrum repens* sensu auct. non (Willd.) Hubb.; *Tricholaena repens* (Willd.) Hitchc.

Recent introduction. S. Africa. Common. Erect perennial grass, 40 to 90 cm high, rooting at the lower nodes, usually much-branched at the base, with green to bluish-green stems, often purplish at the joints; leaves, 5 to 15 cm long and 2 to 6 mm wide, flat bluish-green; inflorescence, a feathery panicle, 8 to 15 cm-long, bearing dark red or purplish flowers, which fade to silver-pink when old, borne on fine ascending branchlets; spikelets, about 5 mm long, clothed with fine silky hairs, about 3 to 5 mm long. Found in clusters in waste places on coastal strip and plateau and occasionally in mined areas. 3(58655), 4(170N), 5(49), 6, 7, 8(9567).

PONTEDERIACEAE (Pickerel Weed Family)

Eichhornia crassipes (Mart. & Zucc.) Solms-Laub. "water hyacinth"
syns. *Pontederia crassipes* Mart. & Zucc.; *Eichhornia speciosa* Kunth

Recent introduction. Trop. and Subtrop. America. Rare. Usually floating, perennial herb, up to 60 cm tall, with masses of fleshy, more or less horizontal, black roots, rooted only at flowering time by long slender roots; leaves, up to 7 to 10 cm wide, rounded or oblong, on bulbous air-filled petioles which act as floats; inflorescence, a flower spike, about 40 cm long, bearing showy 6-petaled pale violet flowers, about 5 cm in diameter, with a blue patch with a spot of bright yellow on the larger upper lobe, about eight to a stem, rising above the leaves; some forms have pink and yellow flowers. Water weed in Buada Lagoon and planted in tubs at Location. Commonly planted as an ornamental; has escaped to become a serious pest in many areas of the world where it clogs rivers and causes flooding and obstructs navigation. All parts are reportedly edible 6(255).

STRELITZIACEAE (Bird of Paradise Family)

Heliconia collinsiana R.F. Griggs "hanging heliconia", "fish-pole heliconia"
syn. H. pendula Wawra

Recent introduction. Guatemala. Rare. Erect herb, up to 2 m tall; inflorescence, up to 30 cm or more long, hanging, almost plastic-looking, parrot-beak-, or claw-like, with bright red flower bracts, each 5 cm or longer, with yellow and green lower margins, and white waxy powder. Planted ornamental. 5, 6.

Heliconia humilis (Aubl.) Jacq. "heliconia", "lobster claw"
syn. *Musa humilis* Aubl.

Recent introduction. Trop. S. America. Rare. Erect herb, less than 2 m tall; leaves, broad, paddle-shaped, 3 to 6 in number; inflorescence, an erect flowering stalk, up to 120 cm tall, among the leaves, bearing pointed lobster-claw-shaped bright red flower bracts with dark green upper margins, each up to 12 cm long. Planted ornamental. 5, 6(236).

Heliconia psittacorum L. "heliconia"

Recent introduction. Trop. S. America. Occasional. Erect herb, less than 1.5 m tall; leaves, few, 3 to 5 in number; inflorescence, an erect flowering stalk bearing small bright orange flowers with green tips. Planted ornamental. 5, 6, 7.

Heliconia sp. "heliconia"

Recent introduction. Trop. America. Rare. Erect herb. Planted ornamental. 5 (174).

TACCACEAE (Polynesian Arrowroot Family)

Tacca leontopetaloides (L.) O. Kuntze "Polynesian arrowroot"
damagmag, damogmog (N); te makemake (K); masoa, vatia (T)
syns. *Leontice leontopetaloides* L.; *Tacca pinnatifida* Forst.

Aboriginal introduction. Paleotropics. Occasional. Large stemless herb, up to 1 m high; leaves, large, palmately 3-parted, deeply-lobed, on long petioles, 60 cm or more in length, emerging directly from starchy underground tubers resembling potatoes, 20 to 25 cm in diameter; inflorescence, a hollow flower stalk (scape), up to over 1 m high, bearing a terminal umbel or cluster of 10 to 40 hanging green flowers, about 15 mm long, surrounded by 6 leafy bracts, 4 to 5 cm long and 2 cm wide, and numerous hanging green and purplish filaments, up to 25 cm long; fruit, 2 to 2.5 cm in diameter, fleshy, ribbed, globose, which turns yellow when mature, and is crowned with floral parts. Occurring spontaneously in old gardens and in escarpment forest. Tubers grated and washed to eliminate poisonous substances, and made into edible starch in the past, but apparently not used by Nauruans to the extent that it was used in other parts of Micronesia and Polynesia. Paste from tuber used as an adhesive for barkcloth and other handicrafts in Polynesia and Melanesia and the fibers from the flower stem for weaving in parts of Polynesia. 5, 6(119).

ZINGIBERACEAE (Ginger Family)

Alpinia purpurata (Vieill.) K. Schum. "red ginger"
syns. *Guillainia purpurata* Vieill.; *Languas purpurata* (Vieill.) Kaneh.

Recent introduction. Indonesia to Pacific Is. Occasional. Erect herb, 1.2 to 4 m tall, with leafy stems; leaves, up to 30 cm long, lance-like; inflorescence, a flower spike, about 25 to 30 cm long, erect or drooping, with large, open, dark red bracts, each accompanied by a small inconspicuous white ephemeral flower, about 2.5 cm long, with new plantlets, which sprout among the bracts, taking root as the dying flower spike collapses to the ground. Planted ornamental. 3(59710), 5, 6, 7.

Alpinia zerumbet (Pers.) Burtt & R.M. Smith "shell ginger"
syns. *Costus zerumbet* Pers.; *Alpinia nutans* (Andr.) Roscoe; *A. speciosa* (Wendl.) K. Schum.; *Catimbium speciosum* (Wendl.) Holttum.

Recent introduction. S.E. and E. Asia. Rare. Erect herb, up to 2.5 m tall; leaves, 50 to 70 cm long and 7 to 15 cm wide, oblong-lanceolate; inflorescence, an arching flower stem, 1.5 to 3 m long, bearing a somewhat lax or pendant open flower cluster. about 25 cm long, bearing irregularly bell-shaped flowers with waxy white bracts and red-tipped corollas, up to 5 cm long, with yellow lips with reddish lines or veins; fruit, about 2 cm in diameter, globose, ridged, red. Planted ornamental. 6.

Hedychium coronarium Koen. "white ginger"

Recent introduction. India. Rare. Erect herb with stems, up to 1 m tall; leaves, about 50 to 60 cm long and 10 cm wide, narrowly oblong or lance-shaped, with short petioles; inflorescence, about 20 cm long, dense, spike-like, terminal, with overlapping bracts, each bearing 2 to 3 fragrant white flowers, 6 to 8 cm long, with slender tubes and a pale green spot on the lip, which turn yellow with age. Planted ornamental and pot plant. 3(59671), 5, 6, 7.

Nicolaia elatior (Jack) Horan. "torch ginger"
syns. *Alpinia elatior* Jack; *Phaeomeria speciosa* (Bl.) Koord; *P. magnifica* (Roscoe) K. Schum

Recent introduction. Mauritius. Rare. Large clump-forming perennial herb, up to 2 to 5 m high, with arching leaf stems; leaves, 25 to 60 cm long and 10 to 15 cm wide, pointed, numerous, alternating in two rows up the stem; inflorescence, highly ornamental, consisting of numerous red, white-margined bracts, the basal bracts being large, waxy, flowerless and forming a nest for a cone-like flowerhead, about 12 cm long, composed of numerous overlapping bracts, which are spirally arranged and accompanied by small flowers. Planted ornamental. 6.

Zingiber officinale Roscoe "ginger"
keung (C)
syn. *Z. zingiber* Karst.

Pre-World War II introduction. India and China. Rare. Erect smooth herb, up to 90 cm high, arising from edible, thick, hard, often palmately-branched, pale-yellow (within) rootstalks or rhizomes, about 1.5 to 2.5 cm in diameter; leaves, 5 to 30 cm long and 2 to 3 cm wide, annual, lance-shaped, sheathed at the bases; inflorescence, a flowering stem, about 6 to 12 cm high, bearing flower spikes, 4 to 7 cm long and 1.5 to 2.5 cm wide, with bracts, 2 to 3 cm long, and greenish-yellow three-lobed flowers, about 1.5 to 2.5 cm long. Planted in Chinese food garden at Location. Rhizome used as a spice. An increasingly important commercial crop for export and local processing in Fiji. 5, 6.

Zingiber zerumbet (L.) Sm. "wild ginger"
syn. *Amomum zerumbet* L.

Recent introduction; reintroduced recently by Fijian expatriate community Trop. Asia. Rare. Erect perennial herb, up to 1.5 m tall, with leafy stems rising from tuberous aromatic rootstalks or rhizomes; leaves, mostly 15 to 30 cm long, usually shorter, oblong lance-shaped, sheathing at the bases; inflorescence, a spike-like flower stalk (scape), up to 30 cm long, arising from the rhizomes, bearing ovoid to cylindrical reddish or green flower heads, 5 to 20 cm long, with many bracts, 2 to 3 cm long, and inconspicuous three-lobed white to cream flowers, about 5 cm long. Planted ornamental or medicinal plant. An important aboriginal introduction throughout much of Melanesia and Polynesia, where it is an important medicinal plant. 3, 6.

DICOTYLEDONAE

ACANTHACEAE (Acanthus Family)

Asystasia gangetica (L.) Anders. "asystasia", "Chinese violet"
syns. *Justicia gangetica* L.; *Asystasia coromandeliana* Nees

Recent introduction. Paleotropics. Occasional. Perennial trailing herb, or sub-shrubby plant, with ascending stems, up to 30 to 50 cm or longer, especially if climbing among taller vegetation; leaves, opposite, ovate to heart-shaped, up to 4 to 6 cm long; flowers, 6 to 10, tubular or bell-shaped, somewhat narrower or curving upwards at the base, and borne in racemose clusters, up to 15 cm or more long, with a 5-parted calyx, and a light-violet and white, or yellow, in some varieties, corolla, about 2 to 3 cm long, with five broad spreading lobes; fruiting capsule club-shaped, four-seeded. Planted ornamental and naturalized in some ruderal places. 3, 4(127N), 5, 6(231), 7.

Asystasia sp.

Recent introduction. Pot plant. 3(58702).

Barleria cristata L. "Philippine violet", "bluebell barleria"

Recent introduction. India. Rare. Small erect shrub, 60 cm to 1.2 m or higher, with downy branches; leaves, 2.5 to 10 cm long rough, hairy, short-stemmed, oval and pointed at both ends; flowers, 1 to 3, attractive stemless and funnel-shaped, with a four-parted calyx, about 2 cm long, and a five-lobed violet or white and violet corolla, about 5 to 7 cm long, developing at the ieaf axils, each accompanied by 2 spiny-edged green to white narrow lanceolate bracts, about 2 cm long. Planted ornamental. 3(58797), 6.

Barleria prionitis L. "porcupine flower"

Recent introduction. Paleotropics. Occasional. Erect shrub, up to 1 m high; leaves, 5 to 6 cm long by about 2 cm wide, elliptic to ovate or obovate, obtuse, acute or even somewhat petiolate, narrowed to base; flowers, up to 3.5 cm long, with yellow corollas and bracts converted into three-forked spines, 1 to 2.5 cm long. Planted ornamental and naturalized in ruderal sites and on disturbed slope below plateau. 3(58772), 6, 7.

Blechum brownei Juss.
syns. *Barleria pyramidatum* Lam.; *Blechum pyramidatum* (Lam.) Urb.

Recent introduction. Peru. Rare. Erect, prostrate or ascending branched shrub, 10 to 50 cm tall, with pubescent stems; leaves, 2 to 7 cm long, simple, ovate to lanceolate, pubescent, pointed at both ends, and on short petioles; flowers borne on terminal spikes, 2 to 5 cm long, with greenish or whitish overlapping ovate bracts, 1 to 1.5 cm long, concealing a white or pale violet funnel-shaped, five-lobed corolla, scarcely longer than the bracts; seed capsule oblong, 5 to 6 mm long. Weed in lawns. 5(60), 6.

Crossandra infundibuliformis (L.) Nees "crossandra"
syns. *Justicia infundibuliformis* L.; *Crossandra undulaefolia* Salisb.

Recent introduction. India. Rare. Shrub, 30 to 90 cm high; leaves, 7.5 to 12.5 cm long, shiny green, narrow, ovate, wavy-margined, and pointed at both ends; flowers borne on long narrow downy spikes, about 10 cm long, with overlapping bracts bearing showy tubular salmon-orange flowers with a five-lobed calyx and a corolla with a narrow tube, about 2 cm long, and one lip which is 2.5 to 5 cm across and has 3 to 5 shallow lobes; fruiting capsule, oblong, containing 4 scaly seeds. Planted ornamental. 6.

Eranthemum pulchellum Andr. "blue eranthemum"
syns. *Justicia nervosa* Vahl; *Eranthemum nervosum* (Vahl) R. Br.

Recent introduction. India. Rare. A smooth shrub, 60 cm to 1.5 m high; leaves, 10 to 20 cm long, oval, pointed at both ends, with prominent veins and shallow-toothed margins; flowers borne on narrow spikes, 2.5 to 7.5 cm or longer, with overlapping whitish, green-veined oval bracts bearing a five-lobed calyx and a narrow-tubular bright-blue corolla, up to 2.5 cm long, the five lobes overlapping spirally in bud, but spreading to a diameter of under 2 cm; fruiting capsule ovoid or oblong, 4-seeded. Planted ornamental. 6.

Fittonia argyroneura Coem. "snail plant", "nerve plant", "silver-net leaf"
syn. *F. verschaffeltii* var. *argyroneura* Nichols.

Recent introduction. Peru. Rare. Perennial creeping herb, up to 30 cm high, rooting at the joints; leaves, 5 to 10 cm long and 2.5 to 6 cm wide, broad, ovate, ornamental, with a network of fine white veins; petioles 0.5 to 3 cm long; inconspicuous flowers borne on spikes, up to 6 cm long, with obovate bracts, less than 1 cm long, with a calyx about 0.5 cm long and a two-lipped tubular yellow corolla, 1.5 to 2 cm long. Ornamental pot plant. 6.

Fittonia verschaffeltii (Hort. ex Lemaire) Coem. "snail plant", "nerve plant", "painted net-leaf"

Recent introduction. Peru. Rare. Perennial creeping herb, up to 30 cm high, rooting at the joints; leaves, 6 to 12 cm long and 3 to 8 cm wide, broad, smooth, ovate, ornamental, with a network of fine pink to bright carmine veins; petioles 0.5 to 3 cm long; inconspicuous flowers borne on erect narrow spikes, up to 6 cm long, with overlapping obovate greenish bracts, less than 1 cm long, a calyx about 0.5 cm long, and a tubular yellow two-lipped corolla, 1.5 to 2 cm long. Ornamental pot plant. 6.

Graptophyllum pictum (L.) Griff. "caricature plant", "morado"
syns. *Justicia picta* L.; *Graptophyllum hortense* Nees

Recent introduction. New Guinea. Rare. Erect shrub, up to 2 m high; leaves, 8 to 20 cm long and 3 to 13 cm wide, smooth, leathery, variegated, elliptic-oblong, opposite, with slightly wavy margins, and pointed at both ends, some green, with irregular yellowish blotches or markings in the center and other varieties with red-purple leaves with pinkish to cream-colored blotches along the center; petioles 1 cm long or less; flower spikes with small bracts bearing clusters of flowers with a short 5-small-lobed calyx and a 2-lipped, funnel-shaped crimson-purple corolla, about 4 cm long, the upper lip with 2 short lobes, the lower with 3 long narrow lobes; fruiting capsule 2-seeded. Planted ornamental. 6, 7.

Hemigraphis alternata (Burm.f.) T. Anders. "cemetery plant"
syns. *Ruellia alternata* Burm.f.; *Hemigraphis colorata* (Bl.) Hall.f.; *Ruellia colorata* Bl.

Recent introduction. Java. Rare. Creeping perennial herb, rooting at the joints; leaves, 2 to 8 cm long, ovate to heart-shaped, metallic- to greenish-purple above and reddish-purple beneath, and with sunken veins and scalloped margins; petioles nearly as long as blades; erect flowering spikes, 2 to 3 cm long, with crowded overlapping narrow purple bracts, about 1 cm long, bearing a calyx with 5 narrow lobes, each less than 1 cm long, and a white, purple-lined corolla, about 2 cm long; fruiting capsule slender, 4- to 20-seeded. Planted ornamental ground cover. 6.

Justicia fulvicoma Schlecht. & Chamisso "shrimp plant", "red shrimp plant"
syns. *Beloperone guttata* Brand. non Wallich; *Justicia brandegeana Wassh. & L. B. Smith; Drejerella guttata* (Brandeg.) Bremek.

Recent introduction. Mexico. Rare. A weak-stemmed much-branched shrub, 60 cm to 2 m or higher; leaves, 2.5 to 6 cm long, opposite, entire, pointed, ovate to heart-shaped, somewhat shiny-green and hairy; petioles, 1 to 2 cm long; flower spikes, up to 10 cm long, consisting of conspicuous brick-red, heart-shaped overlapping downy bracts, 1 to 1.5 cm long, those near the tip yellow-green with red veins, from which protrude small white flowers with a calyx with five narrow lobes, and a white corolla, 2.5 to 4 cm long, two-lipped to near the middle, with two rows of maroon spots on the lower, shortly three-lobed lip; fruiting capsule, club-shaped and four-seeded. Planted ornamental and pot plant. 3(58720), 5, 6.

Nicoteba betonica (L.) Lindau "white shrimp plant", "squirrel's tail"
syn. *Justicia betonica* L.

Recent introduction. Trop. Africa to Malaya. Rare. Weak-stemmed shrub, up to 1.5 m or higher; leaves, 7.5 by 3.5 cm or much larger, ovate or narrower, acuminate, smooth, dark green; flower spikes, about 10 cm long, borne at branch tips in erect spikes, with white and lilac flowers, each accompanied by three conspicuous overlapping heart-shaped and ovate pointed bracts which are white with green veins. Planted ornamental. 6, 7.

Odontonema strictum (Nees) O. Ktze. "odonotema", "red justicia"
syns. *O. tubiforme* (Bertol.) O. Ktze.; *Justicia tubaeformis* Bertol.; *Thrysacanthus strictus* Nees; *O. nitidum* (Jacq.) O. Ktze.; *Justicia coccinea* Aubl.(?)

Recent introduction. C. America. Occasional. Erect shrub, up to 1.5 m tall; leaves, mostly 5 to 20 cm long and 4 to 9 cm wide, ovate-oblong or lanceolate-oblong, wavy margins, and smooth above and slightly hairy beneath; petioles, 0.5 to 2 cm long; branching terminal flower spike, with very small bracts and straight slender bright-red corolla tubes, 2.5 cm long and only about 5 mm across, with 5 lobes, each about 3 mm long, crowded at branch tips. Planted ornamental. 5, 6, 7.

Pachystachys lutea Nees "yellow shrimp plant"

Recent introduction. Brazil. Rare. Erect branched shrub, up to 45 cm tall; leaves rich, dark-green, elliptical, and pointed; stems, erect, each terminating in a striking 2.5 to 10 cm-long cone-like spike of conspicuous rich yellow overlapping bracts, from which protrude white tubular flowers, about 4 cm long. Pot plant. 3(58720).

Pseuderanthemum bicolor (Schrank) Radlk.
syn. *Eranthemum bicolor* Schrank

Recent introduction. E. Malaysia. Rare. Erect shrub, up to 1 m tall; leaves, mostly 5 to 15 cm long and up to 6 cm wide, purple or purple-brown, ovate-oblong or lanceolate-oblong, acuminate, glabrous or finely puberulent; flowers borne in axillary cymes, the uppermost sometimes in racemes, with puberulent calyxes, up to 1 cm long, and puberulent 5-lobed white tubular corollas, 3.5 to 4 cm long with red throats, one lobe with a red blotch, and other lobes white; fruiting capsule 2.5 to 3 cm long. Planted ornamental. 6, 7(27810).

Pseuderanthemum carruthersii (Seem.) Guill. var. **carruthersii** "false eranthemum"
te iaro (K)
syns. *Eranthemum eldorado* Hort.; *Pseuderanthemum eldorado* (Williams) Radlk.

Recent introduction. Melanesia? Occasional. Erect shrub, up to 1 m or higher; leaves, 5 to 15 cm long, smooth, elliptic-ovate leaves, mottled yellow-green, with conspicuous netlike veins; petioles 1 to 3 cm long; erect spike-like racemes bearing flowers with inconspicuous bracts, green or reddish 5-lobed calyxes, up to 8 mm long, and white and purple or rosy-purple tubular corollas, the tube, about 1.3 cm long, and the 5 lobes spreading to about 2.5 cm or more in diameter; fruiting capsule, four-seeded, club-shaped. Planted ornamental shrub. 3, 5, 6(201), 7.

Pseuderanthemum carruthersii (Seem.) Guill. var. **atropurpureum** (Bull) Fosb.
"purple false eranthemum", "false face" te iaro (K); lakauuli (T)
syns. *P. atropurpureum* (Bull) Radlk.; *Eranthemum atropurpureum* Bull.; *P. versicolor* (Hort.) Radlk.; *Eranthemum versicolor* Hort.

Recent introduction. Melanesia? Occasional. Erect shrub, up to 1.5 m or more high; leaves, 5 to 15 cm long, dark purplish-red, elliptic-ovate; petioles, 1 to 3 cm long; erect spike-like racemes bearing flowers with inconspicuous bracts, green or reddish 5-lobed calyxes, up to 8 mm long, and 4-lobed white and purple or rosy-purple tubular corollas, the tube and lobes about 1.3 cm long; fruiting capsule, four-seeded, club-shaped. Planted ornamental shrub. 3(58777, 58792), 5, 6, 7.

Sanchezia speciosa Leonard "sanchezia"
syn. *S. nobilis* sensu auct. non Hook.f.

Recent introduction. Ecuador. Rare. Erect shrub, up to 1 m or higher, with smooth four-angled branches; leaves, 6 to 45 cm long, oval, pointed at both ends, and green, with yellow mid- and side veins; narrow flowering spikes bearing wide red bracts, about 2.5 cm long, each pair with clusters of 8 to 10 narrow bright-yellow tubular flowers with corollas about 5 cm long and 5-lobed calyxes; fruiting capsule, narrow, cylindrical, 6- to 8-seeded. Planted ornamental shrub 6(161).

Thunbergia alata Bojer ex Sims "black-eyed Susan"

Recent introduction. Trop. Africa. Rare. Herbaceous or slightly woody pubescent climbing or trailing vine with angular stems, up to 2 m or longer; leaves, 4 to 8 cm long, mid-green, opposite, deltoid ovate or ovate-lanceolate, pointed, palmately-veined, irregularly toothed; winged petioles, about as long as the blade; flowers solitary on axillary stems (pedicels), up to 5 cm long, 2 large bracts, about 2 cm long, calyx ring-like, corolla, yellow-orange to cream, 3 to 4 cm across, with a purple tube, 2 cm long; fruiting capsule depressed-globose, beaked, about 1 cm long; seeds warty and ribbed. Planted ornamental vine. 5.

Thunbergia erecta (Benth.) T. Anders. "bush thunbergia"
syn. *Meyenia erecta* Benth.

Recent introduction. Trop. W. Africa. Occasional. Erect, somewhat sprawling shrub, up to 2 m tall, with 4-angled stems; leaves, 3 to 8 cm or longer, opposite, oval-ovate, palmately 5- to 7-nerved; petioles, slender, up to 4 cm or longer, winged nearly to base; flowers solitary on axillary stems (pedicels), 1 to 2 cm long, with 2 large bracts, up to 2 cm long, calyx, 3 to 6 mm long, corolla curved, funnel-form, 3.5 to 6 cm in diameter and tube 2 or 3 cm long, irregularly 5-lobed, deep blue-violet or white with a yellow throat; fruiting capsule 2 to 2.5 cm long. Planted ornamental erect shrub. 3(58700), 5(110), 6, 7.

Thunbergia grandiflora (Roxb. ex Rottler) Roxb."Bengal clock vine", "Bengal trumpet", "large-flowered thunbergia"
syn. *Flemingia grandiflora* Roxb. ex Rottler

Recent introduction. India. Rare. Climbing vine; leaves, 7.5 to 20 cm long, dark green, nearly as broad, cordate, palmately lobed, 5 to 7- nerved, pubescent; petioles, 4 to 12 cm long; flowers in pendent racemes, calyx pubescent and reduced to a narrow ring, corolla violet or whitish, 6 to 8 cm in diameter, the tube pale yellow, 3 to 3.5 cm long; capsule up to 1.5 cm, the beak to 3 cm long. Planted ornamental. 6(187).

AMARANTHACEAE (Amaranth Family)

Achyranthes canescens R. Br.
syn. *A. velutina* H. & A.

Indigenous? Extinct? Somewhat shrubby herb, up to 1 m tall; leaves, up to 12 cm or longer, opposite, ovate or elliptic, acuminate, slightly blunt; erect unbranched flower spikes bearing spiny bracts, often pinkish or purplish, and greenish calyx and corolla green, about 6 mm long; fruit, 5-seeded, adherent to fur or clothing. Reported by Schumann (1888) as collected by Finsch; reported present by Burges, 1933; not seen since. Extinct? 2.

Alternanthera ficoidea L. var. **bettzickiana** (Reg.) Backer "joyweed", "alternanthera", "telanthera", "calico plant"
syns. *Telanthera bettzickiana* Reg.; *A. versicolor* Reg.; *Alternanthera bettzickiana* (Reg.) Nichols.

Recent introduction. Brazil. Rare. Small erect variable herb with red branching stems, 15 to 30 cm high; nodes usually with tufts of white hair; leaves, about 2.5 cm long, opposite, lanceolate-ovate or ovate, variegated green, pink, red, yellow, and sometimes cream; petiole equal to or longer than the blade; flowers, small white in sessile heads in axils of the upper leaves. Planted ornamental border. 6.

Alternanthera sessilis (L.) R. Br. ex R. & S. "joyweed"
syns. *Gomphrena sessilis* L.; *Alternanthera denticulata* R. Br.; *A. nodiflora* R. Br.; *A. amoena* (Lem.) Voss

Recent introduction. Pantropical. Rare. Spreading or semi-prostrate branching herb, up to about 50 cm long, rooting at the lower nodes; internodes with 2 pubescent lines; leaves, 1 to 6 cm long and 0.4 to 1 cm wide, opposite, green, narrowly elliptic-obovate or oblanceolate, obtuse or acutish, minutely toothed; petiole up to about 1 cm long; flowers, white, small, stemless (sessile) in compact headlike clusters in the leaf axils; fruit enclosed in a small bladder which does not split open. Garden weed. 6(188).

Amaranthus dubius Mart. ex Thell. "spleen amaranth"

Recent introduction. Trop. America. Occasional. Small erect herb, up to about 70 cm high; stem, smooth, except upper portions which are slightly hairy; leaves, 3.5 to 8 cm long and 2 to 5 cm wide, ovate, smooth on both surfaces, margin smooth; petiole, 2 to 7 cm long; flowers, greenish, in dense axillary and terminal clusters, male and female flowers separate, each with 5 sepals; seeds, small, oval, black. Weed in home gardens and at Location. 3, 6, 7(22309, 22312).

Amaranthus hypochondriacus L. "prince's feather"
syn. *A. hybridus* L. var. *hypochondriacus* (L.) Robins.

Recent introduction. Trop. America. Rare. Smooth erect herb, up to 1 m or higher; leaves, bright red-purple to purple-green; flowers, bright red-purple in thick showy feathery panicles. 6.

Amaranthus spinosus L. "spiny amaranth", "thorny amaranth"
ma si han (C)

Pre-World War II introduction? Pantropical. Occasional. Smooth erect, branched herb, 25 to 70 cm high, armed with a pair of sharp needle-like spines, about 1 to 2 cm long, at the base of each petiole; leaf blades, 2.5 to 10 cm long and 1.5 to 4.5 cm wide, green, alternate, broadly lanceolate, pointed at the tip; petioles, about as long as leaf blades, clasping the stem; female flowers, pale green, clustered at leaf axils; male flowers, pale green, borne in terminal panicles; fruit a circumscissile utricle; seeds, very small, lens-shaped, shiny dark-brown. Weed in waste places and in gardens; occasionally cultivated in Chinese contract workers' gardens at Location. Used as a medicinal plant and leaves reportedly occasionally cooked for spinach by Chinese. 5, 6(140).

Amaranthus tricolor L. "Joseph's coat", "Chinese spinach". "amaranth", "pigweed"
te mota, te moota (K); in ts'oi (C)
syns. *A. gangeticus* L; *A. melancholicus* L.

Pre-World War II introduction? Trop. Asia. Occasional. Erect unarmed, branching herb, up to 1.5 m tall; leaves, 3 to 7 cm long, oval, pointed to blunt, long-petiolate, green or blotched with red or purple; flowers in rounded stemless clusters in leaf axils and in terminal panicles, about 5 cm long; fruit, a 1-seed utricle; seed, small, disc-shaped, dark brown, shiny. Food plant in Chinese gardens at Location and Topside workshops. 5(27), 6.

Amaranthus viridis L. "slender amaranth", "green amaranth", "pigweed"
syn. *A. gracilis* Desf.

Recent introduction. Pantropical. Occasional. Erect or decumbent, unarmed herb, up to 20 to 60 cm high; stems, reddish, longitudinally-grooved; leaf blades, 3 to 7.5 cm long and 2.5 to 5 cm wide, alternate, green above, lighter below, broadly lanceolate or ovate, obtuse or slightly notched at tips, smooth on both surfaces; petioles, 2.5 to 5 cm long; flowers, greenish to purplish, in small dense axillary clusters and terminal panicles; fruit, a 1-seeded utricle; seed, small, disc-shaped, dark brown. Weed in waste places, primarily at Location. 4(143N), 5(26), 6.

Celosia argentea L. var. **cristata** (L.) Ktze. "cock's comb"
syn. *C. cristata* L.

Recent introduction. Trop. Americas. Erect annual herb, 30 cm to 75 cm high, stems usually ribbed; leaves, 2 to 16 cm long and up to 5 cm wide, although usually smaller, alternate, narrow lanceolate to ovate, often reddish-green; inflorescence, a dense, flatly-crested, elongated, fan-shaped flower head, 6 to 15 cm across, bearing numerous tiny flowers, pinkish or yellow, but usually magenta or bright red; each fruit with two small, glossy, black seeds. Rare. Planted ornamental. 7.

Gomphrena globosa L. "globe amaranth", "pearly everlasting"

Recent introduction. Trop. America. Rare. Erect branched annual herb, up to 45 cm high; leaves, 10 by 5 cm or smaller, opposite, obovate-oblong, pale-green, hairy, petioles clasping; flowers, numerous, crowded, in globose heads, about 1.5 to 2.5 cm in diameter, white, yellow, pink, red, purple or variegated, borne at the ends of branches, each head having two leafy bracts. Planted ornamental. Flowers used by Nauruans in head garlands and other ornamentation. 5(93)

Iresine herbstii Hook.f. "iresine", "bloodleaf", "achyranthes"

Recent introduction. Brazil. Rare. Fast-growing, erect shrubby perennial herb, up to 30 to 70 cm high, with bright red stems and branches; leaves, up to 6 cm long, opposite, fleshy, round to heart-shaped, the tip blunt or notched, brilliant red-purple to bronze-red, with wide, arching prominent veins, the blade continuing down the petiole; flowers, which may not develop, greenish-yellow, minute, numerous, in fine, much-branched panicles, up to 50 cm long. Planted ornamental. 6.

ANACARDIACEAE (Cashew or Rhus Family)

Mangifera indica L. "mango"
damanko (N); te mangko (K); mago (T)

Pre-World War I introduction. Indo-Burma. Common. Large dense, broad-crowned tree, with dark roughened bark, up to 20 m high; leaves, 10 to 35 cm long and

2 to 8 cm wide, green to light-green, alternate, spirally arranged, simple, oblong-lanceolate, acute to acuminate, leathery (coriaceous) and somewhat shiny, pinnately-nerved, midrib prominent, young leaves often reddish; petioles up to 5 cm or more long, somewhat flattened on the upper surface; flowers, small, about 4 to 8 mm in diameter, numerous, yellowish-white to pinkish-white, 4- to 5-parted corolla, densely covered with short yellowish hairs, in large branched terminal panicles, 10 to 50 cm long; fruit, 8 to 20 cm long, fleshy, fibrous, ovoid, pointed or rounded edible drupe, with thick, smooth, green to yellow-orange or reddish skin, sweet, juicy, yellow-orange to dark orange pulp, and a large, flattened, fibrous, ribbed seed case containing one seed. Large fruit and shade tree planted in home gardens and found growing in mature spontaneous stands near Buada Lagoon. Fruit eaten ripe and green, with ripe fruit occasionally made into jam on Nauru; used for firewood. The leaves, and sap from leaves and fruit, can cause an allergic rash. Common introduced fruit tree, found in houseyard gardens, agricultural areas and naturalized throughout Melanesia, Polynesia and Micronesia, possibly an aboriginal introduction in some areas, but not on Nauru; an important cash crop for local sale and export in Polynesia, Melanesia and the larger islands of Melanesia. 2, 3(58643), 5(147), 6, 7.

Spondias dulcis Park. "Polynesian vi apple", Polynesian plum", "Otaheiti apple"
dagimadere, "Egigu's tree" (N)
syn. *S. cytherea* Sonn.

Aboriginal introduction? Pacific Islands. Rare. Medium to large stiff-branched, smooth, grey-barked, deciduous tree, up to 15 m or taller; leaves, 20 to 40 cm long, alternate, odd-pinnate, clustered at branch ends; leaflets, up to 8 cm or longer and 2.5 cm wide, commonly 4- to 12-paired, with a single unpaired terminal leaflet (8 to 25 in total), shiny, bright green, oval-lanceolate or oblong, acuminate, base acute, entire to finely toothed (crenulate); flowers, tiny, 5-parted, male, female and perfect, develop in large, lax crowded panicles; fruit, up to 8 cm or longer, oval-obovate edible drupe with green to yellow-orange skin and light green to dark yellow pulp, surrounding a single, 5-ridged, fibrous seed case with 1 to 5 seeds. Reported present by Burgess in 1935. The tree, which formerly stood near Buada Lagoon, was reportedly damaged during World War II, and although the Nauruans tried to save it by shoring it up with cement, it died shortly thereafter. Four seeds sent by R. Thaman to J. Audoa in 1981 in an attempt to reintroduce *S. dulcis*, but the result of plantings is unknown. One tree, 3 m tall, seen re-established in fenced food garden surrounding Buada Lagoon in July 1987. Ripe fruit eaten. Tree features in the well-known Nauruan legend concerning a young woman, Egigu, who became the Nauruans' "woman in the moon", after climbing the tree (dagimadere), restoring the sight of a blind women Enibarara who lived at the top, and marrying her third son, Maramen (the moon). 2, 7.

Spondias mombin L. "hog plum"
syn. *S. lutea* L.

Extinct? Trop. Asia. Reported present by Burges. Possibly a doubtful identification. 2.

ANNONNACEAE (Custard Apple Family)

Annona muricata L. "soursop"
dawatsip (N)

Pre-World War II introduction. Trop. America. Common. Small tree, rarely over 8 m tall; leaves, about 10 to 16 cm long and 4 to 7 cm wide, bright green, alternate, entire, oblong or oblong-elliptic, acute or acuminate, glabrous, somewhat glossy above, pungent; petioles short; flowers, 2 to 3 cm or more long, yellowish-green, solitary or in pairs, with 3 thick, broadly deltoid or heart-shaped light yellow sepals and 6 cordate outer petals, borne on the branches and trunk (cauliflorous); fruit, up to 25 cm or longer and weighing 0.5 to 2 kg, fleshy, oblong or ovoid, irregularly heart- or kidney-shaped, with green to yellowish-green skin, covered regularly spaces, short, slightly curved fleshy spines, and white, juicy, somewhat acid, aromatic, cotton-like, edible pulp; seeds, about 2 cm long, numerous, black, embedded in pulp. Planted in home gardens by Nauruans and others and spontaneous on coastal strip, in some areas of escarpment forest, and in the Buada Lagoon area. Ripe fruit eaten raw, often with ice cream. Common recently introduced fruit tree throughout the Pacific. 2, 3(58586), 5, 6, 7.

Annona reticulata L. "custard apple", "bullock's heart"

Pre-World War II introduction. Trop. America. Rare. Small to medium tree, rarely over 9 m tall; leaves, up to 20 cm long and 6 cm wide or more, light green, smooth, alternate, elliptic- or oblong-lanceolate, acute or acuminate, pinnately nerved, brittle; petioles about 12 mm long; flowers, about 2.5 cm long, greenish, axillary, in groups of 2 or 3 on lateral peduncles; fruit, 7 to 13 cm in diameter, yellowish- to greenish-red, ovoid or heart-shaped, with whitish pulp, surface divided by impressed lines into rhomboidal or hexagonal sections; seeds, numerous, glossy brown, embedded in pulp. Planted fruit tree; found growing, possibly spontaneously, behind settlement on Military Ridge. 2, 5(146), 6, 7.

Annona squamosa L. "sweetsop", "sugar apple"
dawatsip (N); nameana (T)

Pre-World War II introduction. Trop. America. Occasional. Small tree, rarely over 8 m tall; leaves, 7 to 14 cm long and 4 to 5 cm wide, pale bluish-green (glaucous), two-ranked, thin, oblong or elliptic-lanceolate, acute, sparsely puberulent on both surfaces when young; petioles, about 1 cm long; flowers, about 2.5 cm long, greenish-yellow, axillary, solitary, pendent, petals narrowly lanceolate, obtusish, concave at base; fruit, about, 8 cm in diameter, light grey-blue-green, subglobose, somewhat heart-shaped, surface divided into prominent protruding knobs or tubercles, which separate, sweet, edible cream-colored soft pulp; seeds, numerous, blackish, embedded in pulp. Fruit tree planted in home gardens and growing spontaneously in inland coastal and lower escarpment forest. Ripe fruit eaten raw. 3(58589), 5(37), 6, 7.

Cananga odorata (Lam.) Hook.f. & Thoms. "ylang-ylang", "perfume tree"
derangerang, derangirang (N)
syns. *Canangium odoratum* (Lam.) Baill. ex King; *Uvaria odorata* Lam.

Recent introduction. Indomalaysia. Uncommon. Tree, up to 15 m or taller, with a crooked trunk, smooth grey bark and drooping, brittle branches; leaves, 7 to 20 cm long and 4 to 9 cm wide, dark green, alternate, simple, entire, elliptic-oblong, acute, base rounded, obtuse, slightly pubescent, pinnately nerved, midrib prominent; petiole, mostly less than 2 cm; flowers, yellowish-green turning yellow, drooping, very fragrant, sepals 3, petals 6, up to 6 or 8 cm long, wavy, linear-lanceolate, on long puberulent pedicels, in axillary hanging (pedunculate) umbellate clusters of 4 to 12 flowers; fruit, 1.5 to 2.5 cm long, greenish-black, oblong, olive-like, fleshy, borne in bunches from a stalk which lengthens as the fruit develops; seeds, 6 to 12. Planted ornamental tree in home gardens in Buada Lagoon area. Flowers used in garlands and for scenting coconut oil. An important aboriginal introduction of considerable cultural importance throughout Melanesia and Polynesia, where the flowers are used in garlands and to scent coconut oil. Used in the commercial production of essential oil in the Philippines and Indonesia. 5(17), 6, 7.

APIACEAE OR UMBELLIFERAE (Parsley Family)

Apium petroselinum L. "parsley"
syns. *Petroselinum petroselinum* (L.) Karst.; *P. crispum* (Mill.) Mansf.

Recent introduction. S. Europe and W. temperate Asia. Rare. Erect biennial or short-lived perennial herb, up to 25 to 40 cm tall, with a stout tap root; leaves, aromatic, shiny, dark green, in dense, tufted rosettes, 2 to 3-pinnate, with leaflets, 1 to 2 cm long, deltoid-ovate, but deeply toothed or lobed, often much crisped; flowers, 2 mm in diameter, greenish-yellow, umbellets, 10 to 20 flowered, borne in flat-topped compound umbels, 2 to 5 cm in diameter; fruit (carpel), 2 to 3 mm long, grey-brown, ovoid, laterally compressed, with 5 slender ridges. Pot herb in European home gardens; planted in a halved 50-gallon drum on Command Ridge. Leaves and stems used by European inhabitants as a spice in cooking. 5.

Coriandrum sativum L. "coriander", "cilantro", "Chinese parsley"
dhania (Hindi), uen sai (C)

Recent introduction. S. Europe and the Mediterranean region. Occasional. Erect annual herb, 15 to 30 cm high; lower leaves, bright green, broad with crenately-lobed margins, upper leaves finely cut with narrow linear lobes; flowers, white to pinkish, in terminal umbels; fruit, about 3 mm in diameter, globose, yellow-brown, ribbed, 2-seeded, with an unpleasant smell when unripe, but later becoming pleasantly aromatic. Pot herb grown in Chinese home food gardens at Location and at Topside workshops. Aromatic leaves used as a spice by Chinese and Indians. Dried, imported seeds an important spice in curries. 5, 6, 7.

APOCYNACEAE (Dog-bane Family)

Adenium coetanum Stapf "desert rose", " mock azalea"
syn. *A. obesum* Balf.

Recent introduction. E. Africa. Rare. A smooth succulent shrub, 40 to 150 cm high, with a thick trunk, short branches and milky sap which is said to be poisonous; leaves, 2.5 to 10 cm long, dark green, shiny, ovate, arranged spirally in tufts at branch tips; flowers, about 5 cm long and 3.8 cm across, red-pink, short-stemmed, funnel-shaped, developing in clusters, 2 to 10 together. Pot plant in home gardens. 3(58716), 5, 6(176), 7.

Allamanda hendersonii Bull "allamanda", "cup of gold"
syn. *A. cathartica* L. var. *hendersonii* (Bull) Bailey & Raff.

Recent introduction. Brazil. Rare. Robust woody vinelike climbing shrub, with milky poisonous sap; leaves, 8 to 15 cm long and mostly 4 to 5 cm wide, bright green, shiny, opposite in pairs or in whorls of 3 or 4, elliptical to sub-obovate, but broadest above the middle, abruptly acuminate, entire, thick and somewhat leathery (coriaceous), midrib prominent; petiole very short; flowers, corolla tube 4 to 5 cm long, showy bright yellow, slightly fragrant, trumpet-shaped, 5-parted with broad, spreading rounded lobes, totalling 6 to 7 cm or wider, borne in axillary and terminal racemose clusters of about 10 flowers; fruit, a prickly capsule. Planted ornamental. 3(58697), 5, 6.

Allamanda violacea Gardn. & Field "purple allamanda"

Recent introduction. Brazil. Rare. Woody vinelike climbing shrub; leaves, similar to *A. hendersonii*, but bearing short, stiff hairs; flowers, similar to *A. cathartica*, but red-purple and 5 to 6.5 cm in diameter. Planted ornamental. 3, 5, 6.

Catharanthus roseus (L.) G. Don "periwinkle", "Madagascar periwinkle"
denea (N); te buraroti (K); losa (T)
syns. *Vinca rosea* L.; *Lochnera rosea* (L.) Reichenb.

Pre-World War II introduction. Madagascar. Common. An everblooming erect perennial herb, up to 50 cm or taller, with white milky sap; leaves, 2.5 to 8 cm long and 2 to 3 cm wide, opposite, oblong or oblong-obovate, apex rounded, tipped with a sharp point, base acute, finely puberulent on both surfaces; midrib pale; flowers, showy white or pink, with or without a red throat, 5-parted, corolla tube, 2.5 to 3 cm long, lobes, 1.5 to 2 cm long, calyx, about 6 mm long, with awl-shaped lobes; fruit, up to 3 cm long, with paired, 2.5 cm long puberulent podlike cylinders containing several cylindrical seeds. Planted ornamental. Flowers used in garlands and reportedly boiled by some people and drunk as a cure for diabetes. 3(58758), 5(127), 6, 7.

Cerbera manghas L. "cerbera", "sea mango"
dereiongo, dereiyongo (N); te reiango (K?)
syns. *C. odollam* sensu auct. non Gaertn.; *C. lactaria* (G. Don) Ham.; *Tanghinia lactaria* G. Don

Indigenous. Trop. Asia to the Pacific Is. Rare. Medium-sized tree, up to 7 m or taller, with white sap; leaves, 15 to 30 cm long and 5 to 8 cm wide, dark green, shiny, simple, entire, lanceolate or obovate-lanceolate, acuminate, base acute-decurrent, spirally and closely arranged; petiole 2 to 3 cm long, narrowly winged by decurrent blade margins; flower, 2.5 to 6 cm wide, tube about 2.5 cm long, 5-petaled, white with red throat, fragrant, calyx with 5 narrow lobes, 1.3 cm long, borne in branching terminal clusters about as long as the leaves; fruit, globose or ovoid, 5 to 7 cm long, smooth, deep purple to black when ripe, single or paired; seed, a woody stone, poisonous. Found near homes on the coastal strip and near church at Buada. Seems to be planted, or at least protected in built-up areas. No reported use by Nauruans, but its poisonous fruit is reportedly used medicinally and to poison fish in Samoa, Tonga and elsewhere in the Pacific. 5(16), 6, 7.

Nerium oleander L. var. **oleander** "oleander"
te orian (K)

Pre-World War II introduction. S. Europe to Iran. Occasional. Large erect shrub, up to 4 m or higher, with arching stems rising from the ground, young growth finely pubescent, young branches slightly 3-angled and all parts extremely poisonous; leaves, 10 to 20 cm long and 2 to 3.5 cm wide, dull grey-green, narrowly oblong-lanceolate, acute at both ends, entire, flat, leathery (coriaceous), midrib prominent, lateral nerves numerous, fine; flowers, 4 to 5 cm wide, showy, white, pink to deep red, slightly scented, with five toothed appendages in the corolla throat, borne in terminal cymose clusters; fruit, 10 to 20 cm long, seldom seen, sometimes developing from single flowers. Planted ornamental. 2, 3(58783), 4, 6, 7.

Nerium oleander L. var. **indicum** (Mill.) Deg. & Deg. "oleander", "sweet scented oleander" te orian (K)
syns. *N. indicum* Mill.; *N. odorum* Soland.

Post World War II introduction? Iran to Japan. Occasional. Large erect shrub, up to 4 m or higher, with arching stems rising from the ground, young growth finely pubescent, young branches slightly 3-angled and all parts extremely poisonous; leaves, 10 to 20 cm long and 1.5 to 3 cm wide, dull grey-green, narrowly oblong-lanceolate, acute at both ends, entire, edges rolled back, leathery (coriaceous), midrib prominent, lateral nerves numerous, fine; flowers, 4 to 5 cm wide, corolla usually double, showy, white, pink to deep red, fragrant, funnel-shaped, with fringed appendages in the corolla throat, borne in terminal cymose clusters; fruit, 10 to 20 cm long, paired, pod-like, seldom seen, sometimes developing from single flowers. Planted ornamental shrub. 3, 5, 6, 7.

Ochrosia elliptica Labill.
eorara, eoerara (N)
syn. *Bleekeria elliptica* (Labill.) Koidz.

Indigenous. Australia to the Pacific Is. Occasional to common. Small to medium-sized tree, up to 8 m or higher, with white milky sap; leaves up to 15 cm long, oval or inverted ovate, blunt or short-pointed, leathery (coriaceous), arranged in pairs, threes or fours, with blades tapering into petioles about 1.2 cm long; flowers, small, cream-colored, fragrant, stemless, developing in short cymose clusters at or near the branch tips; fruit, 2.5 to 4.5 cm long, bright red, ovoid drupe, slightly keeled or flattened on the margins, pointed, twinned, with mealy violet, scented pulp surrounding one or two seeds. Tree in forest remnants on rocky outcrops on the central plateau, in escarpment forests on southern half of the island, and occasionally in home gardens on coastal strip. Wood used by Nauruans for rafters and small timber; leaves used medicinally, being crushed with coconut cream to treat rashes, especially for children; fruit used in children's games, and fruit and flowers used in garlands. 2, 3(58802), 4(168N), 5(92), 6, 7(27812).

Plumeria obtusa L. "white frangipani", "plumeria"
demeria (N); te meria (K); melia, pua Solomona, melia Solomona (T)

Recent introduction. Trop. America. Common. Small to medium-sized, soft-wooded, broad-crowned, knobby, branching evergreen tree, up to 5 m or taller, with thick fragile branch tips and white milky sap; easily planted from cuttings; leaves, 20 to 35 cm long and 6 to 10 cm wide, dark green, glossy, alternate, obovate rounded, blunt, smooth (glabrous), tapered at the base, pinnately nerved, midrib prominent, lateral nerves loop-connected near margin, clustered near the ends of branches; petioles, 4 to 9 cm, stout; flowers, 4 to 6 cm in diameter, all white with a central yellow eye, fragrant, but less so than *P. rubra*, 5-parted, narrowly tubular, petal lobes obovate, longer than tube, borne in terminal cymose clusters; fruit, 15 to 24 cm long, dark green later black, single or twinned, cylindrical, fusiform, with many flat winged overlapping seeds. Flowers used in garlands and dried in sun and used to scent coconut oil (*eir*). 3(58775), 5(111), 6, 7.

Plumeria rubra L. "frangipani", "plumeria", "temple tree", "graveyard tree"
demeria, arabaneit (N); te meria (K); melia, pua Fiti, melia Nauru (T)
syns. *P. acuminata* Ait.f. and *P. acutifolia* Poir.

Pre-World War II introduction. Trop. America. Common. Small to medium-sized, soft-wooded, broad-crowned branching deciduous tree, up to 5 m or taller, with thick fragile branch tips and white milky sap; easily planted from cuttings; leaves, 20 to 35 cm long and 6 to 10 cm wide, pale green to grey-green, alternate, elliptic-oblong, acute or acuminate, smooth (glabrous), tapered at the base, pinnately nerved, midrib prominent, lateral nerves loop-connected near margin, clustered near the ends of branches; petioles, 4 to 9 cm, stout; flowers, 3 to 5 cm in diameter, waxy-white to yellow, pink, deep red or multicolored variations, very fragrant, 5-parted, narrowly tubular, petal lobes obovate, longer than tube, borne in terminal cymose clusters; fruit, 15 to 20 cm long, dark green later black, single or twinned, cylindrical, fusiform, with many flat winged overlapping seeds. Planted ornamental. The name *demeria* seems to be applied to all color forms and to both species of *Plumeria*, with the older name *arabaneit* being reserved for the bright yellow to yellow-white cultivars, which are longer established in Nauru. Leaves used medicinally and mixed with coconut oil for curing fever; flowers used in garlands and dried in the sun and used to scent coconut oil (*eir*). 2, 3(58654), 5(50), 6, 7.

Tabernaemontana divaricata (L.) R. Br. "false gardenia", "paper gardenia", "crepe jasmine", "scentless gardenia"
syns. *Nerium divaricatum* L.; *N. coronarium* Jacq.; *Tabernaemontana coronaria* (Jacq.) Willd.; *Ervatamia divaricata* (L.) Burkill; *E. coronaria* (Jacq.) Stapf; *Tabernaemontana alternifolia* L.; *Nyctanthes acuminata* Burm.f.

Recent introduction. India. Occasional. Smooth erect shrub, up to 2 or 3 m tall, resembling a gardenia, with scanty, white milky sap; leaves, 6 to 15 cm long and 2 to 4.5 cm wide, dark green, lighter below, glossy, opposite, elliptic oblong, acute or obtuse, acute at base, glabrous, thin, with 6 to 10 pairs of curving veins; petiole short, mostly about 1 cm long, clasping the stem; flowers, 2.5 to 5 cm in diameter, usually several, up to about 8, together or rarely solitary, in flat-topped corymbose clusters near branch tips or leaf axils, white, nearly odorless, calyx about 5 mm long, segments rather broad, deltoid and obtuse, corolla, 5-parted, tube 1.5 to 2.5 cm long, cylindrical, lobes, about 2 cm long, often doubled and ruffled, crinkled or crepe-like; fruit, rarely seen in cultivation, 3 to 7 cm long, yellow-orange, paired, oblong, podlike, with 1 to 3 ridges, pubescent, red within; seeds, many, embedded in pulp. Planted ornamental. 3(58706), 5, 6(222), 7.

Thevetia peruviana (Pers.) K. Schum. "be-still tree", "yellow oleander"

syns. *Cerbera peruviana* Pers.; *C. thevetia* L.; *Thevetia neriifolia* Juss. ex Steud.; *T. thevetia* (L.) Millsp.

Recent introduction. Peru. Occasional. Everblooming shrub or small tree, up to 8 m or taller, propagated from seeds and cuttings; all parts reportedly poisonous; leaves, 5 to 15 cm long and 0.5 to less than 1 cm wide, numerous, dark green, somewhat shiny above, paler beneath, leathery (coriaceous), alternate, linear-lanceolate, acute or subobtuse, acute at base; petiole, very short, about 3 mm long; flowers, about 4 to 7 cm long, 5-parted to more than halfway down, showy yellow, mildly fragrant, funnel- or trumpet-shaped, borne in terminal cymose clusters; calyx, 1 to 1.3 cm long, 5-lobed, acute-acuminate; fruit, 4 to 5.5 cm broad, a juicy red drupe, ripening to black, containing a thin layer of pulp and 2 oily seeds. Planted ornamental. 3(58704), 5(78), 6, 7.

AQUIFOLIACEAE (Holly Family)

Ilex sp. "holly"

Recent introduction. Eurasia. Rare. Evergreen shrub with short-stemmed leaves bearing several strong spines. Planted ornamental. 6(164).

ARALIACEAE (Panax Family)

Polyscias balfouriana (Andre) Bailey "panax"

Recent introduction. Melanesia. Rare. Large erect shrub, up to 3 m or taller, with few, rapidly ascending branches; leaves, 20 to 50 cm long, compound, 1-pinnate; petioles, 8 to 22 cm long, petiolules, 2 to 4 cm long; leaflets, 5 to 20 cm long and 5 to 18 cm wide, ovoid to orbicular, cordate, shiny, dark-green, opposite, mostly 3 or 5 in number, terminal leaf largest, crenate. Planted ornamental, commonly in hedges. 5, 6, 7(22324).

Polyscias cumingiana (Presl) Fern.-Vil. "panax"
lautagitagi (T)
syns. *Paratropia cumingiana* Presl; *Nothopanax cumingii* Seem.; *Aralia filicifolia* C. Moore ex Fourn.; *Polyscias filicifolia* (Moore) Bailey

Recent introduction. Malesia, possible to Melanesia. Rare. Large erect shrub, up to 3 m or taller, with few, rapidly ascending weak branches; leaves, mostly 15 to 70 cm long, alternate, 1-pinnate, uppermost leaves turning a showy light-yellow, giving the plant a feathery appearance; petioles, 5 to 20 cm long, petiolules, 1 to 2.5 cm long; leaflets, 6 to 15 cm long and about 5 cm wide, opposite, entire to sharp-toothed or narrowly lobed, 6 to 7 pairs, plus terminal leaflet (13 to 15 leaflets), anise-scented; petioles 1 to 2 cm long. Planted ornamental, commonly in hedges. 6, 7.

Polyscias fruticosa (L.) Harms "panax"
te mamara (K?); lautagitagi (T)
syns. *Panax fruitcosum* L.; *Nothopanax fruticosus* (L.) Miq.

Pre-World War II introduction. India to W. Polynesia. Occasional. Erect, rather few-branched shrub, 1 to 3 m tall; leaves, up to 30 cm or longer, alternate, pinnate, usually bi- or tri-pinnate; leaflets, 5 to 10 cm long, terminal leaf usually the largest, green or variegated, commonly edged with white, glabrous, anise-scented, irregularly-shaped, more or less lanceolate, usually toothed, lobed laciniate or pinnatifid; flowers, small, greenish-white, borne in small umbels, forming large terminal paniculate clusters; fruit, flattened, orbicular, ribbed 2-seeded. Planted ornamental, commonly in hedges or as a living fence. 2, 3(58698), 5, 6(171), 7(22323).

Polyscias guilfoylei (Cogn. & March.) Bailey "panax", "hedge panax"
te toara (K); lautagitagi (T)
syns. *Aralia guilfoylei* Cogn. & March.; *Nothopanax guilfoylei* (Cogn. & March.) Merr.

Pre-World war II introduction. Melanesia to S. Polynesia. Common. Large shrub, 2 to 6 m tall, with weak, rapidly ascending vertical branches and light grey bark; leaves, mostly 15 to 50 cm long, alternate, variable, but commonly broadly ovate or elliptic and coarsely sharply-toothed or laciniate, rarely subentire, commonly variegated with white or pale yellow margins, or sometimes all dark green, shiny; petioles, 2 to 3 cm long, clasping the stem; flowers, rarely seen, small, 5-parted, petals, 2.5 by 1.2 mm, in umbels, borne on a large, much-branched terminal panicle; fruit, usually 3- to 4-celled, with 3 to 4 seeds, 4 by 5 mm. Planted ornamental, commonly as a hedge or living fence. 2, 3(58696), 5(20), 6, 7(27822).

Polyscias scutellaria (Burm.f.) Fosb. "panax"
te toara (K); lautagitagi (T)
syns. *Crassula scutellaria* Burm.f.; *Polyscias pinnata* J.R. & G. Forst.; *Nothopanax scutellaria* (Burm.f.) Merr.

Recent introduction. S.E. Asia. Occasional. Medium-sized erect shrub, 1 to 3 m tall, with weak, ascending branches; leaves, simple (unifoliate) or pinnate, with 3 or sometimes 5 leaflets; petioles, at least 12 cm, petiolules, 2 to 5 cm or longer; leaflets, 5 to 14 cm in diameter, the terminal leaflet of compound leaves largest, orbicular-cordate, concave and saucer-like, glossy, base subcordate-cordate, sometimes obliquely so, green or with white or yellow variegations, some forms wavy or with blunt or rounded teeth (crenate); flowers, borne in umbels on a much-branched panicle, small, about 3 mm long, petals, about 2.5 mm long, 6 or 7 in number; fruit, flattened, 2-seeded (rarely 3-celled and 3-seeded). Planted ornamental, commonly as a hedge or living fence. 3(58693), 5, 6, 7.

Polyscias tricochleata (Miq.) Fosb. "panax"
syn. *P. pinnata* Fosb. cv. *tricochleata* Stone; *Nothopanax tricochleatus* Miq.

Recent introduction. Pacific Islands. Rare. Erect shrub, 1 to 2 m tall; leaves usually trifoliate (rarely 1 or 5 leaflets); leaflets, orbicular, white- or yellow-margined; flowers and fruit unknown. Known to be a mutant form of *P. pinnata*. Planted erect ornamental shrub with white-margined leaflets. 3(58674), 7(22325).

Schefflera actinophylla (Endl.) Harms "Queensland umbrella tree", "octopus tree"
syn. *Brassaia actinophylla* Endl.

Recent introduction. N. Australia. Occasional. Small to medium-sized, soft-wooded tree, up to 10 m or taller, with thick branches marked by conspicuous leaf-scars, sometimes epiphytic; leaves, large, up to 90 cm or wider in diameter, palmately-compound, umbrella-shaped, with 7 to 15, usually 7 to 9, leaflets, forming rosettes at the branch ends; main petioles 15 to 45 cm long, petiolules, 2.5 to 8 cm long; leaflets, 10 to 30 cm long, elliptic-obovate, oblong, sub-acuminate, the central ones longest, shiny, dark-green, leathery (coriaceous); flowers, in small red heads, arranged more or less spicate-racemosely along stout wide-spreading axes, up to 60 cm or longer, several of which radiate, like the tentacles of an octopus, from a central hub-like axis arising from each leaf cluster; fruit, 10- to 12-seeded, nutlets, red-purple. Planted ornamental. 3(58672), 5, 6, 7.

ASCLEPIADACEAE (Milkweed Family)

Asclepias curassavica L. "milkweed", "butterfly weed", "red cotton bush", "bloodflower"
dupaimdupaim, dupaimdupwaim (N)

Pre-World War II introduction? Trop. America. Rare. Slender erect, branched, woody perennial herb, up to 1 m or higher, with milky sap; leaves, 6 to 15 cm long and 1 to 3 cm wide, opposite, oblong-lanceolate, acute at both ends, pinnately-nerved, pubescent on nerves beneath; flowers, many, small, about 60 mm in diameter, borne in 4- to 15-flowered terminal and axillary umbels on finely pubescent peduncles, 3.5 to 6 cm long; corolla, 7 to 9 mm long, red to reddish-purple, with 5 deeply-parted lobes, bent backward (reflexed), and a protruding orange to yellowish-orange scaly crown, 3.5 to 4 mm long; fruit, 5 to 7.5 cm long, erect, pointed, ovoid, podlike, smooth or downy, containing numerous round, flat seeds, 6 to 7 mm long, each bearing a tuft of long, silky, white hairs, 2 to 2.7 mm long. Planted ornamental; flowers used for body ornamentation and making garlands; reportedly poisonous to livestock. 5, 6.

Calotropis gigantea (L.) R. Br. "crown flower", "giant milkweed"
te bumorimori (K)
syn. *Asclepias gigantea* L.

Recent introduction. India to Indonesia. Rare. A large shrub, up to 4 m or higher, with thick downy branches and copious milky sap; leaves, 7.5 to 25 cm long, nearly stemless (shortly petiolate), broad ovate-oblong, thick, pale green, downy, woolly beneath, indented at base; flowers, about 3 to 4 cm in diameter, pale lavender or white, sweetish fragrance that deteriorates when crushed, with 5 curled-back petals and a prominent symmetrical crown, sometimes only consisting of the flower crowns. Planted ornamental at the Meneng Hotel. 3(58771), 5, 6(152), 7.

Hoya carnosa (L.) R. Br. "wax plant", "wax flower"
syns. *Asclepias carnosa* L.

Recent introduction. S. China. Rare. Fleshy waxy climbing vine, climbing by roots, up to 2 m or longer; leaves, 5 to 10 cm long, opposite, narrow to broad ovate-oblong, mid-green, thick, fleshy, shiny, flat; flowers, 1 to 1.3 cm in diameter, 5-parted, white with pink centers, convex, wheel- or star-shaped, waxy, fragrant. Planted ornamental. Single specimen; could have been the Australian species, *H. australis* R. Br. (syn. *H. bicarinata* Gray). 6, 7.

ASTERACEAE OR COMPOSITAE (Aster, Sunflower or Composite Family)

Ageratum conyzoides L. "goat weed", "ageratum"
bwiyat tsige, bwiyat ziege (N)

Pre-World War I introduction. Trop. America. Occasional. Erect to somewhat sprawling, branching, weak-stemmed, strong smelling, annual herb, up to 80 cm high; leaves, 2 to 10 cm long and 1 to 5 cm wide, opposite, ovate or rhombic-ovate, acutish, base rounded and acute at petiole, edges scalloped, pubescent on both surfaces, glandular dorsally; petiole up to 5 cm or longer; flowerheads, small, 4 to 6 mm long, bluish, corymbose, in loose, terminal and axillary clusters; involucral bracts, 3 mm long, acute-acuminate, subglabrous; florets, about 75 per head, about 1 mm long, white or light purplish-blue; fruit (achenes), 1.5 to 2 mm long, numerous, angled, nearly glabrous; pappus, of 5 awned scales. Found on low ground near Buada Lagoon and occasionally in other ruderal habitats. Leaves and flowers used in garlands and body decoration and for scenting coconut oil. 3(58652), 5(11), 6, 7, 8(9574).

Bidens alba (L.) DC. "cobbler's peg", "Spanish needle" kauen oe, kawen oe (N)
syns. *Coreopsis alba* L.; *C. leucanthema* L.; *C. leucantha* L.; *B. pilosa* L. var. *radiata* sensu auct. non Sch.-Bip.; *B. leucantha* (L.) Willd.

Recent introduction. Trop. America. Rare. Erect branching annual herb (in big plants, the branches sometimes straggling), up to 1.5 m tall; leaf blades, 1 to 12 cm long and up to 6 cm wide, lower leaves simple, ovate and serrate, but upper leaves trifoliate or imparipinnate, leaflets ovate or ovate-oblong, acute, basally decurrent, petiolulate, serrate; petioles, up to 6 cm long; flowerheads, few, in panicles; involucral bracts, about 7 or 8, linear-spatulate; heads, 6 to 8 mm long and 6 to 8 mm wide; ray florets bright white, 6 to 8 mm long; disc-florets yellow; fruit (achenes), linear, 7 to 13 mm long, black or dark brown, about 1 mm wide, flat, 4-angled, short-strigose or glabrous, with 2 to 4 barbed awns, about 3 mm long, at the tip. Weed on dirt pile near Topside sports oval; not seen in 1987. 4(142N), 5(76), 6.

Bidens pilosa L. "cobbler's peg"' Spanish needle"

Recent introduction. Trop. America. Common? Slender, erect, branching annual herb, 20 to 90 cm tall; stems, 4-angled, glabrous; leaves, mostly 1 to 5 cm long, simple to compound or deeply 3 to 5-lobed, opposite; lobes or leaflets ovate to lanceolate, acute, decurrent at the base, serrate, mostly glabrous; flowerheads, 5 to 10 mm long, on terminal or upper axillary panicles or solitary on long stalks (peduncles), up to 3 cm long; involucral bracts, 2 to 3-ranked, lanceolate, the outer ones somewhat leaflike; ray florets usually absent; disc-florets, yellow, tubular; fruit, 6 to 12 cm long, a black, ribbed, straight or curved, linear achene, tipped with 2 to 4 barbed awns, which adhere to clothing. Weed in wasteplaces, ruderal habitats and gardens. 8.

Conyza bonariensis (L.) Cronq. "hairy horseweed"

syns. *Erigeron bonariensis* L.; *E. crispus* Pourr.; *E. albidus* (Willd. ex Spr.) A. Gray; *Conyza albida* Willd. ex Spr.

Recent introduction. Pantropical. Rare. Slender, erect annual herb, 30 cm to 1 m or higher, with pubescent stem, the lower portion with leaf scars; leaves, 2.5 to 12 cm long, dark greyish-green, narrowly lanceolate, lower ones, oblanceolate, coarsely dentate, upper ones, linear, entire, pubescent on both surfaces, attached to stem by a broad base; flower heads, 1 to 1.3 cm in diameter, in racemes or racemose panicles; involucral bracts, about 5 mm long, grey-pubescent (downy); ray-florets, usually many, inconspicuous, white to cream; fruit, about 1.6 mm long, narrow, oblong, pale achene tipped with a pappus of light silky hairs, 3 to 5 mm long. Weed in waste places. 4(133N), 5.

Dahlia pinnata Cav. "dahlia"

Recent introduction. Mexico. Rare. Perennial herb, up to 1 m or higher, with tuberous roots; leaves, opposite, simple or divided feather-fashion one to three times; leaflets, toothed or lobed, arranged in pairs with an extra leaflet at the tip; flowerheads, 2.5 to 10 cm in diameter, long-stemmed, single or double, flat to globose; ray-florets, yellow central florets surrounded by conspicuous flat, tubular or rolled outer ray-florets, ranging in color from white and yellow to pink, purple and red, which range from eight to many and often conceal the central ray-florets; fruit, tiny, narrow, flattened and tipped with 2 teeth or untipped. Planted ornamental. 5(79), 6.

Emilia sonchifolia (L.) DC. "purple sow thistle", "floras paintbrush"
syn. *Cacalia sonchifolia* L.

Recent introduction. Pantropical. Occasional. Erect, soft-stemmed, branching annual herb, 10 to 40 cm tall, lower stems pubescent, upper ones nearly glabrous; leaves, 3 to 15 cm long and 5 to 7 cm wide, simple, alternate; lower leaves, deeply irregularly lobed or dentate, subdeltoid to spoonshaped, clasping stem at the base; upper leaves, smaller, lanceolate, toothed to subentire, sometimes purplish beneath on midrib and bluish-green (glaucous) on blade; flower heads, 0.8 to 1 cm long and 2.5 to 6.5 mm wide, few, cylindrical, on slender lax peduncles in loose, branching terminal clusters; involucral bracts, about 8, cylindrical, fused, which split apart and reflex at maturity, almost covering the flowers; ray-florets absent; disc-florets, 30 to 60 in number, 5-lobed, white below, lavender to pink at the tips, tubular, just slightly longer than the involucre; fruit, about 2.5 to 3 mm long, brown, prism-shaped, 5-ribbed achene, with a pappus of numerous, silky white bristles, 6 to 8 mm long. Weed in waste places and as a pioneer in recently mined areas. 5(115), 6, 7(22313), 8.

Gerbera jamesonii Bolus "Transvaal daisy", "gerbera", "African Daisy"

Recent introduction. S. Africa. Rare. Hairy perennial herb, 30 to 35 cm high; leaves, 15 to 30 cm long (blade about 2/3 as long as stem)), many, deeply lobed, feather-fashion, woolly beneath, arranged in a basal rosette; flowerheads, 7.5 to 10 cm in diameter, attractive, daisy-like, pink, red, orange, yellow or cream-colored, solitary, borne on the crest bare flower stalks, about 25 to 40 cm long; central disc-florets, many, surrounded by 1 or 2 rows of narrow orange ray-florets; many single and double hybrid forms exist. Planted ornamental. 5, 6, 7.

Gynura aurantiaca (Bl.) DC. "purple passion flower", "velvet plant"

Recent introduction. Java. Rare. Erect or semi-climbing, up to 75 cm; ovate, deeply lobed or toothed, leaves, dark green, covered with thick, bright purple hairs, giving the plant a velvety appearance; flowerheads, about 2.5 cm in diameter, like a petal-less daisy; disc-florets orange. Ornamental pot plant. 6.

Synedrella nodiflora (L.) Gaertn. "synedrella", "nodeweed"
syn. *Verbesina nodiflora* L.

Recent introduction. Trop. America. Occasional. Coarse, erect to ascending, branched annual herb, 10 to 75 cm high, often rooting at lower, decumbent nodes; leaves, 1.5 to 8 cm long and 1.5 to 5 cm wide, larger leaves usually at the top, simple, opposite, ovate to elliptic, acute tip and cuneate base, subentire to crenate-serrate, scabrous, 3-nerved from base,; petiole, about 1 to 1.5 cm long, winged, pubescent on both surfaces; flowerheads, 0.6 to 1.2 cm long and 5 to 6 mm across, 10 to 20-flowered, subsessile, solitary or few together on short axillary or terminal peduncles; involucral bracts, nearly 1 cm long, only 4 or 5, lanceolate, 2-ranked (2-seriate); ray-florets, about 3.5 to 4 mm long, yellow, strap-shaped, 3-lobed; disc-florets, yellow, with tubular corollas; fruit, 4 to 5 mm long, a black or dark-brown achene, those of ray-florets flat, oval and spiny-edged or winged with 2 terminal awns, those of the disc-florets cylindrical, unwinged with 2 erect spiny terminal awns about half as long as the achene. Weed in low ground around Buada Lagoon and in other ruderal habitats. 3(58648), 4(134N), 5(97), 6, 7, 8(9573).

Tagetes erecta L. "marigold", "Aztec marigold", "African marigold"

Recent introduction. Mexico. Rare. Erect, smooth, few-branching, strongly-scented, annual herb, up to 60 cm high; lower leaves opposite, upper leaves alternate, pinnately parted or pinnate, up to 12 cm long, the segments more or less oblong, acute, distally dentate, up to 9 cm long and 1.5 cm wide; flower heads, 4 to 8 cm in diameter, solitary, flat to globose, borne on peduncles which flare distally; involucral bracts, about 2 cm long, arranged cylindrically; ray-florets yellow to red-orange, many, often concealing the central disc-florets; fruit, achene tipped with pappus, about 1 cm long, and several short scales, 3 to 4 mm long. Planted ornamental. 5, 6.

Tridax procumbens L. "wild daisy", "coat buttons"

Pre-World War II introduction. Trop. America. Common. Pubescent perennial herb with prostrate to ascending stems, up to about 80 cm long; leaves, 1 to 6 cm long and 1 to 3.5 cm wide, opposite, broadly lanceolate, coarsely toothed, acute or subacute, cuneate at base, hispid on both surfaces; petioles, 5 to 15 mm long; flowerheads, about 1 cm long and 2 cm wide, terminal, borne on erect pilose peduncles, 10 to 30 cm long; involucral bracts, 2- or 3-ranked, puberulent; ray-florets, about 4 to 5 mm long, 5 or 6 in number, with a narrow corolla tube and broad ligulate limb, about 3 by 5 mm, white to light yellow; disc-florets, many, the corolla narrow-campanulate, about 8 mm long, bright yellow, 5-lobed and hairy at top; fruit, about 2 mm long, dark grey-brown, densely hairy achene, with a spreading pappus, 5 to 6 mm long, of plumose hairs. Weed in settled areas and near airport; pioneer in recently mined areas. 2, 3(58657), 4(145N), 5(25), 6, 7, 8(9548).

Vernonia cinerea (L.) Less. "iron weed"

syns. *V. parviflora* Reinw. ex Bl.; *V. cinerea* var. *parviflora* (Reinw. ex Bl.); *Conyza cinerea* L.

Pre-World War II introduction. Trop. Asia. Common. Erect loosely branching annual herb, 15 to 60 cm tall, stems longitudinally ribbed; leaves, 1 to 7 cm long and 1 to 2.5 cm wide, simple, alternate, lanceolate to ovate, acute, or variably shaped, the upper ones narrower, smaller and subsessile, the lower ones with surfaces minutely puberulent, base decurrent, irregularly toothed, with winged petioles, 1 to 3 cm long; flowerheads, 6 to 7 mm long, in loose terminal paniculate clusters on slender peduncles; involucral bracts, 4 to 5 mm long, green with brownish tips, lanceolate, 4-ranked (4-seriate), puberulent; ray-florets, absent; disc-florets, about 4 mm long, 20 to 25 in number, tubular, violet or pinkish violet, exerted; fruit, 1.5 to 2 mm long, a grey-brown, cylindrical, appressed pubescent achene, 1.5 to 2 mm long, bearing a terminal pappus of numerous white bristles which spread apart at maturity. Weed in settled areas; pioneer in recently mined areas. 2, 3(58611), 4(118N), 5(67), 6, 7, 8(9538).

Wedelia trilobata (L.) Hitchc. "wedelia"
syn. *Silphium* trilobatum *L.*

Recent introduction. Trop. America. Occasional. Perennial creeping herb, reaching a thickness (height) of about 40 to 70 cm; leaves, 2.5 to 7 cm long, bright green, simple, opposite, three-lobed to lanceolate, toothed; petioles, short, extremely-winged, or lacking, clasping the stem; flowerheads, about 2 to 2.6 cm in diameter, daisy-like, solitary, on slender peduncles, about 5 to 7 cm long; involucral bracts, 6 to 9 mm long, green, lanceolate, 2-ranked, 5 short inner and 5 longer outer bracts; ray-florets, about 1 cm or longer and 0.5 cm wide, 8 to 10 in number, bright yellow; disc-florets, about 8 mm long, light yellow, tubular, 20 to 30 in number, fruit, not seen. Planted ornamental groundcover. 3(58609), 5, 6(237), 7.

Zinnia elegans Jacq. "zinnia"

Recent introduction. Mexico. Erect annual herb, up to 60 cm tall, stems branched; leaves, 2.5 to 14 cm long and 1.5 to 6 cm wide, opposite, ovate to elliptic or oblong, obtuse or acute, hispid, sessile; flowerheads, 3 to 8 cm in diameter, solitary, showy, developing at stem and branch tips; involucral bracts, about 1 cm long, chaffy, in about 3-ranks; ray-florets, about 2 cm long and 1 cm wide, 14 to 20 in number, pistillate, violet, pink, orange, yellow or white; receptacle, convex, paleaceous, bearing numerous 5-lobed central disc-florets, about 5 mm long, yellow; fruit, 3-angled, compressed achene, with 1 to 3 terminal awns. Planted ornamental. 5(128), 6.

BALSAMINACEAE (Balsam Family)

Impatiens balsamina L. "balsam", "garden balsam"

Recent introduction. India or Africa. Rare. Succulent, watery, erect, branching annual herb, up to about 60 cm high; leaves, up to 5 cm long and 4 cm wide, simple, alternate, lanceolate, acuminate, toothed (serrate); petiole, usually glandular at the base; flowers, up to 2.5 cm or more in diameter, short-stemmed, borne on short axillary pedicels on the stem below the leafy tip; sepals, 3 or 5, one usually spurred; petals, 3-lobed, lateral ones bifid, commonly double or long-spurred, showy yellow, white, pink, purple or red flowers; fruit, a woolly, 5-valved capsule, explosively dehiscent, the valves incurling instantly when separated; seeds, subglobose, usually brown, finely pitted. Planted ornamental. 5(117), 6.

Impatiens walleriana Hook.f. "snapweed", "patience plant", "Zanzibar balsam"
syn. *I. sultanii* Hook.f.

Recent introduction. Zanzibar. Rare. Erect, branching, sub-shrubby perennial succulent herb, up to 50 cm high; leaves, alternate along the stem and arranged in a rosette at branch tips, narrow-ovate, acuminate at tip and base, toothed or scalloped, with soft point at each indentation; flowers, 2.5 to 3.5 cm in diameter, petals in one plane, borne, singly or 2 to 3 together, on long axillary pedicels; sepals, 3 or 5, 1 usually spurred; petals, showy, bright scarlet or red to pink, accompanied by a long spur; fruit. which may or may not develop in cultivation, a 5-valved capsule. Planted ornamental. 6.

BASELLACEAE (Basella Family)

Basella rubra L. "Indian spinach", "Ceylon spinach", "Malabar nightshade"
shaan ts'oi (C)
syn. *B. alba* L.

Recent introduction. Trop. Asia. Occasional. Succulent dark-green to reddish-purple-stemmed, glabrous, branching, herbaceous, perennial twining vine, up to 4 m or longer; leaves, 5 to 15 cm long and 4 to 14 cm wide, alternate, entire, broad-ovate, almost heart-shaped, tender, fleshy; petioles, 1 to 2.5 cm long, green or purplish; flowers, 4 to 5 mm in diameter, sessile, closed, white to light reddish-purple, clustered on axillary spikes, 2 to 20 cm long; fruit, about 8 mm in diameter, ovoid, black, berry-like. Food plant in Chinese gardens and containers at Location. Leaves and tender stems cooked as a spinach. 5(138), 6.

BEGONIACEAE (Begonia Family)

Begonia coccinea Hook.f. "angel-wing begonia"

Recent introduction. Brazil. Occasional. Smooth shrub-like herb, up to 1 m or higher, with bamboo-like stems; leaves, 10 cm or longer, oblong, pointed, glossy green above, reddish below, finely edged with red, with a deep indentation at the base and wavy edges; flowers, about 2.5 cm in diameter, coral-red, borne in branched red-stemmed drooping clusters; male flowers, about 2.5 cm in diameter, 4- petaled, with two petals larger than the other two; female flowers, showy, with red, 3-winged ovary, about 2.5 cm long. Ornamental pot plant. 5, 6.

Begonia rex Putz × **B.** spp. "hybrid begonia"

Recent introduction. Trop. America. Occasional. Erect perennial herb, up to 30 cm or higher, with short, thick, underground stems; leaves, variable, more or less ovate, pointing downward, angled or lobed, sometimes waxy, commonly with a silvery, pink, red, copper or bronze patterning on a background of all shades of green zone, and reddish beneath; flowers, variable small, pale pink, in small clusters rising from the leaves. Ornamental pot plant. 7.

Begonia spp. "begonia" cultivars

Recent introduction. Trop. America. Occasional. Pot plants and planted ornamentals. 5(262), 6, 7.

BIGNONIACEAE (Bignonia Family)

Jacaranda mimosifolia D. Don "jacaranda"
syns. *J. acutifolia* Humb. & Bonpl.; *J. ovalifolia* R. Br.

Recent introduction. Brazil. Rare. Tree, up to 15 m or higher; leaves, up to 50 cm or longer, opposite, compound, fernlike, the primary axis with 20 to 40 branchlets (10 to 20 pairs of divisions), each which bears 14 to 24 pairs of oblong, hairy, pointed leaflets, about 6.5 mm long; flowers, terminal and axillary, 40 to 90 in number, borne in erect or drooping panicles, about 20 to 30 cm long; corolla, about 5 cm long, showy light blue-violet, perfumeless, bell-shaped, 2-lipped, 5-lobed; fruit, about 5 cm in diameter, a round, flattened, wavy-edged capsule, which looks like a brown bivalve mollusc. One immature seedling planted as an ornamental. 6, 7.

Spathodea campanulata Beauv. "African tulip tree", "flame of the forest", "fountain tree"

Recent introduction. Trop. Africa. Occasional. Medium-sized tree, up to 20 m tall, with soft, weak wood and a ridged or buttressed trunk; leaves, 30 to 50 cm long, dark-green, shiny, opposite, odd-pinnate, divided feather-fashion; leaflets, 4 to 12 cm long and 2.5 to 5.5 cm wide, 3- to 9-paired with a terminal leaflet, elliptic or ovate, acute-acuminate, entire, deep-veined, pubescent dorsally on nerves; petioles, 1 to 3 mm long; flowers, up to about 10 to 13 cm long, in showy terminal racemose clusters, opening a few at a time; calyx, hairy, closed in bud, opening along one side, boat-shaped, curving upward, nearly as long as corolla, containing water when closed; corolla, about 10 cm long and 5 cm wide, with 5 oval lobes, vivid red-orange to vermilion, the margins dark yellow, obliquely campanulate, gaping, segments crisped-undulate, somewhat tulip-shaped; stamens with yellow filaments; fruit, 15 to 20 cm long and 4 to 5 cm wide, black flattened canoe-shaped capsules; seeds, woody, with a wide parchment-like circular wing. Planted ornamental tree. Flowers used in garlands and for ornamentation. 3(58682), 5(123), 6, 7.

Tecoma stans (L.) Juss. ex HBK. "yellow elder", "yellow bells", "tecoma", "ginger Thomas" yellow flower (N); nei karairai (Miss or Mrs. Karairai)(K); neikarairai (T)
syns. *Bignonia stans* L.; *Stenolobium stans* (L.) D. Don

Recent introduction. Trop. America. Common. Erect shrub, up to 4 m tall; leaves, 10 to 30 cm long, opposite, pinnate; leaflets, 3 to 10 cm long and 2 to 3 cm wide, 5 to 13 in number, lanceolate to elliptic-oblong, serrate, acute-acuminate, base cuneate, sessile or short-petiolate, pinnately nerved; flowers, in large terminal racemose clusters; pedicels to 1 cm long; calyx, 3 to 5 mm long, tubular, campanulate, 5-toothed; corolla, 3 to 5 mm long, bright yellow, slightly fragrant, funnel-form-campanulate or bell-shaped, slightly bilabiate, with 5 wavy lobes; fruit, 10 to 20 cm long and 5 to 6 mm wide, narrow, flattened, rostrate capsule; seeds, many, winged. Planted ornamental. Showy flowers used in garlands and for ornamentation, especially by I-Kiribati. 3-(58656), 5(193), 6, 7, 8(9570).

BOMBACACEAE (Bombax Family)

Ceiba pentandra (L.) Gaertn. "kapok tree", "silk-cotton tree" duwoduwo (N)
syns. *Bombax pentandrum* L.; *Eriodendron anfractuosum* DC.; *Ceiba casearia* Medic.; *Bombax orientale* Spreng.

Pre-World War II introduction. India or Africa. Occasional. Tall deciduous, soft-wooded, light-grey-barked tree, up to 25 m or higher, with a buttressed trunk, commonly spiny below and cylindrical and smooth above, and horizontal tiers (whorls) of widely-spaced spreading branches; leaves, palmately compound, with 5 to 9 leaflets; leaflets, 7 to 18 cm long and 1 to 3.5 cm wide, elliptic to oblanceolate, acuminate, blue-green (glaucous) beneath, entire or obscurely toothed, distinctly petiolate; petioles, 7 to 20 cm long; flowers, which appear just before the leaves, clustered on branches; corolla, 5-petaled, cream-white or pale pink, pubescent; petals about 2.5 cm long; fruit, 7 to 15 cm long, oblong-ellipsoid, capsular, smooth, pendulous, 5-celled, eventually dehiscent, filled with numerous long, soft silky or cotton-like fibers, each 0.8 to 3 cm long; seeds, many, brown. Planted; some possibly spontaneous near Buada Lagoon. Fiber used in the past for stuffing pillows and mattresses. 3(58642), 5, 6, 7.

BORAGINACEAE (Heliotrope Family)

Cordia subcordata Lam. "sea trumpet", "kou" (Hawaii)
eongo, eoongo, eowongo (N); te kanawa (K); kanava (T)

Indigenous. Indian Ocean to Hawaii. Rare to occasional. Medium-sized tree, up to 10 m or taller, with spreading branches and pale greyish slightly fissured bark; leaves, 5 to 20 cm long and 4.5 to 15 cm wide, alternate, pale green, thinly coriaceous, ovate, acute, base rounded, obtuse or truncate, lateral nerves 4- to 6-paired, margins entire or slightly wavy; petiole, 2 to 8 cm long; flowers, few to several, in short-stalked axillary and terminal cymose clusters; calyx, about 15 mm long, 3- to 6-lobed, lobes short-deltoid, pubescent ventrally; corolla, 2.5 to 4 cm long and 3 to 5.5 cm across the mouth (limb, which is plicate in bud)), pale to bright orange, crepe-like, trumpet-shaped, scentless, 5 to 7-lobed, lobes 15 to 25 mm long, rounded; fruit, 2 to 3 cm long, ellipsoid or nearly round, apiculate-acute, enclosed in a fibrous, somewhat corky calyx, green when mature but aging to brown or black; seeds, 1 to 2 (rarely 3 or 4), coarsely muricate. Found on coastal strip near settlement areas, either planted or protected. Soft, durable wood considered by Nauruans to be excellent timber for woodcarving, boatbuilding, construction and furniture; leaves crushed and mixed with coconut milk to prevent baldness; flowers used in garlands. Trunk highly prized for woodcarving and canoe hulls throughout Micronesia, Polynesia and Melanesia. 3(58756), 5(77), 6, 7.

Heliotropium procumbens Mill. var. **depressum** (Cham.) Fosb. & Sachet "heliotrope"
syns. *H. gracile* var. *depressum* Cham.; *H. coromandelianum* var. *depressum* (Cham.) A. DC.; *H. ovalifolium* Forsk. var. *depressum* (Cham.) Merr.

Indigenous. Trop. America. Rare. Prostrate branched perennial herb with a stout taproot; leaves, up to 3 cm long and mostly 3 to 6 mm wide, greenish-gray, pubescent, oblanceolate or linear-oblong, subsessile; flowers, only moderately crowded, rather sparsely pubescent, borne on one-sided coiled spikes on slender forked stalks (cincinni), 5 to 6 cm long; calyx lobes, unequal, longest to nearly 3 mm, lanceolate; corolla, 1.5 to 2 mm long, 5-lobed, white; fruit, globose, breaking into 2 to 4 1-seeded nutlets, about 1 mm high. Found on coastal strip near limestone outcrops? 4(141N), 7(22316).

Tournefortia argentea L.f. "beach heliotrope"
irin (N); te ren (K); tausunu, tauhunu (T)
syns. *Messerschmidia argentea* (L.f.) I.M. Johnst.; *Argusia argentea* (L.f.) Heine; *Tournefortia sericea* Cham.

Indigenous. Indian Ocean to S.E. Polynesia. Common. Small to medium-sized, wide-spreading, short-trunked tree, 2 to 12 m tall, with rather stout twigs and deeply grooved bark; leaves, 10 to 30 cm long and 3 to 12 cm wide, alternate, spiralled, crowded near branch ends, obovate-oblanceolate, decurrent at base, rounded-obtuse to acute at apex, densely appressed, silvery-grey-pubescent on both sides, softly coriaceous, somewhat fleshy; petiole, stout, winged; flowers, small, about 6 mm across, tube 2 mm long, numerous, white, sessile, borne terminally on crowded, many-branched clusters of tightly-coiled, densely-pubescent, scorpion-tail-like spikes or cymes; fruit, 5 to 8 mm in diameter, round, greenish-white to brown, 4-parted, minutely apiculate; seeds (nutlets), 2 to 4, embedded in corky tissue. Found on flats behind beaches. Leaves eaten by pigs; tender leaves and meristem pounded to prepare medicines for curing children's rashes, diarrhea, and fish poisoning; fruit blown through hollow papaya petioles by children. 3(58669), 5(32), 6, 7.

BRASSICACEAE OR CRUCIFERAE (Cabbage or Mustard Family)

Brassica alboglabra Bailey "Chinese kale"
kai laan ts'oi (C)
syns. *B. oleracea* var. *albiflora* O. Kunze; *B oleracea* var. *alboglabra* (Bailey) Musil

Pre-World War II introduction. Asia. Occasional. Erect, sometimes branching perennial herb, up to 30 cm or higher, grown as an annual; leaves, 6 to 20 cm long and 4 to 15 cm wide, alternate, ovate, pale bluish-green (glaucous), glabrous, dull to shiny, petiolate or not clasping; petioles, 4 to 10 cm long; flowers, up to 2.5 cm in diameter, white, perfect, 4-sepaled, 4-petaled, without bracts, borne on slender pedicels along an elongated fleshy terminal flower stem (raceme); fruit, a long, narrow pod, with a conical beak; seeds, small, globose. Planted in Chinese food gardens at Location. Leaves, stems and flowers cooked as a vegetable. 5, 6, 7.

Brassica chinensis L. var. **chinensis** "Chinese cabbage", "Chinese white cabbage"
te kabiti n Tiaina (K); kapisi Saina (T)
syn. *B. chinensis* Juslenius

Pre-World War II introduction. Asia. Common. Erect, loose-heading, biennial herb, grown as an annual, up to 40 cm or higher, with a tap-root; leaves, 10 to 40 cm long and 5 to 20 cm wide, alternate, shiny, dark-green, prominently white-veined, ladle-shaped, terminally rounded, upstanding, radical (coming from the roots) leaves not lobed, stem leaves usually clasping, not forming a compact head; petiole, 3 to 12 cm long, thickened, ivory-white, somewhat fleshy; flowers, about 1 to 1.5 cm in diameter, light to bright yellow, perfect, 4-sepaled, 4-petaled, without bracts, held above unopened buds, petals orbicular, borne on slender pedicels, 1 to 4 cm long, along an elongated terminal flower stem (raceme), up 50 cm long; fruit, 3 to 6 cm long, slender pods, with a conical beak, usually 2-grooved, opening lengthwise; seeds, about 1 to 1.5 mm in diameter, globose, brown to blackish-grey. Commonly cultivated in Chinese food gardens at Location and Topside workshops. Leaves and stems cooked as a green vegetable. 5, 6, 7.

Brassica chinensis L. var. **parachinensis** (Bailey) Tsen & Lee
"flowering white cabbage" paak ts'oi sum (C); te kabiti n Tiaina (K)
syns. *B. parachinensis* Bailey; *B. chinensis* var. *oleifera* Makino

Pre-World War II introduction. Asia. Common. Erect, branched, biennial, non-heading herb, grown as an annual, up to 50 cm or higher; leaves, 10 to 50 cm long and 4 to 10 cm wide, darker-green above, lighter below, stem leaves not clasping, central stem leaves, long and narrow, ovate to lanceolate to oblong, upstanding, not heading, radical leaves more similar to those of var. *chinensis*; petiole, 3 to 12 cm long, slender, light green; flowers, about 1 cm in diameter, light yellow, perfect, 4-sepaled, 4-petaled, without bracts, borne on slender pedicels, 1 to 4 cm long, along an elongated terminal and sometimes axillary flower stem (raceme), up 40 cm long; fruit, 3 to 6 cm long, slender pod, with a conical beak, opening lengthwise; seeds, about 1 to 1.5 mm in diameter, globose, brown to blackish-grey. Commonly cultivated in Chinese food gardens at Location. Leaves, stems, and flowers cooked as a green vegetable. 5, 6.

Brassica juncea (L.) Czern. "mustard cabbage", "Indian mustard", "Chinese mustard"
kai ts'oi (C); te kabiti n Tiaina (K)
syn. *Sinapis juncea* L.

Pre-World War II introduction. Asia. Occasional. Erect, much-branched, non-heading, annual herb, up to 80 cm or higher, with a deep tap root; stem leaves, not clasping, basal (radical) leaves, up to 20 cm long, stalked, usually lyrate-lobed with very large ovate terminal segment; flowers, about 1 cm in diameter, bright yellow, perfect, 4-sepaled, 4-petaled, without bracts, not held above the central unopened buds, petals oval to obovate with a long claw, borne on slender pedicels along an elongated terminal and sometimes axillary flower stem (raceme), up 40 cm long; fruit, about 1.5 to 4 cm long, slender pod, rounded in cross section, with a 4-angled short beak, opening lengthwise; seeds, about 1 mm in diameter, globose, blackish-grey. Food plant in Chinese food gardens at Location. Leaves and stems cooked as a green vegetable. 5, 6, 7.

Brassica oleracea L. var. **capitata** L. "English cabbage"
te kabiti ni Imatang (K); kapisi Palagi (T)

Pre-World War II introduction. Europe. Rare. Biennial herb, usually grown as an annual, up to 30 cm or higher, or 30 cm in diameter, with a short stem and an arrested, compact, much-swollen terminal bud surmounted by a mass of thick overlapping whitish-green to light blue-green leaves forming a loose or compact, round or somewhat pointed head; flowers, virtually never seen, not developing during the first year. Planted in gardens near Buada Lagoon. Leaves cooked as a vegetable. 3, 6, 7.

Brassica pekinensis (Lour.) Ruprecht "celery cabbage", "Shantung cabbage", "Peking cabbage", "pe-tsai" wong pa'ak, wong bok (C); te kabiti n Tiaina (K)
syns. *B. chinensis* var. *pekinensis* (Rupr.) Sun; *B. petsai* Bailey

Recent introduction. N. China. Rare. Erect, loose- to compact-heading, biennial herb, grown as an annual, up to 50 cm or higher, somewhat resembling a large yellow-green romaine or cos lettuce; leaves, 15 to 50 cm long and 5 to 25 cm wide, alternate, light yellow-green, thin, veiny, crinkled undulate, dentate, without distinct petiole, the wide, flat, long whitish base with a dentate wing, radical leaves often forming a compact head, with midrib on the lower surface sometimes having sparse bristle-like hairs; flowers, not seen; seeds, plump, without grooves. Planted in Chinese food garden at Location. Leaves and stems cooked as a vegetable. 6.

Rhaphanus sativus L. var. **longipinnatus** Bailey "white radish", "daikon", "Chinese, Japanese or Oriental radish" loh paak (C)

Pre-World War II introduction. E. Asia. Occasional. Erect annual bristly herb, up to 50 cm or higher, with a large white cylindrical tap root, up to 30 cm long and 10 cm in diameter, or larger, and normally weighing up to 500 g to 1 kg or more; radical leaves, up to 50 cm and 12 cm wide, dark green, bristly (setulose), lyrate-pinnatifid, with 8 to 11 pairs of pinnae; flowers, rarely seen, white to lilac, small, 4-petaled; fruit, 3 to 7 cm long, up to 1.5 cm in diameter, inflated, indehiscent, with 6 to 12 seeds; seeds, about 2.5 to 3 mm in diameter, dark brown, globose. Cultivated in Chinese food gardens at Location. Leaves and fleshy white tap root cooked as vegetables or eaten raw. 5, 6.

CACTACEAE (Cactus Family)

Cephalocereus sp. "Cephalocereus"

Recent introduction. Tropical America. Rare. Jointed cactus with short, funnel-shaped, night-blooming flowers. Planted ornamental. 6(204).

Hylocereus undatus (Haw.) Britt. & Rose "night-blooming cereus"

Recent introduction. Mexico. Rare. Large fleshy, green, epiphytic, rambling or climbing, branching, night-blooming cactus, with 3-angled (3-winged) stems, about 4 to 5 cm in diameter, with scalloped margins, which become more or less horny and bear cushions 2.5 cm or more apart, each with 1 to 3 short spines, and with aerial roots growing from the underside of the stems; flowers, about 25 cm long, night-blooming, lasting only until about noon of the following day, beautiful and showy, fragrant with a mildly spicy odor, waxy, cup- or funnel-shaped, with many narrow, curved, yellowish-green outer segments surrounding many white, erect petals, which are longer than the mass of long, yellow-tipped stamens and a long style tipped with a radiating stigma having about 24 lobes; fruit, rare, oblong, about 10 cm long, red, containing numerous black seeds in white pulp, which is refreshing to eat. Immature ornamental pot plant. 6.

Opuntia sp. "prickly pear cactus"

Recent introduction. Tropical America. Rare. Succulent, erect, shrub-like cactus, up to 2 m or higher, with flattened light-green, thick (up to 1 cm wide), oboval, paddle-blade-like joints or cushions, about 12 to 30 cm long and 5 to 10 cm wide, smooth or with spines, up to 1 cm long; leaves, small, nearly cylindrical, short-lived; flowers and fruit, not seen. Planted ornamental. 5, 6.

Schlumbergia truncata (Haw.) Moran "Christmas cactus", "Easter cactus", "crab cactus"
syn. *Zygocactus truncatus* (Haw.) Schum.

Recent introduction. Brazil. Rare. Small, smooth, day-blooming cactus, up to 30 cm or higher, with numerous, flat, dark glossy-green, jointed branches, about 4 to 5 cm long and 1.5 to 2 cm wide, coarsely toothed, blunt-ended, that fork repeatedly in pairs, resembling crab's claws; flowers, many, 5 to 6 cm long and 1 to 1.5 cm wide, rose-red, rather narrow tubular, curved, with many narrow oblong petals and sepals bent back from long, clustered, protruding white, yellow-tipped stamens and a purple style; fruit. Ornamental pot plant and planted ornamental. 6.

Unknown cactus "cactus"

Recent introduction. Rare. Small cactus pot plant. 6.

CAPPARIDACEAE (CAPPARACEAE) (Caper Family)

Capparis cordifolia Lam. "oceanic caper"
ekabobwiya, ekabobwija (N)
syns. *C. mariana* Jacq.; *C. spinosa* var. *mariana* (Jacq.) K. Schum.

Indigenous. Micronesia and Polynesia. Common. Small, sometimes sprawling, spineless, woody shrub, up to about 1 m high, with rather soft and light wood; leaf blades, about 3 to 5 cm long (rarely to 7 cm) and 2.5 to 5 cm wide, alternate, grayish-green, slightly fleshy, broadly ovate or orbicular, rounded at both ends or truncate or nearly subcordate at base, sometimes notched at the apex, lateral nerves 5- to 8-paired; petiole, slender, about 8 to 14 mm long; flowers, large, attractive, fragrant, pea-flower-like, asymmetric, axillary, solitary, borne on pedicels, 3 to 5 cm long, the bud opening late in the evening and withering the next morning; sepals, up to 2 cm long, 2-seriate, reflexed at anthesis, geleate; petals, 4, up to 2 cm long, attractive, white, glabrous, obovate-suborbicular, glabrous; stamens, numerous (80 to 108), 3 to 4 cm long, showy, white, but fading to pink or even purple; anthers, 3 mm long, purple; fruit, up to 4 to 5 cm long, an oblong or ellipsoid berry, with reddish ribs and elsewhere green, ripening to dull yellow; seeds, about 3 mm long, dark brown, reniform. Found on limestone cliffs and limestone rock outcrops on coastal strip. Crushed leaves used by Nauruans as a fish poison. 2, 3(58636), 4(132N), 5(101), 6, 7.

Capparis quiniflora DC.
syn. *C. richii* A. Gray

Indigenous. E. Indonesia (Celebes and Lombok) to Melanesia and Nauru. Occasional. Thorny, woody, high-climbing vine, with paired recurved spines, 1 to 3 mm long; leaves, up to 10 cm long and 6 cm wide or larger, variable, narrowly lanceolate to ovate; petioles, 5 to 20 mm long; flowers, small, 2 to 10 in number, serially arranged in axillary or subterminal rows on pedicels, 6 to 20 mm long, which thicken and reach 5 cm long when in fruit; sepals, up to 5 by 3 mm; petals up to 7 by 4 mm; fruit, about 40 by 35 mm, subglobose-ellipsoid. Found in plateau forest and on limestone pinnacles and cliffs of the escarpment. 3(58591, 58799, 58804a), 5, 6.

Cleome rutidosperma DC.

Recent introduction. Origin? Common. Slender ascending to sprawling or creeping, elongate, sparingly pilose, annual or short-lived perennial, odorless or nearly odorless herb; leaves trifoliate on very slender petioles, up to 2.5 cm long; leaflets, 2 to 2.5 cm by about 1 cm, thin, the middle leaflet longest; flowers, axillary, small, petals blue-violet or pink, fading to white, on filiform pedicels, up to 3 cm long; fruit, 3 to 4 cm long, a linear-fusiform capsule, on stipes 5 to 10 mm long; seed depressed-globose, conspicuously rugose with long curving ridges or wrinkles, dark reddish-brown. Weed in waste places, around buildings, and in areas recently cleared for phosphate mining. 3(58601, 58616, 58751), 4(108N), 5, 6, 7(22303), 8(9540).

Cleome viscosa L.
syns. *C. icosandra* L.; *Polonisia icosandra* (L.) W. & A.; *P. viscosa* (L.) DC.

Recent introduction. Trop. Asia or Old World Tropics. Common. Erect, sticky, scarcely branching annual herb, up to 20 cm high, with longitudinally-grooved and densely glandular hairy stems and a offensive odor; leaves, up to 7 cm by 7 cm, alternate, compound, palmately 3- to 5-foliate, long petiolate, glandular pubescent; leaflets, 1.5 to 4 cm long, the terminal leaflet longest, obovate to elliptic, tip acute to rounded, base cuneate to oblique, margins entire; petiole, about as long a terminal leaflet; flowers, solitary in upper leaf axils, on pedicels, 8 to 25 mm long; calyx, caducous, 4-lobes, about 5 mm long, falling soon; petals, 4, about 7 to 12 mm long, yellow, oblanceolate; fruit, 3 to 7 cm long, podlike, curved, longitudinally grooved, densely pubescent, 2-valved, splitting longitudinally (dehiscent); seeds, about 1.3 mm in diameter, roughly circular, numerous, small, reddish-brown, ridged (reniform). Weed found primarily in lowland waste places, roadsides, and areas recently cleared for phosphate mining. 3(58653), 4(125N), 5(45), 6, 7(22310), 8(9542, 9572).

CARICACEAE (Papaya Family)

Carica papaya L. "papaya", "pawpaw"
dababaia, dababaiya (N); te mwemweara, te babaia (K); olesi (T)

Pre-World War I introduction. Trop. America. Occasional. Soft-wooded, un- or few-branched, rather palm-like, small, quick-growing tree, up to 4 m or higher, with thick, hollow, tapering, nearly smooth trunks or stems with light bark and numerous almost heart-shaped leaf-scars, copious, thick, sticky, irritating milky sap, and leaves that drop as the tree grows; trees usually male or female, although some are bisexual (hermaphroditic) with both male and female flowers on the same tree; leaves, up to 60 cm or more across, alternate, clustered near top, large, round in outline, deeply palmately 7- to 11-lobed, the lobes irregularly acuminately toothed and lobed; petioles, longer than blade, often over 1 m long, hollow; male flowers, about 2 cm wide, numerous, white or cream-colored, fragrant, borne on loose clusters on long axillary peduncles, 30 to 90 cm long; female flowers, about 4 to 6 cm wide, white, fragrant, subsessile, 5-petaled, solitary or few together in leaf axils; fruit, 10 to 40 cm long, variably shaped from subglobose or pear-shaped to cylindrical, green turning yellow or orange, with orange to red-orange flesh; seeds, 3 to 5 mm long, globose, many, around the edges of a central cavity, dark gray-green to black, wrinkled, caper-like, enclosed in a firm gelatinous membrane. Fruit tree in home gardens and in contract worker gardens at Location and the Topside Workshops. Ripe fruit eaten, and made into jam, primarily by resident European community; fruit known to be a laxative; juice and flesh from green fruit (which contains the enzyme papain) used to tenderize pork and beef; white sap from small immature fruit used as a cure for ringworm; fragrant flowers used in garlands; and hollow leaf petioles used by children as "pea shooters" for the fruit of *Tournefortia argentea* (irin). Common, often naturalized, in houseyard gardens and agricultural areas and an important local cash crop throughout the Pacific, and a commercial export crop in areas such as Hawaii, Fiji, Tonga and the Cook Islands. 2, 3(58694), 5, 6, 7, 8.

CASUARINACEAE (Casuarina Family)

Casuarina equisetifolia L. "casuarina", "she oak", "ironwood", "beefwood"
tanenbaum (German for Christmas tree)(N); te katurina, te burukam (K); toa (T)
syn. *C. litorea* L.

Pre-World War I introduction. Indian Ocean to Polynesia and Micronesia. Occasional. Medium to large, hard-wooded, fast-growing, pine-like tree, up to 15 m or higher, with numerous, short-lived, long, thin, drooping, needle-like, gray-green, cylindrical, jointed, striate, photosynthetic branchlets; leaves, whorled, reduced to lanceolate or subulate, awl-shaped scales at each branchlet node; flowers, unisexual, in catkins; male flowers, brown, terminal, with whorled bracts, in spike-like inflorescences at the ends of branchlets; female flower heads, reddish-brown, condensed, lateral, each flower in the axil of a bract, protected by two lateral bracteoles, the female catkin enlarging, the bracts becoming woody in fruit; fruit, 1 to 2 cm long, globose, cone-like, dull-green ripening to brown, many-seeded. Planted, occasionally as a street tree or windbreak, and spontaneous on the coastal strip, and as a naturalized pioneer on some mined areas to where they have spread from trees planted near the Topside workshops. Although a common indigenous tree on sandy and rocky shores, and sometimes inland, throughout most of the western Pacific, and possibly an aboriginal introduction to some groups, such as Samoa, the casuarina seems to have been a recent post-European introduction to Nauru. 2, 3(58776), 5(81), 6, 7.

CHENOPODIACEAE (Goosefoot or Saltbush Family)

Atriplex nummularia Lindl. "Australian saltbush"

Said to have been introduced in 1916, but not seen in 1978 or later.

Beta vulgaris L. var. **cycla** L. "Swiss chard", "silverbeet", "leaf beet"

Recent introduction. Europe. Rare. Biennial glabrous herb, up to 40 cm or taller; leaves, up to 40 by 20 cm or more, dark green, shiny, alternate, simple, feather-shaped, fleshy with thickened white midribs; flowers, rare, small, 3- to 4-flowered cymes arranged on a spike, each subtended by a small narrow leaf; fruit, mostly an aggregate formed by the cohesion of 2 or more fruits forming an irregular nutlike cluster held together by swollen perianth bases. Food plant in Chinese garden at Location. Leaves cooked as a spinach. 5, 6.

Spinacea oleracea L. "spinach"
poh ts'oi (C)

Recent introduction. S. W. Asia. Rare. Small biennial herb, up to 25 cm high; leaves, 5 to 15 cm long and 3 to 8 cm wide, ovate to cordate, acuminate or somewhat sagittate; petioles, 2 to 10 cm long; fruit, an aggregate formed by the cohesion of 3 to 6 fruits forming an irregular nutlike cluster. Food plant in garden at Location. Leaves cooked as a spinach. 5, 6, 7.

CLUSIACEAE OR GUTTIFERAE (Mangosteen Family)

Calophyllum inophyllum L. "tomano"(Hawaii) "Portia tree", "Alexandrian laurel", "beach mahogany", iyo, ijo (N); te itai (K); fetau, itai (T); fetau (T)

Indigenous. Trop. Africa to E. Polynesia and Micronesia. Very abundant. Medium to large, hard-wooded, often crooked, slow-growing tree, 10 to 20 m tall, with a broad, low-branching, spreading crown, rough gray bark, and sticky yellowish sap; leaves, 10 to 20 cm long and 6 to 10 cm wide, simple, opposite, dark green, glossy, glabrous above, densely covered with minute silvery-white scales beneath, stiff, leathery, elliptic-oblong, rounded or emarginate, base acute, pinnately nerved, with a stout pale yellow-green midrib, lateral nerves very fine, numerous, parallel; petioles, 1 to 2.5 cm long, stout, caniculate; flowers, about 2 cm in diameter, showy, waxy white, very fragrant when fresh, 4- to -5 petaled (rarely 6 to 8), with numerous yellow stamens, borne on pedicels, up to 3 cm long, in solitary axillary, 4 to 15-flowered racemose clusters, up to 10 cm long; sepals, 4, concave-orbicular, the outer pair smaller, about 8 mm long, the inner pair, 10 mm long; fruit, about 2.5 to 5 cm long, green to purple-black, globose, hard, heavy, thin-fleshed, with a bony shell which encloses a somewhat poisonous single kernel or seed surrounded with cork, hanging from a long stalk. Dominant large tree in original pre-mining plateau (Topside) forest vegetation, common on escarpment slopes and on coastal strip. Timber provided the best wood for house posts (*iyor*, *yor*), furniture, woodcarving and for canoe hulls in the past; sticky sap (*erebeniyo*) used for caulking canoes; kernel of green and mature fruit (*i kuan iyo*) crushed to yield oil which is applied to hair to make it long and black; old decayed fruit skewered on coconut midribs (*engow*) in past and burned as traditional Nauruan light; and mature fruit burned as a mosquito repellent. Trees now being indiscriminately felled and burned as refuse at a Topside dump to prepare land for phosphate mining. A tree highly valued for its timber and other purposes throughout the Pacific, the seed kernel (known commercially as "punnai nut") yielding a dark green oil formerly exported from Fiji. 2, 3(58740), 4(164N), 5(120), 6, 7.

COMBRETACEAE (Terminalia Family)

Quisqualis indica L. Rangoon creeper"

Recent introduction. Trop. Asia. Occasional. An erect, vigorous shrub, growing into a large woody vine, from 2 to 7 m long, with slender stems and rusty-brown young growth; leaves 7 to 15 cm long, light green, soft, opposite, oval or oblong, acute, base rounded; flowers, borne in short showy drooping clusters in the leaf axils, changing color from pink to white as they open, and then darkening to red, pleasantly fragrant, calyx tube, 0.5 to 7.5 cm long, tipped with 5 short points, 5 oblong petals and 10 short stamens; fruit, about 2.5 cm long, dry, narrow ovoid, 5-angled, 1-seeded. Planted ornamental. 3(58790), 5(113), 6, 7.

Terminalia catappa L. "beach almond", "Indian almond", "Malabar almond", "tropical almond", "coastal almond" etetah, eteto (N); te kunikun (K); talie, te ipe (T)

Indigenous. Trop. Asia and Australia to W. Polynesia and Micronesia. Common. Medium to large, deciduous or semi-deciduous tree, up to 30 m tall, with whorled, horizontal, wide-spreading branches arranged in tiers, and reddish timber; leaves, 15 to 30 cm long and 10 to 22 cm wide, clustered in rosettes at the ends of the branches entire, leathery, shiny, dark-green turning red and yellow before dropping, new leaves appearing almost immediately, obovate, broadly rounded, obtuse or acute, base narrowing, narrowly and abruptly obtuse at petiole, pinnately-nerved, midrib slightly pubescent; petioles, 0.5 to 1 cm long, stout; flowers, small, numerous (35 to 80), white, petal-less, with a 5-lobed, bell-shaped calyx, which soon falls, and 10 stamens, borne in axillary, spikelike racemes, about 10 cm to 24 long, near ends of branches; fruit, 5 to 7 cm long, green turning yellow, then red, ovoid, subelliptic or subobovoid, hard, flattened, two-keeled (narrowly-winged), drupe, with thin fleshy pulp surrounding a single edible almond-like kernel. Tree in original plateau forest, on escarpment and on the coastal strip; occasionally planted or protected in home gardens. Timber used in light construction and for woodcarving; roots used by some people to prepare a cure for dysentery; outside rind of fruit eaten when yellow and kernel eaten after the mature fruit has fallen; fruit strung as necklaces and used in black magic or sorcery. 3(58662), 5(116), 6, 7.

CONVOLVULACEAE (Morning-Glory Family)

Ipomoea aquatica Forsk. "water spinach", "swamp cabbage", "water convolvulus"
Lorenzo (N); ung ts'oi (C); cangcong (F)
syns. *I. reptans* Poir.; *Convolvulus reptans* L.; *I. repens* Roth

Pre-World War II introduction. Trop. Asia, Africa and Australia. Occasional. Creeping, trailing or sometimes floating, semi-aquatic, hollow-stemmed, perennial herbaceous vine, producing long shoots, rooting freely at the nodes; leaves, 5 to 15 cm long and 2 to 10 cm wide, light green, soft and limp (flaccid), variable, commonly oblong-lanceolate or heart-shaped, the base hastate or truncate, long-petiolate; petioles, 3 to 15 cm long, hollow; flowers, 1 to 7 in cymes, peduncles, 2 to nearly 18 cm long, pedicels, 2 to 6 cm long; sepals, obtuse, ovate-oblong, 7 to 9 mm long; corolla, 3.5 to 5.5 cm long, pinkish-violet, often darker in the throat, rarely white; fruit, to 1 cm long, ovoid; seeds, finely pubescent. Food plant in Chinese and Filipino gardens at Location and Topside Workshop gardens; naturalized in muddy areas of Buada Lagoon, where it was formerly planted by the Japanese during World War II. Tender leaves and shoots cooked as a green vegetable; usually propagated by cuttings. 5(24), 6, 7.

Ipomoea batatas (L.) Lam. "sweet potato", "kumara"
te kumara (K); kumala (T); fan shue (C)
syn. *Convolvulus batatas* L.

Pre-World War I introduction. Trop. America. Occasional. Smooth or pubescent creeping, herbaceous, perennial, vine with milky sap, forming large, edible tuberous roots; leaves, 4 to 15 cm long and 3 to 11 cm wide, green, limp, variable, deltoid-ovate to ovate orbicular, entire or palmately 3- to 5-lobed or -parted, cordate or subcordate, commonly with 2 prominent basal lobes, acute; petioles, slender, 3 to 15 cm long, often longer than blade; flowers, several to many in long-peduncled cymes; corolla, usually 3 to 5 cm long, tubular and spreading, pale rose-violet, darker purplish in the throat, rarely white; sepals (calyx-lobes), about 10 to 15 mm long, briefly mucronate; fruit, a capsule; tubers, about 5 to 10 per plant, normally 10 to 30 cm long and 100 g to 1 kg in weight, fusiform to globular, usually smooth but sometimes ridged, skin white, yellow, orange, red, purple or brown, flesh waxy-white, yellowish, orange, reddish or purple, developing in the top 25 cm of the soil by secondary thickening of adventitious roots. Cultivated in contract laborers' food gardens at Location and Topside workshops; spontaneous along roadsides in some areas of Topside. Tuberous roots cooked as a staple and young leaves of some varieties occasionally cooked as a green vegetable. Dominant staple food plant and livestock feed in most of Papua New Guinea, parts of Solomon Islands and an important supplementary staple in many areas of Polynesia and Micronesia; leaves are also cooked as a vegetable green and an important livestock feed in some areas of the Pacific. 5, 6, 7.

Ipomoea fistulosa Mart. ex Choisy "bush morning-glory"
syn. *I. crassicaulis* (Benth.) Rob.

Recent introduction. Brazil. Occasional. Perennial shrub, up to 3 m tall, with stiff but rather rambling branches; leaves, 6 to 25 cm long and 4 to 17 cm wide, ovate to heart-shaped, acuminate, midrib dorsally with 2 basal glands; petiole, 3 to 15 cm long; flowers, mostly 5 to 9 cm long, tubular, rather pale pink, but darker within the tube, day-blooming, borne in axillary, few-flowered cymes; sepals, 5, about 5 mm long, ovate orbicular; fruit, 1.5 to 2 cm long, ovoid; seeds, brownish pubescent. Planted ornamental, often along borders of home allotments. Has become naturalized in other areas of the Pacific and in S. E. Asia. 3(58617), 5(198), 6, 7.

Ipomoea hederifolia L.
syn. *I. angulata* Lam.

Recent introduction. Trop. America. Rare to occasional. Slender, branching, herbaceous, nearly glabrous, right-twining vine, up to 4 m high; leaves, up to 5 o 6 cm or longer and about 4 cm wide, variable, entire or irregularly lobed, ovate-cordate, acute, mucronate, basal sinus wide, marginally more or less coarsely dentate or sub-lobate, 7-nerved from base, midrib branched upward, long-petiolate; petiole, slender, as long as blade; flowers, few to several in branching, long-pedunculate, axillary clusters; corolla, 3 to 4 cm long, bright red, attractive, tubular, limb flaring to about 2.5 cm in diameter, calyx lobes long-pointed; fruit, 7 mm in diameter, a globose capsule, opening by 4 valves; seeds, 4, about 4 mm long, black, densely short hairy. Found growing spontaneously in ruderal sites on the coastal strip, climbing in a *Leucaena leucocephala* thicket and over roadside shrubbery in Ijuw near Anibare boundary in 1987. 5(149), 6, 7(22307).

Ipomoea littoralis Bl.
syns. *I. denticulata* (Desv.) Choisy; *Convolvulus denticulatus* Desv.; *I. gracilis* sensu auct. non R. Br.; *I. choisiana* Wight ex Safford

Indigenous. Malaysia and the Pacific. Rare. Slender, creeping or twining herbaceous maritime vine, with glabrous stems; leaves, 4 to 10 cm long and 3 to 8 cm wide, alternate, light-green, subglabrous, ovate-cordate (heart-shaped) to reniform, entire or 3-lobed, acute or acuminate to obtuse, sometimes emarginate, base cordate with broad sinus, 7-nerved from base, midrib branched upward; flowers, solitary or few on peduncles, 1 to 4 cm long, pedicels 2 to 5 cm; sepals (calyx-lobes), all approaching 1 cm, but unequal, apex slightly mucronate, inner lobes wide as long; corolla, about 3 to 4 cm long, funnelform with spreading limb, dark pink to lavender, darker in the throat; fruit, approaching 1 cm, a glabrous, 2-celled capsule; seeds, 4, glabrous. Roadside and waste places. 8.

Ipomoea macrantha R. & S. "wild moon flower"
erekogo (N); te ruku (K); fue (T)
syns. *Convovulus tuba* Schlect.; *I. tuba* (Schlecht.) G. Don; *I. grandiflora* sensu Koidz. non Lam.; *I. glaberrima* Boj. ex Bouton; *I. alba* sensu Taylor non L.; *Calonyction tuba* (Schlect.) Colla; *C. comosperma* Boj.

Indigenous. Pantropical. Occasional. Coarse, somewhat woody (sub-herbaceous), creeping or twining, night-blooming (climbing) vine; leaves, 5 to 16 cm long and about equally wide, alternate, ovate-suborbicular to heart-shaped, acuminate, mucronate, base rounded, deeply cordate with open sinus, entire to slightly undulate, 7- to 9-nerved from base, midrib branched upward; petioles, up to 8 cm or longer; flowers, solitary or few, commonly in pairs, on elongate axillary peduncles, 8 to 14 cm long and 10 to 14 cm across the limb, pedicels, about 2 cm long, bracteate; sepals (calyx-lobes) subequal, 1.5 to 2.5 cm long, broadly suborbicular, rounded, persistent, containing slimy sap; corolla, 7 to 12 cm long, funnelform, attractive, white with pale greenish bands, opening about midnight, fading and wilting by morning; fruit, 2 to 3 cm long, globose, dry, borne in the persistent calyx, splitting into 4 1-seeded capsules; seeds, about 1 cm long, dark, glabrous or with two rows of minute hairs. Found climbing on trees in coastal and plateau forests and creeping on open ground in some ruderal places. Leaves possibly used medicinally by Nauruans? 3(58666, 58735), 4(131N), 5(118), 6, 7.

Ipomoea pes-caprae (L.) Sweet ssp. **brasiliense** (L.) v. Ooststr. "beach morning-glory"
erekogo, irekogo (Burges)(N); te ruku (K); fue (T)
syns. *Convolvulus brasiliensis* L.; *C. maritimus* Desr.; *I. brasiliense* (L.) Sweet

Indigenous. Pantropical. Abundant. Vigorous, prostrate, creeping, somewhat fleshy, herbaceous, vine, with a long main root and reddish-purple stems, rooting at nodes and extending up to 5 to 10 m; leaves, 5 to 12 cm long and wide, sometimes wider than long, alternate, glabrous, somewhat goat-foot-shaped and folded along the midvein, somewhat succulent, ovate-orbicular, base cordate to rounded, apex notched or 2-lobed, areolate veiny; petioles, 2 to 10 cm long, sometimes longer than blade, with 2 glands at apex; flowers, borne in solitary or several-flowered cymes, on long axillary peduncles to about 15 cm long; sepals (calyx-lobes) to 1 cm long, ovate, mucronate or notched at apex; corolla, 4 to 5 cm long, funnelform, dark rosy-pink to violet, purplish in the throat: fruit, about 1.3 to 2.5 cm across, subglobose capsule, splitting at the top into 4 sections; seeds, 4, densely pubescent. Found on beach sand, not far from the sea, and on coastal vegetation. Leaves crushed to yield juice which prevents hair from falling out. 2, 3(58729), 4(129N), 5(29), 6, 7.

Merremia quinquefolia (L.) Hall.f.
Convolvulus quinquefolia L.

Recent introduction. W. Indies. Herbaceous prostrate or climbing vine; leaves, palmately compound with 5 leaflets, leaflets oblong to lanceolate, 2.5 to 6 cm long; petioles, 2 to 5 (rarely up to 9) cm long; flowers, borne in axillary, solitary or several-flowered cymes, the peduncles glandular in the upper part and sometimes mixed with spreading bristly hairs; sepals, 4 to 8 mm long, narrowly ovate to oblong, obtuse, subequal or the outer ones shorter; corolla, 1.8 to 2.5 cm long, pale yellow or whitish; fruit, about 9 mm long, capsular, globose, stramineous, 4-valved; seeds, about 4.5 mm long, shortly curled-pilose, blackish. Weed seen in one place in semi-open area on escarpment. 3(58765).

CRASSULACEAE (Orpine Family)

Kalanchoe pinnata (Lam.) Pers. "air plant", "miracle plant", "life plant"
te ang (K)
syns. *Cotyledon pinnatum* Lam.; *Bryophyllum pinnatum* (Lam.) Kurz; *B. calycinum* Salisb.

Pre-world War II introduction. Indian Ocean Islands. Occasional. Succulent, glabrous, erect, un- or sparingly-branched, pale gray-green, perennial herb, with reddish stems marked with oblong light spots, somewhat woody at the base, up to 60 cm or higher; leaves, up to 20 cm long by 10 cm, opposite, simple or pinnately compound with 3 to 5 leaflets, broadly elliptic, margins crenate (scalloped), each crenation bearing at the notch a vegetative bud which (when leaf is detached) may produce rootlets and stem, eventually yielding a complete new plant; petioles, up to 10 to 12 long; petiolules, 3 to 5 mm long; flowers, 3 to 6 cm long, red or red-pink and green, cylindrical, pendent, calyx and corolla 4-parted, dangling in terminal panicles; fruit, follicular. Planted ornamental. Common pot plant; naturalized and spreading around water tank near Topside Workshop food gardens. 2, 3, 5, 6, 7.

Kalanchoe tubiflora (Harvey) Hamet "chandelier plant"
syns. *Bryophyllum tubiflorum* Harvey; *B. verticillata* Scott-Elliot

Recent introduction. Madagascar. Rare. Succulent erect perennial herb, up to 50 cm or higher; leaves, 2 to 12 cm long and about 6 mm thick, generally dull green, with purplish blotches or transversely striped, slender, nearly cylindrical or tubular (subterete), usually whorled in threes at the stem nodes or crowded toward stem ends, 7-toothed at the apex where vegetative buds develop; flowers, about 2 to 2.5 cm long, reddish, pendent, corolla much longer than calyx, both 4-parted. Ornamental potplant. 3(58715), 4 (52).

CUCURBITACEAE (Melon Family)

Benicasa hispida (Thunb.) Cogn. "wax gourd", "ash pumpkin", "winter melon", "white gourd" tung kwa (C)
syns. *B. cerifera* (Fisch.) Savi; *Cucurbita hispida* Thunb.; *C. cerifera* Fisch.

Pre-World War II introduction. Java. Occasional. Wide-spreading, herbaceous, pubescent or hispid, annual climbing vine, to several meters, with short, branched tendrils; leaves, 10 to 35 cm across, rounded, cordate, pubescent, palmately 5- to 11-lobed; petioles, 10 to 20 cm long; flowers, 6 to 12 cm in diameter, monoecious, solitary, axillary; calyx, 5-lobed; corolla, yellow, 5-petaled; male flowers on peduncles, 5 to 15 cm long; female flowers, subsessile, ovary densely hairy; fruit, 20 to 120 cm long and 15 to 80 cm wide, weighing up to 10 kg or more, melon-like, globose to oblong-cylindrical, green, with a easy-to-remove white waxy covering, more or less hairy when young; flesh (pulp), white, spongy; seeds, about 1 to 1.5 cm long and 5 to 7 mm wide, numerous, central, buff-colored, smooth, flat, ovate-elliptic, with narrow base. Food plant in Chinese gardens at Location. Flesh of fruit cooked as a vegetable. 5, 6, 7.

Citrullus lanatus (Thunb.) Matsum. & Tan. var. **caffrorum** (Alef.) Fosb. "watermelon"
te meren (K); meleni (T)
syns. *Citrullus vulgaris* var. *caffrorum* Alef.; *C. vulgaris* Schrad. ex Eckl. & Zeyh.

Pre-World War II introduction. S. Africa. Rare. Slender, much-branched, wide-spreading, prostrate, hairy, herbaceous, annual creeper, with rather thin, angular, grooved stems, 1.5 to 5 m long, branched (bifid or trifid) tendrils and an extensive and superficial root system; leaves, 5 to 20 cm long and 2 to 12 cm wide, alternate, scabrid or harshly pubescent, deeply pinnately lobed, the lobes again pinnately lobed and toothed, with broad apices; flowers, monoecious, solitary, axillary, on short pedicels, 3 to 5 cm long, bell-shaped (campanulate), usually more male than female flowers; calyx, 5-lobed; corolla, 2.5 to 3 cm in diameter, deeply 5-parted, pale yellow, petals, 1 to 1.5 cm long; male flowers, greenish; female flowers, longer-pedunculate, ovary ovoid with woolly hairs; fruit, large, up to over 50 cm long and 25 cm in diameter and weighing up to 4 to 20 kg, rounded (globose) or oblong; rind, mostly glabrous, dark-green, striped or patterned, hard, but not durable; flesh (pulp), red to whitish-pink (rarely yellow), watery, sweet; seeds, 6 to 15 mm long and 5 to 7 mm wide, many, black, sometimes white mottled, smooth, flattened, with swellings on either side of the apex. Food plant in home gardens and as spontaneous juveniles around residences and dump heaps. Fruit eaten raw. 2, 3, 5, 6, 7.

Cucumis melo L. var **cantalupensis** Naud. "cantaloupe", "rock melon"
te meren (K); meleni (T); heung kwa, t'im kwa (C)

Recent introduction. S. W. Asia and Africa to the Mediterranean. Occasional. Softly hairy, trailing, herbaceous, annual vine, with ridged or striated stems, tender unbranched tendrils, and an extensive and superficial root system; leaves, 7 to 13 cm across, simple, rounded or kidney-shaped, usually 5-angled and sometimes shallowly 3- to 7 lobed; petiole, 8 to 16 cm long; flowers, about 2.5 cm across, generally andro-monoecious (with hermaphroditic and male flowers on the same plant), yellow; male flowers, often in groups, each on a slender pedicel; hermaphroditic (and female) flowers, solitary, with shorter and thicker pedicels; fruit, 12 to 24 cm long and 10 to 18 cm in diameter, globose or oblong, hollow; rind, thick, scaly, rough, netted or often deeply grooved; flesh (pulp), soft, juicy, pale-orange, slightly sweet or fragrant; seeds, 8 to 12 mm long, many, whitish or buff, smooth, flat, in a central cavity with fleshy placentas. Food plant in Chinese gardens at Location. Fruit flesh eaten raw. 5,·6.

Cucumis melo L. var. **conomon** Makino "Oriental pickling melon"
ts'it kwa (C)

Pre-World War II introduction. China. Rare. Softly hairy, branching, trailing, occasionally climbing, herbaceous, annual vine, with ridged stems, tender unbranched tendrils, and an extensive and superficial root system; leaves, 7 to 13 cm across, simple, rounded to heart- or kidney-shaped; flowers, about 2.5 cm across, generally andro-monoecious (with hermaphroditic and male flowers on the same plant), yellow; male flowers, often in groups, each on a slender pedicels; hermaphroditic (and female) flowers, solitary, with shorter and thicker pedicel; fruit, 20 to 30 cm long and 6 to 8 cm in diameter, oblong, cylindrical, cucumber-like, slightly hollow; rind, thin, pale whitish-green to yellowish-green, longitudinally lined, smooth or slightly pubescent; pulp, soft, white to greenish-white, almost tasteless; seeds, 5 to 10 mm long, many, whitish or buff, smooth, flat, in a central cavity with fleshy placentas. Trailing or climbing food plant in Chinese gardens at Location and Topside. Fruit cooked as a vegetable, often in soups. 5, 6.

Cucumis sativus L. "cucumber"
te kukamba (K); kukampa (T); tseng kwa, wong kwa (C)

Pre-World War II introduction. N. India. Rare. Scabrid, climbing or trailing, herbaceous, annual vine, climbing from 1 to 5 m, with strongly 4-angled stems, unbranched tendrils and an extensive and superficial root system; leaves, 8 to 20 cm long, hispid or rough, base cordate, apex acuminate, scarcely angled, unlobed or shallowly 3- to 5-lobed with acute sinuses, dentate, palmately 5- to 7-nerved; petioles, 5 to 18 cm long; flowers, 2 to 4 cm long, monoecious, yellow, bell-shaped, deeply 5-partite, hairy, wrinkled; calyx, 5 to 10 mm long, with 5 narrow lobes; male flowers, predominant, borne in axillary clusters on slender pedicels; female flowers, solitary or few, axillary, on stout peduncles; fruit, 15 to 25 cm long, pendulous, slenderly oblong or cylindric, often slightly curved, dark to light-green skinned, glabrous or covered with tiny bristly tubercles or warts (echinate), particularly when young; flesh, pale whitish-green; seeds, 8 to 10 mm long and 3 to 5 cm wide, many, whitish, oblong, flat, margin defined only at the apex. Food plant in houseyard gardens. Fruit eaten raw, and occasionally cooked. 5, 6, 7.

Cucurbita maxima Duch. "pumpkin", "winter squash", "autumn squash"
dabamakin (N); te baukin, te bamakin, te bangke (K)

Recent introduction? S. America. Rare. Prostrate, long-trailing, slightly rough, herbaceous, annual vine, with branched tendrils; stems, soft, round in cross-section; leaves, 6 to 19 cm long and 7 to 20 cm wide, slightly kidney-shaped (subreniform), nearly orbicular in outline, shallowly 5-lobed, cordate with a very deep sinus, margins denticulate, green, occasionally with white blotches, coarsely pubescent, not rigid; petioles, up to 20 cm long; flowers, solitary, monoecious, bell-shaped, acute or obtuse in bud, corolla lobes curved outward, bright yellow; male flowers, 4 to 7 cm long on peduncles, 10 to 17 cm long; sepal lobes, linear; calyx lobes, narrow subulate; female flowers, on a soft corky peduncle, thickening to a fruit-stalk, up to 7 cm long, thicker than stem, spongy, nearly cylindrical, not expanded at point of attachment to fruit; fruit, variously shaped, hard, green to dull orange or yellow, often mottled, usually hollow; flesh, yellow to orange, rather fibrous; seeds, 16 to 20 mm long and 8 to 12 mm wide, not separating easily and cleanly from pulp, dull white or buff, usually smooth or glossy, sometimes with fine wrinkles, ovate, attachment acute and asymmetrical, apex nearly straight across or oblique, margin or rim, smooth, obtuse, single, slightly raised. Food plant, often adventive in gardens. Fruit cooked as a vegetable. 3.

Cucurbita pepo L. "pumpkin", "field pumpkin", "summer squash", "marrow"
dabamakin (N); te baukin, te bamakin, te bangke (K); panikeni (T)

Pre-World War II introduction. Trop. America. Prostrate, long-trailing (rarely somewhat erect), slightly rough, hard-stemmed, herbaceous, annual vine, with 4- to 5-branched tendrils; stems, harsh to touch and spiculate, round in cross-section; leaves, 6 to 19 cm long and 7 to 20 cm wide, broadly triangular or heart-shaped, often pointed, palmately, deeply 5-lobed, broad sinus between lobes, central lobe longest, rather finely toothed, harsh to the touch and spiculate, more prickly than *C. maxima*, cordate with narrow, acute sinuses, green, occasionally with white blotches, stiff and more or less rigid, foliage held upright; petioles, up to 15 cm long; flowers, solitary, monoecious, bell-shaped, acuminate in bud, corolla lobes nearly always upright, bright yellow to yellow-orange; sepals, short, awl-shaped; calyx lobes, narrow subulate; male flowers, 5 to 6 cm long on peduncles; female flowers, on a hard, sharply 5-angular, grooved peduncles, maturing into a short fruit-stalk, without cork development and not, or only slightly enlarged at point of attachment to fruit; fruit, variable, usually spherical-oblate, dull orange to orange-brown, sides radially round-ridged, hollow; flesh, orange, coarse-grained, rather fibrous; seeds, 10 to 18 mm long and 8 to 11 mm wide, separating easily and cleanly from pulp, dirty white or creamy white, smooth or finely granular, ovate, attachment obtuse and symmetrical, apex usually straight across, thin or fairly plump, margin or rim, smooth, obtuse, clearly defined, usually appearing double. Occasional. Food plant, often adventive in waste places and gardens at Location and elsewhere on the coastal strip. Fruit cooked as a vegetable. 3, 5, 6, 7.

Luffa acutangula (L.) Roxb. "angled loofah", "vegetable sponge", "ridge gourd", "dish-cloth gourd" sze kwa (C)
syn. *Cucumis acutangulus* L.

Pre-World War II introduction. India, Paleotropics. Occasional. Stout, climbing, glabrous, herbaceous, annual vine, with pentagonal stems, 3- or more-forked tendrils and fetid when bruised; leaves, 10 to 24 cm long and wide, rounded, rather shallowly palmately 5- to 7-lobed, coarsely and shallowly toothed, scabrous, pale beneath; flowers, 4 to 5 cm in diameter, monoecious, axillary, pale yellow, 5-petaled, petals almost completely distinct, male and female flowers borne together in the same axil, opening in the late afternoon or evening; male flowers, in racemes of several flowers, peduncle 10 to 25 cm long, stamens 3; female flowers, solitary, stigmas 3, ovary 10-ribbed; fruit, 15 to 40 cm long and 5 to 10 cm in diameter, green to gray-green, very narrowly obovoid, with 10 acute longitudinal ridges or ribs, crowned with enlarged sepals and style; flesh, white, somewhat spongy, becoming fibrous when old; seeds, 10 to 13 mm long and 7 to 9 cm wide, black, pitted, flattened. Climbing foodplant in Chinese gardens at Location and Topside. Young green fruit cooked as a vegetable. 4(162N), 5, 6, 7, 8(9577).

Luffa cylindrica (L.) Roem. var. **insularum** (A. Gray) Cogn. "smooth loofah", "wild vegetable sponge", "scrubber gourd", "dish-cloth gourd"
syns. *Momordica cylindrica* L.; *M. luffa* L.; *Luffa aegyptica* Mill.; *L. insularum* A. Gray

Pre-World War II introduction; although variety *insularum* seems to be indigenous to many Pacific islands, it was probably introduced to Nauru. Trop. Asia. Locally common. Vigorous, climbing, somewhat pubescent, herbaceous annual vine, with pentagonal stems and 2- to 3-, or more-forked tendrils; leaves, to 20 cm long and nearly as wide, much longer than petiole, orbicular-ovate to almost kidney-shaped (subreniform), deeply 5- to 7-angled or -lobed, acuminate or acute, base deeply cordate with open sinus; petiole, 5 to 10 cm long, scabrid or hispid; flowers, 5 to 9 cm in diameter, monoecious, axillary, yellow, petals almost completely distinct, male and female flowers in the same axil, opening in the early morning; male flowers, 4 to 20, crowded near the end of a solitary axillary peduncle, stamens 5; female flowers, solitary, stigmas 3, ovary not ribbed; fruit, 12 to 30 cm long, oblong-cylindrical, smooth or slightly ribbed or striped, crowned with stout sepals and style, fleshy at first, becoming dry; flesh, white, spongy, becoming fibrous when old; seeds, 10 to 15 mm long, black, smooth, flat, faintly winged. Weedy found on edges of forest, waste places, and spreading over Topside topsoil dump on plateau. 3(58587, 58731), 5(75), 6, 7.

Momordica charantia L. "bitter gourd", "bitter melon", "balsam apple"
fu kwa (C); ampalaya (P)

Pre-World War II introduction. Paleotropics. Occasional. Slender, high-climbing, herbaceous, annual vine, 2 to 4 m long, with slightly pubescent, 5-angled, furrowed stems and unbranched tendrils; leaves, 5 to 15 cm in diameter, palmately 3- to 5- lobed, the lobes more or less undulate or coarsely toothed, base cordate, smooth or slightly pubescent; petiole, 10 to 12 cm long; flowers, 2.5 to 3.5 cm in diameter, monoecious, axillary, yellow, corolla deeply-lobed; calyx, deeply 5-parted; male flowers, single or racemose, stamens 3; corolla, deeply 5-parted, 1.5 to 2 cm long; female flowers, solitary, on peduncles with a kidney-shaped bracteole at base, stigmas 3; fruit, 5 to 20 cm long, pendulous, ovoid to oblong-cylindric or pear-shaped, irregularly longitudinally ridged with numerous bumpy tubercles, short-pointed at tip, light green to orange or dark yellow when ripe, splitting at the tip into three irregular valves; pulp, bitter when green and slightly sweetish when ripe; seeds, 12 to 16 mm long and 5 to 9 mm wide, numerous, light brownish to light gray patterned, covered with a soft, fleshy red aril. Food plant in Chinese and Filipino gardens at Location and in Chinese gardens at Topside workshops and surrounding Buada Lagoon. Fruit and young leaves occasionally cooked as vegetables. 4(144N), 5, 6, 7.

ERICACEAE (Heath Family)

Rhododendron sp. "azalea"

Recent introduction. Rare. Asia. Evergreen shrub. Flowers not seen. Planted ornamental. 6.

EUPHORBIACEAE (Spurge Family)

Acalypha amentacea Roxb. var. **wilkesiana** (Muell.-Arg.) Fosb.
"copper leaf", Jacob's coat" "beefsteak plant", "fire dragon plant"
Kayser bush (N); te aronga (K); kalakalaapuki, kakarapus, ogoogo, lakau kula (T)

syn. *A. wilkesiana* Muell.-Arg.

Pre-World War I introduction. Melanesia. Common. Perennial shrub, up to 2 m or higher, with pubescent young branches; leaves, 5 to 20 cm long and 3 to 15 cm wide, alternate, simple, mostly ovate, crenate-serrate, acuminate, pubescent, rather curved and coarsely crisped, pinnately-nerved, attractive, commonly dark or bright-red, red-green or green, often mottled with various shades of red, dark pink or bronzy green, sometimes with whitish or reddish-white margins resembling a thin marbling of fat on a beefsteak; petioles, 2 to 10 cm long; stipules, 3 to 11 mm long, oblong-lanceolate; flowers, monoecious, tiny, about 1 cm across, petal-less, borne alternately on slender axillary or terminal spikes, 4 to 15 cm or longer; bracts, about 4 to 10 mm across, red to deep purple, 5- to 13-toothed, only slightly cupular, subtending single flowers; male spikes slender, elongated, hanging among lower leaves, accompanied by smaller bracts; female spikes somewhat shorter, nearly erect, among leaves at branch tips, each cluster (1 to 5) accompanied by a larger triangular, toothed bract, often with a rounded central lobe; ovary, 1.5 to 2 mm wide, green, puberulent; styles whitish, hair- or bristle-like, curved; fruit, a small capsule. Planted ornamental and hedge plant. 3(58743, 58757), 5(41), 6, 7.

Alcalypha amentacea Roxb. var. **wilkesiana** f. **circinata** (Muell.-Arg.) Fosb.
te aronga (K)
syn. *A. wilkesiana* Roxb.f. *circinata* Muell.-Arg.

Recent introduction. Pacific Is. Occasional. Perennial shrub, up to 2 m tall; leaves, 3 to 14 cm long and wide, suborbicular or reniform or broadly ovate, often rounded at the apex, somewhat flabellinerved, green, commonly variegated with a white margin. Planted ornamental, often as hedges. 3(58769), 5, 6, 7.

Acalypha hispida Burm.f. "cats' tail", "chenille plant", "red-hot poker"

Recent introduction. Indonesia. Rare. Perennial shrub, up to 2 m high; young branches pubescent; leaves, 5 to 18 cm long and 3 to 10 cm wide, green, alternate, ovate, dentate-crenate, acuminate, pinnately-nerved; petioles, 3 to 9 cm long; stipules, 5 to 10 mm long, oblong-lanceolate; flowers (female), axillary, petal-less, borne in pendulous, bright-red, velvety, tassel-like spikes, 10 to 50 cm long and 1 to 2.5 cm in diameter, resembling a cat's tail; bracts, minute, entire, subtending flower clusters; fruit, not seen. Planted ornamental. 3(58705), 5, 6,.

Breynia disticha J.R. & G. Forst var. **disticha** f. **nivosa** (W.G. Smith) Croizat
"leaf-flower of the Pacific islands", "snow bush" eomonon (N)(Burges,1933)
syns. *B. nivosa* (Bull) Small; *Phyllanthus nivosus* Bull

Pre-World War II introduction. Pacific Is. Rare. Perennial glabrous shrub, up to 3 m or taller, with slender, densely, two-ranked branches; leaves, 2.5 to 5 cm long, alternate, 2-ranked or spirally arranged, oval-ovate, entire, green, variegated with white, pink ,light red or purple, obtuse or abruptly pointed; petioles, short; stipules, very small, triangular acute; flowers, monoecious, small, green, petal-less, on short axillary pedicels; male flowers, 3 to many, borne in close clusters (fascicles) in the lower axils; female flowers, solitary, with a green, 6-lobed or -toothed, bell-shaped or cuplike calyx, borne in the upper axils. Planted ornamental. 2, 3, 5, 6, 7.

Codiaeum variegatum (L.) A. Juss. "croton", "codiaeum"
syns. *Croton variegatum* L.; *Phyllaurea variegata* (L.) Wight; *P. codiaeum* Lour.

Pre-World War II introduction. Malaysia to Melanesia. Common. Glabrous, densely-branched, shrub or small tree, up to 4 m or taller; leaves, 7 to 32 cm long and 2 to 15 cm wide, alternate, spirally arranged, thick, leathery, extremely variable in shape, size and color, commonly entire, sometimes interrupted, wavy, twisted or 3- or more-lobed, linear-lanceolate, oblong or ovate to obovate, mostly acuminate, pinnately-nerved, plain, spotted, mottled, variegated, or decoratively patterned green, red, purple, pink, yellow and white, nerves often brightly colored, red or yellow; petioles, 1 to 9 cm long; flowers, monoecious, small, petal-less, borne in lax axillary narrow spikes, 15 to 25 cm long; male flowers, about 6 mm wide, with 5 or 6 sepals and petals and 15 to 35 free stamens, chestered; female flowers, solitary, lacking petals, scattered; fruit, small, a subglobose, thin-walled, 3-lobed capsule. Planted ornamental and hedge plant. 3(58714), 5, 6(199, 200), 7.

Euphorbia antiquorum L. "cactus spurge", "false cactus", "Malayan spurge tree"

Recent introduction. India, S.E. Asia. Rare. Erect, spiny, cactus-like shrub, up to 3 m or higher, with thick, green, succulent, ridged, 3- to 4-angled stems and branches; spines, up to 7 mm long, brown, on ridge elevations; leaves, none or commonly falling soon, 6 to 13 mm long, thick, oval; flowers, small, yellowish or greenish, borne in upper leaf axils. Planted ornamental. 3(58680), 5(130), 6, 7.

Euphorbia chamissonis (Kl. & Gke.) Boiss. "beach spurge"
e mai (B)(N); te tarai (K); teluna (T)
syns. *E. atoto* sensu auct. (Burges) Micr. non Forst.f.; *Anisophyllum chamissonis* Kl. & Gke; *Chamaesyce atoto* sensu auct. non (Forst.f.) Croizat

Indigenous. Trop. Pacific. Rare. Erect to semi-erect or sprawling, freely-branching, glabrous subshrub, up to 1 m tall, with decumbent or ascending stems, which are branched, appear jointed and thickened at the nodes, a woody rootstock and white sticky latex; leaves, 1.5 to 3 cm long and 1 to 2 cm wide, opposite, entire, somewhat fleshy, ovate-oblong, oval-ovate or oblong subspatulate, base cordate and somewhat unequally 2-sided, apex acute to obtuse, sometimes mucronate, palmately veined, glabrous, light-green or glaucous above, whitened beneath; petioles, up to 2 mm long; flowers, numerous, monoecious, white or greenish, petal-less, in cyathia borne in small axillary or terminal branching clusters (cymes); involucres of cyathea usually 1.7 to 2.3 mm long, glands with minute appendages; fruit, about 3 mm long, a glabrous, dehiscent capsule; seeds, small, smooth, released when dry fruit opens. Spreading shrub on seashore. 2(38.5), 3, 5(106), 6, 7.

Euphorbia cyathophora Murr. "painted leaf", "Mexican fire plant", "hypocrite plant", "wild poinsettia", "Christmas bush", "dwarf poinsettia"
deriba, deribeh (N); te kabekau (K)
syns. *E. heterophylla* L. var. *cyathophora* (Murr.) Griseb.; *Poinsettia cyathophora* (Murr.) Kl. & Gke.

Pre-World War II introduction. Trop. America. Occasional. Erect annual herb, up to 80 cm or higher, with glabrous, green, longitudinally-grooved stems, sparingly pubescent young shoots and white latex; leaves, 3 to 8 cm long and 1.5 to 3.5 cm wide, alternate below, opposite above or in threes, somewhat fiddle-shaped (pandurate), pinnately, sharply and shortly 2- to 4-lobed, usually with a deep, rounded notch or incision on each margin, those of the basal leaves sometimes simply ovate, entire or obscurely distantly serrate, mostly glabrous, the upper leaves crowded beneath the flowers, the uppermost, bract-like leaves near the flowers with a bright red basal blotch; petioles, 1 to 4 cm long, slender; flowers, monoecious, small, inconspicuous, greenish, petal-less, in cyathia packed in short terminal clusters (cymes), 2 to 4 cm wide; involucre of cyathium, 3 to 5 mm long, on a stalk of equal length, cup-shaped, 5-lobed, green, enclosing several male flowers and 1 female flower, and bearing a funnel-shaped gland with a large elongated opening, about 1.5 cm long; male flowers, tiny, numerous, surrounding the female flower and reduced to a single stamen, anthers, yellow; female flowers, one per cyathium, consisting of a stalked, 3-lobed ovary; fruit, 3 to 5 mm long, glabrous, subglobose, 3-lobed capsule (schizocarp), splitting at maturity into three 1-seeded segments; seeds, 2 to 2.5 mm across, dark brown, tuberculate, obovoid or globose, basally flattened, apically subconic. Roadside and waste place weed. 1(23.R), 2, 3(58628), 4(104N), 5(31), 6, 7(27818), 8(9556).

Euphorbia geniculata Ortega "wild spurge"

Recent introduction. Texas, Mexico and the W. Indies. Occasional. Erect annual herb, to about 60 cm or higher, with somewhat hairy, green hollow stems and white latex; leaves, 3 to 8 cm and 1.5 to 3.5 cm wide, basal and apical leaves opposite, other leaves alternate, entire, ovate or oblong-rhomboidal, acute-acuminate, obscurely dentate toward base, lower leaves all green, glaucous beneath, the uppermost bract-like leaves near the flowers with a white or pink basal blotch; petioles, 1 to 5 cm long; flowers, monoecious, small, inconspicuous, greenish, petal-less, in cyathia packed in short terminal clusters (cymes), 2 to 4 cm long; involucre of cyathium, cup-shaped, 5- to 7-lobed, green, enclosing several male flowers and 1 female flower, and bearing a single funnel-shaped gland at one side; male flowers, tiny, numerous, surrounding the female flower and reduced to a single stamen, anthers, yellow; female flowers, one per cyathium, consisting of a stalked, 3-celled ovary with 3 bifid styles; fruit, 3 to 5 mm across, subglobose, 3-lobed capsule (schizocarp), splitting at maturity into three 1-seeded segments; seeds, 2.5 to 3.2 mm across, grey-brown, angular, sharply keeled on one side, slightly tuberculate. Weed of roadsides and wasteplaces. 5(72), 6, 7, 8(9580).

Euphorbia heterophylla L. "wild spurge"
syn. *Poinsettia heterophylla* (L.) Klotzsch & Garcke

Recent introduction. Mexico. Occasional. Erect, unbranched annual herb, up to 70 cm high, with hollow stems; leaves, alternate, the lower entire, oval or elliptic, with irregularly-toothed margins, the upper leaves deeply lobed, the topmost leaves green or with a purple-spotted (never red) base and clustered beneath the inflorescences; inflorescences, separately male and female borne in terminal cyathia; cyathium, a 5-lobed green cup enclosing several male and one female flower and bearing a gland with a small circular opening; fruit, a 3-celled capsule, explosively dehiscent; seeds, 1 to a cell, 2 to 2.5 mm across, subglobose, dark brown to black, rugose or tuberculate, with a keel and a transverse groove at right angles to it. Weed of roadsides and ruderal sites. 3(58623, 58667), 4(102N).

Euphorbia hirta L. "garden spurge", "asthma plant", "hairy spurge", "old blood"te tarai, te tarai Kutaie ("Kusaie, Kosrae")(K)
syns. *E. pilulifera* L.; *Chamaesyce hirta* (L.) Millsp.

Pre-World War II introduction. Pantropical. Abundant. Erect or decumbent, scarcely branching, widely spreading, densely hairy annual herb, 6 to 60 cm high, with white latex; leaves, 1 to 4 cm long and 0.5 to 1.5 cm wide, opposite, simple, elliptical, oblong or ovate-rhomboidal, acute to obtuse tip, base obliquely acute, finely serrate, stipulate, leaf surfaces appressed pubescent, green, often with red, brown or purplish tinge, paler beneath; petioles, 2 to 3 mm long; flowers, monoecious, very small, greenish white, petal-less, in cyathia arranged in 1 to 2 dense, axillary, globose clusters (cymes) on short pedicels, 3 to 15 mm long; involucre 4- to 5-lobed, enclosing several male flowers and 1 female flower, and with minute glands; male flowers, minute, surrounding the female flower, each consisting of a single stamen; female flowers, on per cymatium, consisting of a 3-celled ovary; fruit, 1 to 1.3 mm across, globose, hairy, brown, 3-lobed schizocarp splitting into three 1-seeded segments at maturity; seeds, about 1 mm long, irregular oblong with some faint transverse ridges. Weed in waste places and open areas; pioneer plant in recently mined areas. 2, 3(58627, 58677), 4(114N), 5(21), 6, 7, 8(9554).

Euphorbia hypericifolia L. "spurge", "graceful spurge"
te tarai (K)
syn. *Chamaesyce hypericifolia* (L.) Millsp.

Recent introduction. Trop. America. Occasional. Slender, reddish-stemmed, glabrous, branching herb, 10 to 50 cm high, with a taproot and white latex; leaves, 1 to 2.5 cm long and 0.3 to 1 cm wide, thin, opposite, elliptic or elliptic-lanceolate, entire or minutely toothed, base oblique, green, rarely pinkish or reddish-purplish, glaucous below; petioles, short, about 1 to 2 mm long; flowers, monoecious, small, inconspicuous, greenish, petal-less, in cyathia borne in small cymes, on pedicels, 1.2 to 3 cm long, in upper axils; involucral bracts, white, aging to pink; fruit, a 3 lobed capsule, with one seed to a lobe, and forked styles; seeds, less than 1 mm long, ribbed, reticulate, dark red to purplish. Garden and ruderal weed. 3(58658), 5(72), 6(223), 7, 8(9555).

Euphorbia milii Ch. des Moul. var. **splendens** (Bojer) Ursch & Leandri
"crown of thorns"
syn. *E. splendens* Bojer

Recent introduction. Madagascar. Rare. Erect branching shrub, up to 1 m or higher, with hard, succulent, nearly cylindrical, subterete or slightly ridged stems, sometimes twining, beset with many slender spines, up to 2.5 cm long; leaves, 2 to 5 cm long and 1.5 to 4 mm wide, obovate, thinly fleshy, bright green, crowded toward branch tips, soon falling; flowers, monoecious, very small, petal-less, in cyathia borne on long axillary peduncles near the branch tips, each subtended by two opposite, rounded, wing-like, bright- or salmon-red bracts, 8 to 10 mm long. Planted ornamental and pot plant. 6(178).

Euphorbia prostrata Ait. "prostrate spurge"
te tarai (K)
syn. *Chamaesyce prostrata* (Ait.) Small

Pre-World War I introduction. Trop. America. Abundant. Prostrate annual herb, much-branched at base, with white latex and slender purplish or pinkish stems, 2 to 20 cm long, which are glabrous or minutely puberulent on one side only; leaves, 2 to 10 mm long and 1.5 to 6 mm wide, opposite, simple, oblong-elliptic to oblong-obovate, tip rounded to obtuse, base rounded to obliquely unequilateral, margins finely serrate (serrulate), glabrous or sparsely puberulent dorsally, glaucous with a purplish tinge; petioles, short, about 1 mm long; stipules, on upper side of stem distinct, linear, pilose, those of lower side fused, apically toothed; flowers, monoecious, very small, purplish, petal-less, borne in cyathia arranged in short, few-flowered axillary clusters (cymes) on short pedicels; involucre, 4 to 5- lobed, enclosing several male and 1 female flowers, and bearing purple glands; male flowers, minute, surrounding the female flower, each consisting of a single stamen; female flowers, one per cymatium, consisting of a 3-celled ovary; fruit, about 1 mm long, subglobose, 3-lobed schizocarp, sparsely hairy on the margins, pinkish or purplish, on a stalk as long as the fruit, splitting at maturity into three 1-seeded segments; seeds, about 0.8 mm long, narrowly ovoid, truncate basally, apically obtuse, tetragonal, reddish or grayish, 5- to 7-grooved transversely. Weed along paths and open waste places; pioneer plant in recently mined areas. 1(62.R), 3(58630, 58631), 4(116N), 5(22), 6, 7, 8(9552).

Euphorbia pulcherrima Willd. ex Klotszch "poinsettia"
syn. *Poinsettia pulcherrima* (Willd.) R. Grah.

Recent introduction. Mexico. Rare. Erect, glabrous, branching, soft-wooded shrub, up to 2 m or higher, with white latex; leaves, 8 to 25 cm long and 5 to 15 cm wide, elliptic to elliptic-ovate, acute, entire or slightly sinuate-toothed or lobed, often somewhat fiddle-shaped, bright green, pubescent; petioles, 3 to 8 cm long; uppermost bracteal leaves bright red (rarely pink, white or yellow), lanceolate, forming a rosette, borne at the tips of long arching stems; flowers, monoecious, inconspicuous, greenish, petal-less, in rather large cyathia; involucre, 8 to 10 mm high, green, with reddish 5-laciniate lobes, with a large yellowish gland about 4 mm long; styles, bifid, red; fruit, about 1.5 cm long, a long-stipulate capsule, glabrous, nodding; seeds, about 6 mm across, subglobose, pale, smooth. Planted ornamental. 6.

Euphorbia rubicunda Bl. "thyme-leafed spurge", "dwarf spurge"
te tarai (K)
syn. *E. thymifolia* sensu auct. non L.

Recent introduction. India. Occasional. Small prostrate, hispid, annual herb, with pinkish stems and white latex; leaves, up to 1 cm long, opposite, obliquely oblong obtuse, crenulate, glabrous or puberulent, coppery; stipules, less than 1 mm long, elongate fimbriate; flowers, monoecious, minute, petal-less, borne in cyathia arranged in short, few-flowered axillary clusters (cymes) on short pedicels; involucre enclosing several male and 1 female flowers, gland small or none; fruit, about 1 mm long, very shortly-stalked, white-pubescent, 3-celled capsule; seeds, about 0.7 mm long, 1 per cell, blunt, light-brown, 4-angled, with 5 or 6 shallow transverse furrows. Weed along roadsides and around buildings. 3(58824, 58661), 6, 7, 8(9561).

Euphorbia tirucalli L. "pencil plant", "pencil tree", "naked lady", "milk hedge", "milk bush"

Recent introduction. E. Africa and India. Occasional. Medium to large, freely branching shrub, up to 4 m or higher, with numerous slender, cylindrical, leafless, green articulated branches; leaves, 0.7 to 2.5 cm and up to 0.5 cm wide long or less, narrow, reduced to linear scales on youngest branch tips, early caducous; flowers, inconspicuous, borne in cyathia in sessile, axillary and terminal, clusters (cymes); involucre, with 5 glands (nectaries); fruit, a 3-valved capsule; seeds, smooth, ovoid. Planted ornamental. 5, 6(168).

Jatropha integerrima Jacq. "rose-colored jatropha", "red-flowered jatropha"
syns. *J. hastata* Jacq.; *J. panduraefolia* Andr.

Recent introduction. Cuba. Common. Slender shrub up to 1 to 3 m high, with little or no watery latex; leaves, 6 to 16 cm long and 4 to 10 cm wide, alternate and spirally arranged, ovate to fiddle-shaped (panduriform), acuminate, mostly entire with obscure basal teeth or marginally incised or toothed;; petioles, 3 to 10 cm long; stipules, minute, subulate-deltoid, entire; flowers, monoecious, 5-petaled, dissected, attractive rich pink to bright red, petals about 10 to 13 mm long, borne in terminal or axillary umbels with long, branched stalks, about 6 to 14 cm long; male flowers, distal, usually with a dissected disc, stamens, 8 to 10, anthers yellow to salmon-orange; female flowers, lower, with cupular or pulviniform disk, ovary 3-locular; fruit, about 1 cm long, shallowly lobed, breaking into 3 segments; seeds, ellipsoid, with crustaceous testa. Planted ornamental. 3(58796), 5, 6(276), 7.

Jatropha podagrica Hook. "gout stalk", "coral plant"

Recent introduction. Central America. Rare. Succulent, un- or little-branched perennial shrub, up to 1 m or higher, with a swollen stem, much swollen at the base, and white latex; leaves, 10 to 30 cm in diameter, peltate to broadly ovate, entire to palmately 3- or 5- angled or -lobed, whitish beneath, sinuses rounded, lobes broad and acute, attached within the margin by long petioles; petioles, 5 to 12 cm long; stipules, divided into small rigid segments; flowers, about 12 mm across, orange-red to vermilion, borne in dense umbels on long peduncles; calyx, eglandular, orange-red, 5-petaled, petals 5 to 8 mm long, red to vermilion; pistil, prominent, about 4 mm long, light orange-yellow (ovary) to yellowish-green (stigma and style); fruits, about 1.5 cm long, capsular, broad-ellipsoid, breaking into 3 segments; seeds, ellipsoid, with crustaceous testa, poisonous. Ornamental pot plant. 6.

Manihot esculenta Crantz "cassava", "manioc", "tapioca"
te tabioka (K); tapioka, kasava (T)
syns. *M. utilissima* Pohl; *M. manihot* (L.) Karst.; *Jatropha manihot* L.

Pre-World War II introduction. Brazil or Trop. S. America. Common. An erect, glabrous, slightly glaucous, half-woody, branched or unbranched shrub, up to 3 m or higher, with milky latex, stems bearing prominent nubby leaf scars, and large edible tuberous roots; leaves, 10 to 30 cm across, alternate, spirally arranged, somewhat pendulous, palmately 3- to 9-lobed (usually 5- to 7-lobed), the lobes, 4 to 22 cm long and

1 to 6 cm wide, very slenderly lanceolate-elliptic, or obovate-lanceolate, acuminate, deeply separated, dark to light green and glabrous above, glaucous and pale beneath, sometimes red-tinged, sometimes slightly hairy beneath, midrib green to deep red; petioles, 5 to 32 cm long, green to deep red; stipules, usually with 3 to 5 lanceolate lobes to 1 cm long, deciduous; flowers, about 1 to 2 cm across, monoecious, petal-less, often not developing, pendulous, borne in few-flowered, lax, axillary paniculate clusters, 3 to 10 cm long, with male and female flowers in the same inflorescence, the latter near the base; bracts, linear, deciduous; sepals 5, pale yellow or tinged with red, glabrous without, puberulent within; male flowers, on pedicels 0.5 to 1 cm long, calyx, 3 to 8 mm long, campanulate with 5 triangular lobes extending to middle of calyx, stamens 10 in 2 whorls, alternately short and long, filaments free, anthers small, basal disk orange, fleshy with 5 double lobes; female flowers, on pedicels 1 to 2.5 cm long, usually larger than males, calyx 5-partite to base, 1 cm long or more, ovary, 3 to 4 mm long, 3-carpellary, 6-ridged, glabrous, greenish-white with pink or red streaks, on a 10-lobed disc, style connate, surmounted by 3 lobed white stigmas, each lobe much divided; fruit, 1.5 to 2 cm long, subglobose to ellipsoid capsule with narrow longitudinal wings or ridges, 3-seeded, splitting explosively; seeds, about 12 mm long, ellipsoid, smooth, gray mottled with dark blotches, carunculate, with a thin crustaceous testa; tubers, developing as swellings on adventitious roots at a short distance from the stem, usually 4 to 10 per plant, 10 to 100 cm long and 3 to 15 cm in diameter, usually weighing 1 to 10 kg or more, cylindrical or tapering, occasionally branched, outer skin, rough or smooth, light to darker brown to white or pinkish, inner rind or cortex usually white, but sometimes tinged with pink or brown, core or pith consisting of rich white or yellowish starch with few xylem bundles and latex tubes. Food plant in I Kiribati and Tuvaluan gardens at Location and Topside workshops. This easy-to-grow plant, which thrives on the poorest of soils, has become the dominant staple root crop, displacing taro and yam as the dominant staple in many areas of high-island Micronesia, and in Fiji, Tonga, parts of the Cook Islands, and in the drier areas of Vanuatu, New Caledonia, and Papua New Guinea. 5, 6, 7.

Pedilanthus tithymaloides (L.) Poit. "slipper flower", "slipper spurge", "shoe spurge", "zigzag plant", "redbird cactus", "ribbon cactus"
syns. *P. carinatus* Spreng.; *Euphorbia tithymaloides* L.

Recent introduction. Caribbean. Occasional. Erect or somewhat decumbent, sparsely branching, slightly succulent subshrub, up to 1 m or higher, with white latex and fleshy, cylindrical stems which zigzag from node to node; leaves, 5 to 10 cm long, alternate, soon falling, fleshy, waxy, ovate to lanceolate, subsessile, often variegated or streaked green, white, yellowish or pink tinted, or in some forms completely albino; flowers, monoecious, inconspicuous, petal-less, yellowish, borne in cyathia in axillary or terminal cymose clusters; cyathium, about 12 mm long, narrow, boat- or slipper-shaped red or pink bracts containing 1 female and several male flowers, with 4 glands; fruit, 7.5 by 9 mm, capsular; seeds, 5 mm long, ovate. Planted ornamental. 3(58681), 5, 6, 7.

Phyllanthus amarus Sch. & Th. "sleeping plant"
te kaimatu (K)
syn. *P. niruri* L. sensu auct. plur. non L.

Recent introduction. Trop. America (despite African type locality). Common. Erect to semi-prostrate, diffusely branched annual herb, somewhat woody at the base, 10 to 50 cm high; leaves, 4 to 10 mm long and 2 to 4 mm wide, numerous, crowded, simple but appearing pinnately compound, alternate, in two rows on opposite sides of the branchlets, oblong-elliptic or squarish, tip and base rounded, entire, green, lighter beneath, glabrous, subsessile; stipules, about 1.5 mm long, narrow-triangular; flowers, monoecious, minute, petal-less, greenish, borne in axillary cymules, on the branchlets, under the leaves, and containing 1 male and 1 female flower per node; calyx lobes 5, acute; pedicels 2 mm long; male flowers, with 3 stamens; female flowers, with a 3-celled ovary and 3 bifid styles; fruit, about 1.5 mm wide, solitary, capsular, 3-celled, depressed globose, glabrous, greenish to yellow-brown, borne on a stalk about 1.5 mm long, splitting at maturity into three 2-seeded segments; seeds, about 1.5 mm long, wedge-shaped, rounded dorsally, light brown, longitudinally 5- to 7-ribbed on back. Weed of gardens and waste places. 3(58685, 58733), 4(155N), 5(47), 6, 7, 8(9571).

Phyllanthus societatis Muell. Arg.
eoemangemang, ewemangemang, eoemangmang (N)

Indigenous. Polynesia and Micronesia. Common. Erect, or half-erect, branching shrub, up to 50 cm or taller; leaves, 0.6 to 2.5 cm long, alternate, simple but appearing pinnately compound, alternate, in two rows on opposite sides of the branchlets, sessile, mucronate, cuneate; flowers, monoecious, minute, petal-less, greenish, borne in axillary cymules; male flowers, numerous, slender stalked, sepals 6, oblong-ovate, having 6 alternate glands at base, stamens 3, filaments united; female flowers, mostly solitary, sepals 6, waxy white, ovary 3-lobed subtended by an entire glandular disc; fruit, 6 to 7 mm in diameter, depressed, splitting at maturity into three 2-seeded sections. Found as scattered individuals and small communities in unmined areas on plateau, on slopes around plateau, at base of escarpment and on coastal strip, around cemeteries, and occasionally in revegetated mined areas and as a pioneer plant on limestone pinnacles on the coastal strip. Straight main stems used as toy spears by children. 3(58595, 58748, 58801), 5(48, 51), 6, 7(22317), 8(9590).

Ricinus communis L. "castor bean", castor oil plant"

Recent introduction. Africa. Rare. Coarse, erect, branching, glabrous, semi-woody shrub, up to 3 m or higher, with spreading, hollow greenish or reddish stems and branches with well-marked nodes and leaf scars, watery sap, and a well-developed taproot; leaves, 10 cm to 75 cm in diameter, alternate, spirally arranged, round-ovate in outline, peltate, mostly deeply palmately 5- to 11-lobed, lobes sharply acuminate or acute, serrate, palmately nerved, green to somewhat purplish when young, paler beneath; petiole, 8 to 50 cm long, with 2 glands at apex; flowers, monoecious, small, petal-less in large terminal (appearing axillary) paniculate clusters (cymules), 10 to 35 cm long, with male flowers at the base and female flowers on the top; male flowers, with 3 to 5 calyx lobes, very numerous stamens variously connate in branching clusters; female flowers, with caducous, spathaceous calyx, ovary 3-celled, styles spreading usually bifid; fruit, 1 to 2 cm long, ovoid, capsular, softly spiny, green to purplish-brown, with three 1-seeded lobes, dehiscent; seeds, 0.5 to 1.5 cm long, oblong-ellipsoid, compressed dorsally, smooth, mottled with brown, black and grey or white, very oily. Weed of roadsides and waste places. 3, 4(137N), 5(145), 6, 7, 8.

Synadenium cupulare (Boiss.) Wheeler

Recent introduction. Trop. Africa. Rare. Large, succulent shrub, 1 to 1.6 m high, with thick cylindrical, thornless branches; leaves, 5 to 10 cm long, alternate, inverted ovate or obovate, thick, cuneate, taprring to a short petiole; flowers, small, red, borne in cyathia in axillary and terminal umbels, with a greenish-yellow gland. Pot plant at Cliff Lodge. 5, 6.

FABACEAE OR LEGUMINOSAE (Bean, Pea or Legume Family)

Acacia farnesiana (L.) Willd. "sweet acacia", "West Indian blackhorn", "cassie flower", "klu" (Hawaii) katin, debena (B)(N); te bakoa, te kai bakoa (K)
syns. *Mimosa farnesiana* L.; *Vachellia farnesiana* (L.) W. & A.

Pre-World War II introduction. Trop America. Occasional. Erect, much-branching shrub, up to 3 m or higher, the trunk and branches bearing numerous straight, slender stipular spines, 4 to 30 mm long; leaves, dark green, finely divided, bipinnate, with 2 to 6 (rarely 8) pairs of compound leaflets (pinnae), 1 to 4 cm long, each with 8 to 25 pairs of small leaflets, 3 to 6 mm long and 1 to 1.5 mm wide; flowers in pedunculate axillary heads, 1 to 3 heads together, peduncles, 1 to 3 cm long; flower heads, about 1.3 cm across, subglobose, yellow to yellow-orange, fragrant, stamens numerous; fruit, a pod, 5 to 8 cm long and 8 to 15 mm in diameter, plump, cylindrical or subterete, curved, dark brown to black, indehiscent; pulp, sweetish; seeds, compressed, elliptic, brown. Found in waste places and on roadsides. Glue made from seed pod. 2, 3(58640), 4(159N), 5, 6, 7, 8(9568).

Acacia sp. "acacia"

Recent introduction. Australia? Rare. Planted ornamental tree. 3(58699).

Adenanthera pavonina L. "red-bead tree", "false wiliwili" (Hawaii)
bin ("bean")(N); lopa (T)

Pre-World War II introduction? Malaysia. Common. Medium-sized, deciduous tree, up to 7 m or higher; leaves, bipinnate, with 2 to 8 pairs of compound leaflets (pinnae), each with 6 to 12 pairs of alternate leaflets, 2 to 5 cm long and 1 to 3 cm wide, ovate, obtuse, glabrous, rather pale green, thin; petiolules about 2 mm long; flowers, greenish-white to yellowish, sweet-fragrant, short-pedicellate, borne in slender, elongate axillary or aggregated terminal pedunculate racemose clusters, up to 15 cm or more long; calyx, campanulate, 4- to 5-toothed; stamens 8 to 10; fruit, a pod, up to 25 cm or longer and 2 cm wide, slender, flattened, linear at first, becoming falcately curved or contorted, brown, smooth and shiny inside, 2-valved, dehiscent, becoming spirally twisted after dehiscence; seeds, about 8 mm across, 10 to 12 per pod, lenticular, suborbicular, hard, very ornamental, dark or bright red. Spontaneous tree in escarpment and Buada forests and in older strip-mined areas. Seeds used in necklaces and eaten by children. 3(58804), 5(142), 6, 7.

Alysicarpus vaginalis (L.) DC. "alysicarpus", "one-leaved clover"
syns. *Hedysarum vaginale* L; *A. nummularifolius* (L.) DC.

Pre-World War II introduction. Paleotropics. Common. More or less prostrate, somewhat suffruticose hispid branching, spreading herb, with jointed stems up to 1 m or more long; leaves, 0.3 to 5 cm long and 0.2 to 3 cm wide, alternate, somewhat dimorphic, the proximal elliptic-subobovate, the distal narrower, lanceolate, rounded at the tips, obtuse or truncate at base; petioles, 1 to 8 mm long, slender; stipules, prominent; flowers, about 6 mm long, pinkish to reddish purple, short-pedicellate, borne in rather dense short terminal racemose clusters, up to 8 cm long, 6 to 12 flowers to a cluster; fruit, pods, 1 to 2.5 cm long, crowded, 5 to 7 seeded, cylindric, rugose, jointed, indehiscent, but breaking at the joints between seeds at maturity; seeds, about 1.5 mm long, oblong-oval, brown to pale brown or yellowish. Weed in open or semi-open places, along jeep tracks in unmined forest, and a pioneer plant in recently mined areas. 2, 3(58744, 58763), 4(115N), 5(88), 6, 7.

Bauhinia monandra Kurz "pink bauhinia", "orchid tree", "pink butterfly tree",
"St. Thomas tree"

Recent introduction. Burma. Occasional. Shrub or small tree, up to 5 m or higher, with a rounded crown, smooth gray bark and brown-hairy young growth; leaves, 7 to 20 cm long and wide, alternate, ovate-oblong in outline, cordate to rounded at base, palmately 3- to many-nerved, pubescent beneath when young, deeply divided at apex into 2 wing- or butterfly-like lobes which extend about a fifth to half way to the base, lobes obtuse to subacuminate; calyx, spathaceous or 5-lobed; flowers, orchid-like, up to 10 cm across, several together in terminal or axillary racemes; petals 5, erect or spreading (4 obovate, 1 ovate), each about 3 to 5 cm long and 2 to 3 cm across, white to pink with red or purple blotches or dots, the uppermost one with deeper red, yellow or yellow margined; fertile stamen 1, staminodes 5, small; pods, 15 to 18 cm long and about 3 cm wide, oblong or linear, flattened, leathery, rather shiny brownish or black; seeds, ovate, compressed, dull brown, free or separated by tissue or septa. Planted ornamental. 3(58785), 5, 6(224), 7.

Bauhinia variegata L "white bauhinia", "orchid tree", "butterfly tree", "purple orchid tree", "mountain ebony"

Recent introduction. India, Burma and China. Rare. Shrub or small tree, up to 8 m high; leaves, 5 to 14 cm long and wide, alternate, broadly ovate to suborbicular, cordate to truncate at based, palmately-nerved, split at apex into 2 wing-like lobes which extend about a third of the way or less to the base, lobes rounded; flowers, several together in terminal or axillary racemes; petals 5, obovate, 4 to 6 cm long and 2 to 3 cm across, the uppermost one broader, variable from pale purple to rose or white or yellow, with one petal variegated with red and yellow; fertile stamens 5, staminodes 5, about half as long as the stamens; pods, up to 30 cm long and 2.5 cm wide. The tree is variable with the two main varieties being *B. variegata* var. *variegata*, with pale purple to rose petals, with purple or crimson veins or blotches, and var. *candida* with white petals with green veins, and somewhat purplish on the exterior. Planted ornamental tree. 6(194), 7.

Caesalpinia bonduc Roxb. "beach nicker", "gray nicker", "nicker bean" dugienae, dogienae (N)

Indigenous. Pantropical. Rare. Scrambling to climbing shrub with long branches with sharp, recurved, hooked spines, young parts brown pubescent; leaves, 30 to 80 cm long, bipinnate with 6 to 12 pairs of pinnae; stipules pinnate, subpersistent, leafy, composed of 2 or 3 superimposed parts, caducous; leaflets (pinnae), 1.5 to 6.5 cm long and 0.5 to 3 cm wide, opposite or subopposite, ovate to elliptic-oblong, inequilaterally rounded or cuneate at base, obtuse to subacute at apex, slightly pubescent; petiolules, 2 to 3 mm long; flowers, about 1 cm long, numerous, in supra-axillary racemose clusters, calyx greenish brown, corolla yellow, pedicels at antithesis 6 to 12 mm long; pods, 4.5 to 9 cm long and 3 to 5 cm wide, oblong, inflated, prickly, dehiscent; seeds 1 or 2, about 1 to 1.8 cm in diameter, subglobose, smooth, glossy gray or olive green, very hard. Large shrub in coastal thicket and in overgrown garden on Command Ridge. 5(114), 6(158, 212, 269).

Caesalpinia pulcherrima (L.) Sw. "pride of Barbados", "dwarf poinciana", "Barbados flower fence"
syn. *Poinciana pulcherrima* L.

Recent introduction. Trop. America. Occasional. Shrub, up to 2 to 3 m tall, with branches bearing short, stiff, scattered prickles; leaves, up to 30 cm long, alternate, bipinnate, pinnae 4 to 8 pairs, each with 5 to 13 pairs of leaflets; leaflets, about 2 to 2.5 cm long and up to 1 cm wide, light green, elliptic, obtuse or with shallow notch at apex, obliquely inequilateral; flowers, on long pedicels in long terminal racemes, petals 5, 15 to 25 mm long, spreading, orbicular or oblong, crinkly-edged, usually long-clawed, scarlet to orange-red or red-and-yellow, usually with yellow wavy margins, or all yellow (var. *flava*); filaments, 5 to 7.5 cm long, mostly scarlet, longer than petals; pedicels, 2.5 to 10 cm long; pods, up to 10 cm long and 2 cm wide, coriaceous, oblong, smooth, brown to black, several-seeded, dehiscent; seeds, 6 to 8 per pod, brown, compressed, Planted ornamental. 3(58789), 5(38), 6, 7.

Cajanus cajan (Mill.) Millsp. "pigeon pea", "red gram", arhar dhal (Hindi)
syns. *C. indicus* Spreng.; *C. flavus* DC.; *Cystisus cajan* L.

Pre-World War II introduction. India and southeast Asia. Said to have been introduced in 1935, but not seen in 1978 or thereafter, but possibly re-introduced since then by expatriate Indian contract employees. Erect, short-lived, perennial pubescent shrub, 1 to 3 m or higher, with prominently ribbed stems and a pronounced taproot, sometimes grown as an annual; leaves, spirally arranged, pinnately trifoliate; leaflets, 2.5 to 12 cm long and 1.5 to 4 cm wide, elliptic to lanceolate, acute, dotted beneath with resin glands, grayish-green pubescent, soon glabrate above, finely silvery-pilose beneath, longer-stalked terminal leaflet usually larger than short-stalked laterals; petiole, grooved, about 2 to 8 cm long; stipules, ovate, hairy, about 4 mm long; flowers, about 2.5 cm long, in long-pedunculate terminal panicles, also axillary and subcapitate-racemose, subequal to the leaves in length; calyx 4-lobed, two upper lobes united (connate); corolla, 12 to 17 mm in diameter, petals, usually suborbicular, reflexed auriculate at base, bright yellow, marked with dark reddish-brown to crimson lines within and often flushed with brown to red without, wings yellow, keel yellow-green; pods, 4 to 10 cm long and 6 to 15 mm wide, linear-oblong, flattened, inflated, pubescent-glandular, pointed, with diagonal depressions between the seeds, often streaked with purplish black to reddish brown, tardily dehiscent; seeds, variable in shape and color, 2 to 8, up to 8 mm in diameter, globose, compressed, cream-colored to reddish or brownish or speckled with small white hilum, edible. Cultivated food plant.

Calopogonium mucunoides Desv. "calopogonium", "calopo"

Recent introduction. Trop. America. Rare. Slender creeping or twining perennial herbaceous vine, coarsely brown-tawny pubescent; leaves pinnately trifoliate; leaflets, petiolate, nearly equal in size, about 3 to 7 cm long and 2 to 6 cm wide, ovate to rhomboid, obtuse to apiculate-subacute at apex, densely pubescent; flowers, 7 to 10 mm long, axillary, short- to long-pedunculate, sessile or nearly so, medium to pale blue or slightly purplish, sometimes with proximal yellow blotches; pods 2 to 4 cm long and 3 to

5 mm wide, compressed-convex, slightly constricted between the seeds, coarsely pubescent; seeds 4 to 8, cube-like, flattened, about 3.5 by 3 by 2 mm, pale brown. Locally abundant weed in low ground around Buada Lagoon. Probably originally introduced as a green manure and nitrogen-fixing plant, but now naturalized. 3(58651), 6(153).

Canavalia cathartica Thouars "Mauna Loa bean" (Hawaii)
erekogo, irekogo (N); te kitoko (K); saketa (T)
syns. *C. microcarpa* (DC.) Piper; *C. turgida* Graham (of Burges list)

Indigenous. Pantropical. Occasional. Rather coarse creeping and high climbing herbaceous vine; leaves, about 20 cm long, alternate, trifoliate; leaflets, 8 to 15 cm long and 7 to 10 cm wide, ovate to acuminate, base rounded, obtuse, papery, whitish puberulent; flowers, 3 to 4 cm long, fragrant, short-pedicellate, few, borne on rather long, axillary peduncles up to 20 cm long, pedicels about 2 mm long; calyx, 5-lobed, about 14 mm long, white-puberulent, upper lip much shorter than calyx tube; corolla 5-petaled, pink to lavender, the wings and keel petals somewhat paler than the others; pods, 10 to 12 cm long and 3 to 4.5 cm wide, thick, inflated, indehiscent or tardily dehiscent, 3-angled on one edge, pointed, tan or brown; seeds, about 6, about 1.8 cm long, ovoid, slightly flattened, brown to dark reddish-brown, hilum 9 to 14 mm long. Climbing on trees in escarpment forest of Anibare. 2(49.5), 3(58737, 58800), 5(135), 6, 7.

Canavalia ensiformis (L.) DC. "Jack bean", "horse bean"
syn. *Dolichos ensiformis* L

Pre-World War II introduction. W. Indies. Reported by Schumann (1898) as collected by Finch, but not seen in 1978. Bushy erect annual herb, 1 to 2 m high, the tips of branches tending to twine; leaves trifoliate; leaflets, 6 to 15 cm long and 5 to 10 cm wide, ovate-elliptic, obtuse or shortly acute, shortly white puberulent especially on petioles and petiolules; petioles, stout, grooved above, usually longer than leaflets, terminal leaflet long-stalked, lateral leaflets short-stalked with unequilateral base; flowers, 2 to 2.8 cm long, short-pedicellate, borne on axillary peduncles of 10 to 50 flowers in groups of 3 to 5 on swollen pedicelar glands, pedicels 2 mm long; calyx, 14 mm long, 5-lobed, with 2 upper and 3 smaller lower lobes, puberulent, the upper lip only slightly shorter than the calyx tube; corolla 5-petaled, rose to violet; pods, 20 to 35 cm long and 2 to 3.5 cm wide, stout, somewhat compressed, pale tan or straw-colored when ripe, pendant, spirally dehiscent, ribbed near upper suture; seeds, 8 to 20, about 2 cm long and 1.3 cm wide, oblong, somewhat compressed, ivory white with brown scar, hilum about 9 mm long, pale brown with orange margin.

Canavalia rosea (Sw.) DC. "sea bean", "bay bean"
erekogo (N); te kitoko (K)
syns. *C. maritima* (Aubl.) Thouars; *C. obtusifolia* (Lam.) DC.

Indigenous. Pantropical. Rare. Prostrate, rather coarse trailing or weakly climbing glabrous or slightly pubescent herbaceous vine; leaves, alternate, trifoliate; leaflets, 6 to 12 cm and nearly as wide, fleshy-coriaceous, elliptic to suborbicular, subovate or subobovate, obtuse or slightly emarginate-notched at apex, base rounded, obtuse to acute, with pubescent appressed hairs; flowers, 2 cm to 3 cm long, short-pedicellate, in long-pedunculate axillary few-flowered racemes, up to 20 cm long, slightly shorter than the leaves; pedicel about 3 mm long; calyx 5-lobed, about 12 mm long, whitish-puberulent, upper lip much shorter than tube, lowest tooth 2 mm long; corolla, 5-petaled, about 3 cm long (standard), pink to purple, commonly with white blotch or yellowish proximally, the wings and keel petals pale magenta; pods, 8 to 15 cm long and 2 to 3 cm wide, broadly linear, inflated or only slightly compressed, spirally dehiscent, pale tan; seeds, about 1.8 cm long, elliptic, slightly compressed, brown with dark marbling, hilum about 7 mm long. Found in beach vegetation. 7(27804).

Cassia alata L. "golden candelabra bush", "Roman candle tree", "candle bush", "ringworm bush"
syn. *Senna alata* (L.) Roxb.

Recent introduction. Mexico. Rare. Coarse erect shrub or small tree, 2 to 5 m tall, with downy green branches and strong-smelling foliage and bark; leaves, 50 to 80 cm long, with 5 to 13 pairs of large leaflets; leaflets, 5 to 18 cm long and 3 to 9 cm wide, the distal ones largest, ovate-oblong, obtuse, truncate, or even slightly notched at apex, subsessile; stipules, obliquely deltoid, 6 to 16 by 3 to 10 mm; inflorescence, a striking long-pedunculate erect dense cone-like racemose spike, 15 to 60 cm long, bearing many crowded and overlapping flowers; calyx, 5-parted, sepals up to 16 mm long, yellow or orange; petals 5, 16 to 23 mm long, bright yellow, subtended by yellow or yellow-orange floral bracts; pods, 12 to 19 cm long and 2 to 3 cm wide, straight, widely ascending, sharply tetragonal, papery or leathery in texture, winged lengthwise down the middle of each valve; seeds, numerous, up to 60, flat. Planted ornamental; leaves widely used as a cure for ringworm, but reportedly not in Nauru. 5, 6.

Cassia fistula L. "golden shower tree", "Indian laburnum", "pudding-pipe tree"
te katia? (K)

Recent introduction. Trop. Asia. Occasional. Small to medium tree, up to 10 to 15 m or higher, with a short bole and spreading crown; leaves, with 3 to 8 pairs of leaflets; leaflets, 8 to 21 cm long and 5 to 9 cm wide, subsymmetrically ovate or elliptic, acute to subacuminate; inflorescence, 15 to 65 cm long, a drooping many (15 to 75)-flowered axillary raceme, resembling in size and shape a large bunch of grapes, often occurring 2 or 3 together; pedicels 3 to 6 cm long; calyx 5-sepaled; corolla, 4 to 6.5 cm across, 5-petaled, petals 1.6 to 3.2 cm long, bright golden yellow, subequal, shortly clawed; stamens 10, strongly accrescent (crescent-shaped) toward the abaxial side of the flower, the filaments of 3 long abaxial stamens sigmoidally arcuate, gradually and slightly thickened in the middle, and much longer than the anthers; pods, 30 to 60 cm long and 2 cm or less thick, cylindrical or narrowly terete, straight, smooth, hard-walled, dark brown, with seeds embedded in sweet, sticky, blackish pulp; seeds, many, up to 100, brownish. Planted ornamental. 3(58529, 58788), 5, 6, 7.

Cassia glauca Lam. "scrambled-egg tree?"
syns. *C. sulfurea* DC. ex Colladon; *Senna sulfurea* (DC. ex Colladon) Irwin & Barneby

Recent introduction. India. Rare. Small tree, 4 to 6 m high; leaves, up to 30 cm long with 4 to 7 pairs of leaflets; leaflets, up to 8.5 cm long and 3.8 cm wide, usually elliptic, paler beneath; inflorescence, a 7 to 15-flowered axillary raceme; pedicels, 2 to 4 cm long; calyx 5-sepaled, innermost sepal 8 to 11.5 mm long; corolla 5-petaled, petals, up to 23 to 30 mm long, ovate to oblong-obovate, bright yellow to orange-yellow; pod, 10 to 17 cm long and 1.3 to 1.8 cm wide, plano-compressed, brown; seeds, transverse, compressed parallel to valves. Planted ornamental. 6(170, 175), 7.

Cassia grandis L.f. "pink shower tree", "horse cassia"
te kasia? (K)

Recent introduction. Central America. Rare. Medium-sized tree up to 10 m or higher; leaves with 8 to 17 pairs of leaflets; largest ones 3.5 to 6.5 cm long and 1.2 to 2.5 cm wide, oblong, obtuse at apex; inflorescence, 8 to 27 cm long, a 20 to 45-flowered raceme, axillary or borne on branches, becoming obliquely geotropic from drooping branches; pedicels, 8 to 20 mm long subtended by bracts; bracts, 2 to 5 mm long, ovate, caducous as pedicels begin to elongate; corolla, 5-petaled, longest petals 8.5 to 11 mm long; pods, 40 to 90 cm long and 3.5 to 5 cm wide, massively linear-oblong, slightly laterally compressed, keeled dorsally by 1 and ventrally by 2 parallel blunt ribs; seeds, 14 to 16 mm long and 9 to 10 mm wide. Planted in home garden at Buada. 7.

Cassia occidentalis L. 'coffee senna", "arsenic bean"
tan braua ("sunflower")(N); te katia? (K)
syn. *Senna occidentalis* (L.) Link

Pre-World War II introduction. Trop. America. Abundant. Erect, branching fetid annual subshrub, up to 2 m high, with glabrous longitudinally grooved stems and often woody near the base; leaves, 11 to 24 cm long, alternate, pinnately compound, with 4 to 6 pairs of opposite leaflets; leaflets, 3 to 12 cm long and 2 to 4 cm wide, the terminal pair largest, elliptic or ovate-lanceolate, acute to acuminate, base inequalaterally rounded, entire, glabrous; petiole with conspicuous gland near base, petiolules 1 to 2 mm long; inflorescence, a short 1- to 5-flowered axillary or terminal raceme, each flower subtended by an acute, caducous bract; calyx deeply divided into 5 pinkish or brown-tinged sepals with rounded tips; corolla, 5-petaled, each petal about 9 to 16 mm long, obovate, yellow, drying whitish and brown-veined; pods, 6 to 15 cm long and 5 to 9 mm wide, erect or narrowly ascending, linear, flattened, glabrous, falcate, the margins somewhat thickened, purplish in colour with green margins turning brown; seeds, 15 to 50, about 3 mm long, ovate, brown, mostly with broad faces turned toward septa. Weed of waste places and roadsides. Dried seeds boiled as a tea substitute during World War II, a use learned from the Japanese; soft leaves cooked as a spinach and used medicinally by the Chinese. 2, 3(58529), 4(128N), 5(13), 6, 7, 8(9547).

Centrosema pubescens Benth. "centro"

Pre-World War II introduction. Trop. S. America. Extinct. Trailing or climbing herb, with slender pilose stems, often forming tangled mats; leaves trifoliate, petiolate, the terminal leaflet larger; leaflets, 3 to 9 cm long and 1.5 to 5 cm wide, ovate to elliptic, apex mucronate, base rounded, short-pilose but glabrate on both sides; inflorescence, compact, axillary, several-flowered pseudo-raceme, each flower subtended by bracteoles about 8 mm long and equal in length or smaller than calyx; flowers blue to purple or mauve with darker veins and a white or yellowish patch down the middle of largest petal (standard), the standard, up to 4 cm broad and 3 cm long, broadly orbicular, rather reflexed with a spur scarcely 1 mm long, pubescent without, the keel petals nearly as long as the wings; pods, up to 17 cm long and 7 mm wide, excluding persistent style, compressed, margins thickened, with 4 prominent ribs or wings near the sutures, dehiscent, the style often persistent as a beak; seeds, often about 20, 5 by 3 by 2 mm, oblong or subglobose, compressed, olive-green with red markings to red-brown with black streaks, hilum small. Reported in 1935 to have been introduced, but not seen in 1978 or thereafter. A widely used pasture legume and nitrogenous cover or green manure crop.

Cicer arietinum L. "chick pea", "garbanzo bean", "Indian gram", "common gram", "chana" (Hindi)

Pre-World War II introduction. W. Asia. Extinct. Erect or spreading, much-branched, annual herb, 25 to 50 cm tall, downy with all parts covered with clavate glandular hairs and with tetragonous stems and a well developed tap root; leaves, about 5 cm long, imparipinnate with 9 to 15 leaflets, yellowish-green to dark bluish-green; stipules, about 8 mm long, ovate, notched; leaflets, 0.8 to 2 cm long and 0.5 to 1.5 cm wide, opposite or alternate, ovate, elliptic or obovate, serrate; inflorescence, an axillary jointed peduncle, bearing solitary flowers, 2.4 to 4 cm long, borne on pedicels 5 to 10 cm long and slightly longer than peduncles; calyx, united with 5 teeth; corolla, white, greenish, pink, purplish red or blue, pink flowers fading to blue with age, standard (largest petal), 1 to 1.5 cm long, broad and clawed, wings free, keel incurved; stamens 10; pods, 1.5 to 3 cm long and 1 to 2 cm across, 1- to 2-seeded, oblong, swollen, beak obliquely placed, sometimes sterile; seeds, 0.5 by 1 cm in diameter, angular, oblong-obovoid, with pointed beak and small hilum, testa smooth, wrinkled or rough, ranging in color from white, yellow, red, brown to nearly black. Common food and fodder legume reported in 1935 to have been introduced, but not seen in 1978 or thereafter.

Clitorea ternatea L. "butterfly pea"

Recent introduction. Trop. America or Pantropical. Fast growing perennial climbing or sprawling herb with slender stems, up to 3 m long, and a woody rootstalk, young growth somewhat pubescent; leaves, alternate, compound, odd-pinnate, with 5 to 9 leaflets, one terminal; leaflets, 2 to 7 cm long and 1.5 to 4 cm wide, oblong to elliptic, obtuse, base acutish, apressed-pilose but subglabrate on both sides; petiolules, about 2 mm long; stipules, short linear; flowers, mostly solitary, sometimes paired in leaf axils on pedicels about as long as petioles; calyx, about 1.5 to 2 cm long, longish-tubular subtended by 2 conspicuous basal bracteoles and lobes about half as long as tube; petals large, up to 4 by 5 cm, the standard the largest, other petals very small; standard, erect, half-tubular, wavy-margined, bright vivid blue to violet with a pale yellow or white proximal blotch, finely puberulent dorsally, wings much shorter, also blue with pale basal parts; pods, 8 to 12 cm long awns 0.8 to 1 cm wide, linear-oblong, compressed, 2-valved, sharp-beaked, thick-margined and slightly broad-margined distally, apressed-pilose but subglabrate, dehiscent; seeds, 5 to 10, up to 8 by 4 by 2.5 mm, ellipsoid or subglobose, compressed, greenish to pale or dark brown with darker mottling, hilum small. Occasional. Planted ornamental. 3(58778), 5(71), 6(246), 7.

Crotalaria goreensis Guitl. & Pers. "rattlepod"

Recent introduction. W. Africa. Common. Erect subshrub, 50 cm to 1 m tall, branching below; leaves, alternate, long-petiolate, trifoliate; petioles, 2 to 4 cm long; stipules foliaceous, trifoliate, similar to, but smaller than leaflets, stipular leaflets, 3 to 8 mm long and 1 to 3 mm wide, stipular petiolules 3 to 8 mm long; leaflets, 1 to 4 cm long and 4 to 8 mm wide, the terminal leaf longest, narrowly elliptic, acute, obovate or slightly mucronate, base acute, light gray-green, glabrous; inflorescence, a leaf opposed peduncle, 3 to 7 cm long, bearing solitary flowers, pedicels about 1 to 2 mm long; calyx funnelform, about 2 mm long; corolla, yellow; pods, 1 to 1.8 cm long, 2-valved, oblong, inflated, beaked, dehiscent; seeds, small, about 3 mm long, club- or kidney-shaped, dark brown. Widespread weed of waste places, roadsides and other ruderal sites on coastal strip and on plateau. 3(58593, 58612, 58738), 4(106N),5(3, 58), 6, 7(22311), 8(9569).

Crotalaria retusa L. "rattlepod"

Recent introduction. Trop. Asia. Rare. Coarse short-lived subshrub or stiff herb, 40 to 100 cm high, with pilose ribbed stems; leaves, 4 to 8 cm long and 1.5 to 2.5 cm wide, simple, alternate, obovate-oblong to oblanceolate, rounded, emarginate or mucronate, cuneate at base, shortly-stalked, finely pubescent, the hairs minute and closely appressed; stipules, 1 to 5 mm long, subulate; petioles, about 3 mm long; inflorescence, a dense terminal many-flowered raceme, up to 30 cm long; flowers, 2 to 3 cm long, borne on short downward bent pedicels; calyx, 2-lipped, the upper deeply bifid, the lower 3-toothed; petals bright yellow, the standard, about 2 cm high and 3 cm wide, reflexed, yellow marked with purplish veins or blotches, the wings, about 1.5 cm long, yellow, almost hiding the keel, the keel with a short twisted beak; pods, 3 to 5 cm long and 1.3 to 1.8 cm wide, oblong-clavate, inflated, dehiscent, held horizontally, black when dry; seeds, about 20, about 4 mm long, yellowish or golden-brown. Weed of ruderal habitats and roadsides. 4(158N).

Crotalaria spectabilis Roth "rattlepod"
syn. *C. sericea* Retz.

Recent introduction. India and Paleotropics. Occasional. Erect robust, smooth-stemmed subshrub, up to 1 m or higher, leaves, 5 to 13 cm long, obovate, oblanceolate or sometimes spoonshaped, base acuminate or cuneate, shortly petiolate, glabrous above, with soft silky hairs (villose) below; stipules sessile and persistent; inflorescence, a loose peduncle, 30 cm or longer, bearing 20 or more flowers; flowers, 2.5 cm or longer, bright yellow or purple?; floral bracts, leaflike, oval or cordate; calyx, about 12 mm long, glabrous, cleft more than halfway to the base; pods. 2.5 to 5 cm long, 2-valved, bladder-shaped, glabrous, containing a small number of seeds, which at maturity become loose in the pod. Weed near Buada Lagoon, in gardens, and near coast in Nibok; occasionally cultivated in home gardens. 3(58647), 4, 6, 7, 8(9579).

Cyamopsis tetragonoloba (L.) Taub. "cluster bean", "guar" (Hindi)
syns. *C. psoraloides* (Lam.) DC.; *Psoralea tetragonoloba* L.; *Dolichos psoraloides* Lam.

Pre-World War II introduction. India. Extinct. Robust bushy annual, 1 to 3 m high, with stiff, erect, angled, grooved, white-pilose branches; leaves, alternate, trifoliate; leaflets, ovate, sparsely serrate; inflorescence, a dense axillary raceme bearing 6 to 30 solitary flowers in axils of caducous bracts; calyx, cupuliform, oblique, the lowermost tooth the longest; petals 5, strongly veined, the standard, about 8 mm long, obovate, not clawed, white, the wings, oblong free from the keel, pinkish, the keel petals erect, slightly gibbous or short-calcarate; pods, 4 to 10 cm long, linear, compressed, with a marked beak, a double ridge on the dorsal side and a single ridge on the ventral side, septate between the seeds, dehiscent, borne in stiff erect clusters; seeds 5 to 12, about 5 mm long, compressed-oval, white to gray or blackish. Cultivated food plant, the young tender pod which are cooked as a vegetable; reported in 1935 to have been introduced, but not seen in 1978 or thereafter.

Delonix regia (Bojer) Raf. "poinciana", "royal poinciana", "flame tree", "flamboyant", "flame of the forest" bin ("bean"), red tree (N); te tua (K); fuatausaga (T)

Pre-World War II introduction. Madagascar. Occasional. Rapidly growing, medium-sized, spreading, broad-crowned deciduous tree, up to 10 to 12 m high and several times as wide, with smooth, light-colored bark; leaves, mostly 20 to 60 cm long, alternate, bipinnate, frond-like, with 10 to 20 pairs of pinnae; pinnae, about 10 cm long, each with 25 to 35 pairs of leaflets; leaflets, 0.5 to 1 cm long, opposite, oblong-elliptic, obtusish, base oblique, subsessile, glabrous, medium green; stipules, inconspicuous, forked at base, the divisions pinnate, with 3 to 6 leaflets; inflorescence, an axillary corymbose-raceme bearing large, showy flowers, 7.5 to 10 cm across, aggregated near ends of branchlets; bracts, small, caducous, bracteoles none; calyx, short-tubed, sepals 5, valvate, subequal, free at antithesis; petals 5, about 4 to 7 cm long, subequal in size, brilliant crimson to scarlet or red-orange, conspicuously clawed, imbricate (overlapping), the uppermost with whitish or yellowish streaks or mottling, broad-bladed and stalked with their distal part abruptly expanded, orbicular with wavy edges; pods, 13 to 60 cm long and 3 to 5 cm wide, linear-oblong, parallel-edged, flattened, shortly-beaked at tip, woody or coriaceous, pendent, septate, dark reddish-brown turning black, filled within between the seeds, many-seeded, persistent, dehiscent; seeds, oblong-cylindric, transverse, gray with pale margins, testa hard. Planted ornamental; flowers used in garlands. 3(58620), 5(121), 6, 7.

Derris trifoliata Lour. "beach derris root", "beach poison vine"
syns. *Derris uliginosa* Benth.; *Robinia uliginosa* Willd.

Indigenous. Trop. Africa to Polynesia. Occasional. Glabrous creeping and climbing shrub with prostrate rooting stems and rather large, scattered lenticels, climbing to a height of 5 to 6 m; leaves, alternate, 3 to 7-foliate; leaflets, 4 to 12 cm long and 2 to 6 cm wide, ovate to elliptic-ovate, acute-acuminate or cuspidate at apex (acumen rounded or emarginate at tip), base obtuse or rounded-subtruncate, subcoriacious, rather glossy medium-green, slightly paler but not glaucous dorsally, the secondary nerves prominulous beneath, petiolate; petioles, 4 to 8 mm long; inflorescences, axillary short-pedunculate racemes bearing flowers on short slender pedicels; calyx, 2 to 3 mm long, pale green; corolla, 6 to 8 mm long, petals, pale pink or greenish-white and faintly pink-tinged; the filaments and styles white; pods, 3 to 5 cm long and 2 to 3.5 wide, subreniform or subrhomboid to broadly oblong, flat, with a wing, 1 to 2 mm broad, along the upper suture, greenish or tan, conspicuously veiny, 1- to 2-seeded; seeds, 1.5 to 2.4 cm long, oblong-reniform. In forest on cliffs and steep slopes of escarpment surrounding the central plateau. No reported use in Nauru, although the roots, which contain rotenone, are often used for fish poison throughout the Pacific. 3(58803), 6.

Desmodium tortuosum (Sw.) DC. "Florida beggarweed"
syns. *D. purpureum* (Mill.) Fawc. & Rendle; *Hedysarum purpureum* Mill.; *H. tortuosum* Sw.

Recent introduction. W. Indies and Central America. Common. Erect subshrub or annual, somewhat woody (ligneous), branching herb, up to about 2 m high, with slender densely and finely pubescent longitudinally grooved stems; leaves, alternate, trifoliate; petioles, often reddish; stipules, asymmetrical, distinctly auriculate at base on side away from petiole (and less obviously on side toward petiole), acuminate from a broad base, sometimes reflexed, persistent; leaflets, 2.5 to 13 cm long and 1.5 to 7 cm wide, the terminal leaflet largest, narrowly elliptic to ovate, acute to mucronate, base acute to rounded, laxly pilose with long hairs and/or short, uncinate hairs; inflorescences, simple or branching racemes, 20 to 50 cm long; calyx, deeply 5-lobed, densely pubescent, borne on a thin pedicel, 5 to 17 mm long, with many basally thickened hairs; corolla, 4 to 5 mm long, pea-like (papilionaceous), white or greenish-yellow to pink shading to mauve; stamens 10, diadelphous; pods, 1.5 to 3 cm long, twisted, brown, segmented, each segment (article) 3 to 6.5 mm long and 3 to 4 mm wide, the articles suborbicular, the isthmi comparatively narrow, about one-fourth as broad as articles, 2- to 7-seeded, each seed in a separate compartment which separates at maturity; seeds, compressed. Weed on roadsides, on slopes in settled areas, and in waste places. 3(58639, 58741), 4(110N), 5(87), 6, 7(22308).

Desmodium triflorum (L.) DC. "tropical trefoil", "three-flowered beggarweed"
syn. *Hedysarum triflorum* L.

Recent introduction. Pantropical. Occasional. Diminutive prostrate freely-branching perennial creeping herb with slender stems with appressed or weakly spreading hairs, up to 1 mm long, and a woody rootstalk, commonly forming a thick mat; leaves alternate, trifoliate, clover-shaped, lower leaves sometimes unifoliate; stipules symmetrical at base, lanceolate, acuminate; leaflets, 4 to 10 mm long and almost as wide, terminal leaflet largest, sometimes bearing 2 white marks, obovate to elliptic-obovate or obocordate, rounded (obtuse) and usually distinctly (but slightly) emarginate, base narrowed to a short petiolule; inflorescence, a lax, 2- to 3-(rarely 5)-flowered fascicle (occasionally solitary), up to 6 cm long, borne opposite the leaves, each fascicle subtended by a soon caducous primary ovate-acuminate, not congested bract,; pedicels or peduncles, 3 to 10 mm long, lengthening in fruit to over 1 cm, puberulent with straight or weakly spreading hairs, 0.7 to 1 mm long, or glabrous; calyx, appearing subequally 5-lobed, lobes shallowly connate at base for less than half their length; petals pale or rich pink to reddish-violet, the standard obovate, 4 to 5 mm long; pods, 6 to 20 mm long and about 2.3 mm broad, indented on the lower suture, segmented into 2 to 5 articles, each 2 to 4 mm long and broad, indehiscent, with only uncinate hairs, the isthmi two-thirds to three-quarters as broad as the articles; seeds, bean-shaped (reniform). Weed in gardens, lawns and in shaded ruderal habitats on plateau. Possibly deliberately introduced as a green manure and cover crop. 3(58708, 58803), 4(126N), 5(148), 6, 7.

Dolichos lablab L. "hyacinth bean", lablab bean", "dolichos", "bovanist bean", "Egyptian bean", "Indian bean", "bataw or batani bean (Philippines)
syns. D . *purpureus* L.; *Lablab purpureus* (L.) Sweet; *L. niger* Medik.; *L. vulgaris* Savi; *L. cultratus* DC.

Recent introduction. Paleotropics. Rare. Vigorous perennial, glabrous or finely pubescent twining or scrambling herbaceous vine, from 1.5 to 6 m long or high, all parts often flushed with purple; leaves, alternate, trifoliate; petioles, 6 to 26 cm long; leaflets, 5 to 15 cm long and nearly as wide, entire, broadly triangular ovate, lateral leaflets oblique, acute-acuminate, base obtuse, subglabrous or softly pubescent, 3-nerved from base, midrib branched upward, the terminal leaf longer stalked; inflorescences, erect, terminal and axillary peduncles, 5 to 40 cm long, bearing pseudoracemose clusters of 1 to 5 flowers together at nodes along the peduncle, each about 1.5 cm long, on slender pedicels up to 1 cm long; bracts and bracteoles, 2 to 5 mm long, caducous; calyx, about equal in length to the pedicels, 4-lobed, campanulate, bilabiate, the 2 upper lobes joined into an entire or emarginate lip, the lower lip 3-lobed; petals, small, violet or whitish, the standard up to 14 mm long and 20 mm across, orbicular, reflexed, auriculate at base, the wings obliquely obovate, longer than the keels, the keel petals incurved at a right angle, obtuse with a small convex pocket at base; stamens 10; pod, 6 to 12 cm long by 2 to 4 cm wide, 2-valved, obliquely oblong, flattened, often curved, beaked at tip with persistent style; seeds, 3 to 6, usually not larger than 15 by 9 by 5 mm, ovoid, slightly compressed, dark brown, reddish or pale tan or white, often speckled, the hilum linear with whitish rim-aril. Food plant in Filipino gardens at Location; the young pods and tender seeds cooked as a vegetable. Said to have been introduced in 1935 and established by 1936. 5, 6.

Erythrina variegata L. var. **variegata** "variegated coral tree"

Recent introduction. Pacific Is. Rare. Differs from *E. variegata* var. *orientalis* (see description below) in having narrower, more leathery leaves, which are mottled or variegated with light yellow along the midribs and side veins, and larger lighter-colored flowers in longer erect clusters. Planted ornamental. 3, 5(39), 6, 7.

Erythrina variegata var. **orientalis** (L.) Merr. "coral tree", "dadap"
yora, yoreh (N)
syns. *E. indica* Lam.; *E. corallodendron* var. *orientalis* (L.) Merr.

Indigenous. Indopacific. Occasional. Medium to large deciduous tree, up to 25 m high, the trunk and branches usually with coarse spiny thorns; leaves, alternate, trifoliate, membranous, rachis not including the petiole 12 to 40 cm long; petioles, 9 to 20 cm long; leaflets, 6 to 30 cm long and nearly as wide, broadly triangular-ovate, rhombic or cuspidate, acute-acuminate, rounded, acutish or truncate at base, lower leaflets somewhat oblique, with prominent glands below the base of petiolules; petiolules, 5 to 14 mm long; inflorescence, a dense axillary or terminal pedunculate raceme, up to 40 cm long, bearing numerous flowers, about 6 cm long, clustered near the end of the raceme; calyx tube in bud closed at orifice, early broken by the emergent corolla; petals, bright dark red or scarlet, very unequal, the standard 5 to 8 by 2 to 3.5 cm, broadly elliptic, narrowed proximally to a short claw, the keel petals separate, obovate, rounded at apex, nearly as long as the wings, these obovate, rounded, about one-third as long as the standard; pod, 10 to 45 cm long and 2 to 3.5 cm in diameter, not or slightly constricted between the seeds, the valves coarsely reticulate-veined, glabrous, black, tardily dehiscent; seeds, 1 to 12, 1.2 by 2.5 cm, ovoid, bright red to brownish red, the hilum oblong. Planted or spontaneous on coastal strip and in old strip-mined land; a number of large specimens along road near Nauru Phosphate Company tennis court area. Trunks and thick branches used for living fence posts, and in canoe construction in the past; flowers used in garlands in the past. 3(58737a), 5, 6, 7.

Gliricidia sepium (Jacq.) Kunth ex Walp. "gliricidia", "madre de cacao (mother of cocoa)", "Nicaragua cocoa shade"
syn. *Robinia sepium* Jacq.

Recent introduction. Central and northern So. America. Small semi-deciduous fast-growing tree, up to 10 m tall, with pale bark and ascending stems; leaves, 15 to 25 cm long, imparipinnate, with 5 to 17 leaflets; leaflets, 3 to 8.5 cm long and 1.5 to 5 cm wide, opposite, ovate, ovate-oblong to elliptic-oblong, obtusely acuminate, often with brown blotches or bronzy and glaucous beneath, dull green above, glabrate; inflorescences, stiff short racemes, 5 to 13 cm long, on the older branches after the leaves have fallen, bearing single flowers, each about 1.8 to 2 cm long, on the rachis; bracts, small, bracteoles none; pedicels, 8 to 12 mm long, jointed at tip; calyx, cupuliform, puberulent, red-tinged; petals 5, rose or paler pink, the standard, large, suborbicular, reflexed, sometimes with small inflexed auricles, claw very short, with a pale yellow central blotch, the wings falcate-oblong, free, shorter than the keel, the keel petals incurved, sometimes partly yellowish; stamens, 10, the filaments of 9 connate into the sheath; pods, 8 to 16 cm long and 1.5 to 1.9 cm wide, 2-valved, linear-oblong, flattened, non-partitioned, dehiscent, the valves coriaceous; seeds, 2 to 9, purplish-brown. Planted roadside ornamental on Meneng Terrace. Widely used in tropical America and elsewhere as a shadetree for tree for cocoa, bananas and coffee and as a living fence and windbreak. 7(22320).

Hardenbergia violacea (Schneev.) F.C. Stern "sarsaparilla"

Recent introduction. Australia. Rare. A climbing or scrambling evergreen herb; leaves, simple; inflorescence, clusters of violet flowers with yellow markings. Ornamental pot plant. 6.

Indigofera hirsuta L. "hirsute indigo"

Recent introduction. Africa and Madagascar to southern Asia and Australia. Occasional. Erect or low spreading shrub, up to 1 m tall, stiffly and copiously brown-hirsute with long hairs and woody at the base; leaves, imparipinnate with 5 to 7 leaflets; leaflets, up to 4.5 by 2.5 cm, opposite, elliptic-obovate, densely pilose on both sides; inflorescence, a dense raceme, 20 to 30 cm long, the peduncle, 2.5 to 8 cm long, both peduncle and pedicels brown pubescent; calyx about 4 mm long, divided nearly to base with linear-setaceous lobes, brown pubescent; corolla, small, with brick-red to salmon-red or rose-colored petals; pods, 1.2 to 2 cm long and about 2 mm in diameter, straight, cylindrical, somewhat tetragonal, with spreading dark brown hairs; seeds, 6 to 9, nearly square or rectangular in outline. In plateau forest along path. 3(58614, 58730), 5(136), 8(9545).

Indigofera spicata Forssk. "creeping indigo"
syns. *I. hendecaphylla* Jacq.; *I. endecaphylla* Jacq. ex Lam. (sphalm?)

Recent introduction. Africa and Madagascar to Yemen, southeast Asia and Australia. Occasional. Spreading or prostrate annual herb, with stems sometimes ascending to 60 cm; leaves imparipinnate with 5 to 11 leaflets (usually 7); leaflets, 3 to 30 mm long, alternate or rarely opposite, elliptic to obovate, apex mucronate, shortly petiolate; inflorescence, an axillary raceme, up to 15 cm long, the peduncle 1 to 4 cm long, the pedicels, about 0.5 mm long; calyx, 2 to 3 mm long, divided nearly to the base; corolla, 4 to 5 mm long, salmon pink; pods, 11 to 25 mm long and about 2 mm in diameter, straight, cylindrical, appressed-strigulose or pubescent; seeds, 5 to 8. Roadside weed on coastal strip and plateau. 4(123N), 6, 7.

Leucaena leucocephala (Lam.) de Wit "leucaena", "koa haole"(Hawaii), "lead tree", "wild tamarind" bin ("bean")(N); te kai tetua (K)

syns. *L. glauca* (L. ex Willd.) Benth.; *Mimosa leucocephala* Lam.; *Mimosa glauca* sensu L.; *Acacia leucocephala* (Lam.) Link

Pre-World War II introduction. Trop. America. Common. Erect slender shrub or small tree, 1 to 5 m high, young growth puberulent; leaves, alternate, bipinnate, to 25 cm long, with 3 to 10 pairs of opposite pinnae, 5 to 10 cm long, each with 7 to 20 pairs of leaflets; petioles, up to 10 cm or longer; leaflets, 6 to 19 mm long and 1.5 to 5 mm wide, opposite, lanceolate to oblong-lanceolate, acute, asymmetrical, inequilateral at base, sessile, somewhat dull grayish-green, glabrous; flowers, 1.5 to 3 cm in diameter, in dense, axillary globose, head-like, pedunculate clusters; peduncles, up to 4 to 6 cm long; calyx, 2.5 mm long, tubular, short-dentate with 5 small lobes at top; petals 5, 4 to 5 mm long, linear, free, pale green or white; stamens, 10, nearly 1 cm long, long-exserted, filaments white, anthers hairy, pale yellow; pods, 8 to 20 cm long and 1 to 2.2 cm wide, clustered, 2 -valved, strap-shaped, linear, flat, beaked at apex, not septate, dark brown, more or less dehiscent; seeds, 15 to 25, about 6 mm long, transverse, oval-oblong, flat, glossy brown. Spontaneous in disturbed habitats on escarpment slopes below plateau and in isolated stands on coastal strip. Used as firewood. 3(58638), 4(161N), 5(9), 6, 7, 8(9564).

Mimosa pudica L. var. **tetrandra** (HBK ex Willd.) DC. "sensitive plant"
syn. *M. tetrandra* HBK ex Willd.

Recent introduction. Trop. America. Rare. Decumbent or prostrate subwoody, loosely branching perennial creeper, up to 50 cm high, with reddish-brown stems bearing scattered curved prickles; leaves, alternate, bipinnate, with 1 to 3 pairs of pinnae, palmately arranged at the end of the rachis, each with 12 to 25 pairs of leaflets; leaflets, 6 to 15 mm long and 1.2 to 3 mm wide, linear or oblong, acute, asymmetrical, sessile, bristly, sensitive with leaves immediately folding at pulvinate joints if touched or jarred; flowers, 1 to 2 cm in diameter, in small globose, head-like, axillary pedunculate clusters; peduncles, up to 2.5 cm long, hairy; calyx, absent or very small; corolla, 4-lobed, sympetalous, very small; stamens 4, 4 to 6 mm long, showy, rose-pink to purple; pods, 0.8 to 2 cm long and 2 to 4 mm wide, clustered, thin, flat, prickly-bristly, indented between the seeds, splitting at maturity from the undivided margins into 2 to 5 one-seeded segments; seeds, 2 to 5, about 2 mm across, rounded, brown. Roadside weed near Buada Lagoon. 4(156N), 6(190).

Peltophorum pterocarpum (DC.) Backer ex Heyne "yellow poinciana", "copperpod", "golden flamboyant", "yellow flame tree"
syns. *P. inerme* (Roxb.) Naves; *P. ferrugineum* (Dcne.) Benth.; *Inga pterocarpa* DC.; *Caesalpinia inermis* Roxb.; *C. ferruginea* Dcne.

Recent introduction. Malaysia to N. Australia. Rare. Medium-sized, heavily-foliaged, broad-crowned tree, 8 to 15 m high; leaves, bipinnate, 30 to 50 cm long, rachises brown puberulent, with 4 to 15 pairs of pinnae, each with 8 to 20 pairs of leaflets; stipules small, caducous; leaflets, about 0.8 to 3 cm long and 3.5 to 10 mm wide, opposite, oblong, rounded or emarginate, base oblique, dark green; flowers, each about 2.5 cm across, fragrant, borne in large terminal racemes aggregated into panicles; bracts, lanceolate, bracteoles none; bracts, buds and axes brownish-reddish pubescent; calyx tube short, 5-lobed, lobes imbricate; petals, 1 to 2 cm long, orbicular to ovate, slightly unequal, imbricate with frilly margins, subequal, bright yellow; stamens 10, free, the filaments curved; pods, 5 to 11.5 cm long and 2 to 2.7 cm wide, 2-valved, oblong-lanceolate, flattened, straight or curved, slightly winged along both margins, copper-colored, red-brown or brown when ripe, blackening eventually but persistent on the tree, veiny on the sides, indehiscent; seeds, 1 to 4, transverse, oblong, flattish, pale brown. Planted ornamental tree on Military Ridge. 5, 6.

Samanea saman (Jacq.) Merr. "rain tree", " monkeypod tree"

syns. *Albizia saman* (Jacq.) F. v. Muell.; *Mimosa saman* Jacq.; *Enterolobium saman* (Jacq.) Prain ex King; *Pithecellobium saman* (Jacq.) Benth.; *Inga saman* (Jacq.) Willd.

Recent introduction. Trop. America. Rare. Large to massive tree, 7 to 25 m high, the trunk up to 1 m in diameter, the crown rounded, usually broader than tall; leaves, bipinnate, with 2 to 9 pairs of pinnae, each with 2 to 10 pairs of leaflets; leaflets, 2 to 8 cm long and 1 to 4.5 cm wide, the distal ones larger than the proximal ones, ovate to obovate or oblong-elliptic, asymmetric, subsessile, shining above, downy beneath, folding (closing) in late afternoon for the night and in cloudy or rainy weather; flowers, in axillary long-pedunculate heads, the central flower larger than the others; calyx, 6 to 7.5 mm long, short lobed; corolla, up to 13 mm long, petals connate up to the middle, pink with greenish or yellowish lobes; stamens many, 2 to 4 cm long, basally connate, exserted, white proximally, shading to pink or crimson distally; pods, 9 to 24 cm long, 1.3 to 2.2 cm wide and 1.5 to 2.5 mm thick, straight or slightly curved, thick but compressed, semi-succulent, internally septate, with thickened sutures, brown turning black when mature, indehiscent, containing sweet, sticky brown pulp within; seeds 15 to 20, exarillate, brown. Ornamental tree in home gardens on Meneng Terrace and at Buada. 5, 6, 7.

Vigna marina (Burm.) Merr. "beach pea"

erekogo (N); te kitoko (K); saketa (T)

syns. *V. lutea* (Sw.) A. Gray; *Phaseolus marinus* Burm.; *Dolichos luteus* Sw.

Indigenous. Pantropical. Common. Prostrate, creeping, sometimes climbing, subglabrous, weak-stemmed, long-trailing herbaceous perennial vine; leaves, alternate, trifoliate; stipules, 2 to 3 mm long, ovate to lanceolate, inconspicuously bilobate at base, early caducous; petioles, 5 to 10 cm long; leaflets, 4 to 10 cm long and 3 to 8 cm wide, broadly ovate or suborbicular to obovate, apex rounded to emarginate, base obtuse, 3-nerved from base, midrib branched upward, lateral leaflets somewhat oblique, inconspicuously appressed-pilose on both surfaces but soon glabrate, somewhat fleshy; flowers, 1.5 to 2 cm long, short-pedicellate, in few-flowered racemose clusters crowded distally on axillary peduncles, up to 15 cm or longer; petals and stamens, pale to bright yellow, the standard usually 12 to 14 mm in diameter, obovate, the keel not much longer than other petals, incurved for about half a complete turn or less; pods, 4 to 8 cm long and 5 to 7 mm wide, linear-oblong or subcylindrical, slightly curved, inflated, slightly contracted between the seeds, splitting open along the two sides when mature, green turning brown; seeds, 2 to 10, up to 7 by 6 by 5 mm, ellipsoidal, brown, with an oblong hilum and undeveloped rim-aril. Found on beaches and in open sites and waste places behind beaches; reported by Burges (1935) to be "growing plentifully wherever soil is fairly heavy and moist, e.g., as at Buada. The natives have always considered that other plants grew better if near *Vigna* . . .." Plant used medicinally; leaves crushed to bathe young girls' hair and to make adult hair grow long and black; leaves used to cover earthen oven. 1(30.R), 2, 3(58610), 4(120N), 5(33), 6, 7, 8.

Vigna unguiculata (L.) Walp. ssp. **sesquipedalis** (L.) Verdc. "long bean", "yard-long bean", "snake bean", asparagus bean", "asparagus pea"
bin ("bean")(N); te bin ("bean")(K); tau kok (C)
syns. *V. sesquipedalis* (L.) Fruw.; *Dolichos sesquipedalis* L.; *Vigna sinensis* (L.) Endl. ex Hassk. var. *sesquipedalis* (L.) Koern.

Pre-World War II introduction. Trop. Africa. Twining, climbing annual herb with glabrous stems, up to 2 to 4 m high; leaves, pinnately trifoliate; stipules, large, produced below the base attachment, more or less persistent; leaflets, 5 to 16 cm long and 4 to 11 cm wide, the terminal leaflet with a long petiolule, ovate to rhombic-ovate, acute, entire or sometimes inconspicuously lobed, the veins sometimes purplish; inflorescence, an axillary long-pedunculate few-flowered raceme, with flowers in clusters of 3 to 6; the bracts and bracteoles small, caducous; pedicels, short, shorter or about as long as the calyx; calyx, campanulate, bilabiate, the two upper lobes completely or partly united, the lower lip 3-lobed; corolla, much exserted, petals, white or greenish, tinged with yellow, blue or purple, the standard orbicular with inflexed auricles, the wings slightly shorter than the standard, the keel petals about as long as the wings or longer, obtuse or beaked, sometimes incurved, truncate; stamens 10, alternately slightly longer and shorter, the filaments of 9 connate into a sheath, the vexillary filament free, the anthers uniform; pods, variable depending on the cultivar, 20 to 100 cm long and 0.3 to 1.1 cm broad, pendent, linear, subterete, straight or somewhat inturned or twisted, sometimes rather flaccid, not septate, more or less inflated and sometimes flabby when young, dehiscent, the style dehiscent; seeds, many, usually 8 to 12 mm long, elongate reniform, variable in color. Common. Food plant in Chinese gardens at Location and Topside workshops. 5, 6.

GENTIANACEAE (Gentian Family)

Fagraea berteroana A. Gray ex Benth. pua (Polynesia); "pua kenikeni" (Hawaii)
eijinut? (B)(N)
syns. *Carissa grandis* Bertero ex. Guill.; *Fagraea berteriana* A. Gray ex Benth.; *F. berteriana* Benth. ex Seem.; *F. grandis* Pancher & Sebert

Indigenous? Pacific Islands, from New Caledonia to as far east as the Marquesas and Hawaii, although possibly an aboriginal introduction in these areas. Extinct; reported by Hambruch in 1910, but not seen in 1933 or thereafter. Medium to large glabrous, often-branching tree, 1.5 to 20 m high, branches with conspicuous leaf scars; sometimes a scrambling, climbing or epiphytic shrub; leaves, up to 15 cm long and 8 cm wide, opposite, oval-ovate or oblong, rounded, obtuse or sub-acute-acuminate blunt, base cuneate or decurrent, entire, rather thick, pinnately nerved, midrib stout, lateral veins slender and obscure; petiole, up to 2.5 cm long; flowers, nearly 5 cm wide, very fragrant, fleshy, in axillary cymose clusters; calyx, 12 to 15 mm long, rather deeply-lobed; corolla, 5-parted, tubular, the tube 3 to 5 cm long, the lobes imbricate spreading, overlapping to the right, creamy-white turning yellow; style greenish; fruit, 3 to 5 cm long and 2 to 4 cm wide, ellipsoidal, obtuse to acute at apex, rather succulent, yellow turning orange to bright red when ripe; seeds, very numerous, embedded in pulp. Fragrant flowers used in garlands and to scent coconut oil in Polynesia and Melanesia. 1.

GERANIACEAE (Geranium Family)

Pelargonium × hortorum "geranium", "fish geranium"
syn. *P. hortorum* Bailey

Recent introduction. So. Africa. Rare. Tender perennial subshrub, up to 50 cm high; leaves, 7 to 13 cm in diameter, rounded, scalloped, downy; flowers, not seen. Pot plant. 6.

GESNERIACEAE (Gloxinia Family)

Columnea gloriosa Sprague "showy column flower", "columnea"

Recent introduction. C. America. Rare. Trailing or pendent perennial herb, stems up to over 1 m long; leaves, about 2.5 cm long, pale green, pubescent; flowers, 3.5 to 7.5 cm long, borne on weeping stems, solitary; calyx, about 1.5 cm long, deeply 5-

parted; corolla, showy, bright scarlet with a yellow throat and underside of tube. Pot plant. 6.

Columnea sp. "columnea"

Recent introduction. Trop. America. Rare. Pot plant. 6.

Episcia cupreata (Hook.) Hanst. "episcia", "peacock plant"
syn. *Achimenes cupreata* Hook.

Recent introduction. Colombia and Venezuela. Occasional. Spreading or creeping pilose perennial herb with long stolons and short, stout stems, rooting at the joints, up to 30 cm or higher; leaves, 10 to 13 cm long to 6 to 8 cm wide, including the petiole, blade about 7.5 cm long, opposite, broadly elliptic to ovate, edges scalloped, pinnately-nerved, succulent, hairy, variable in color from coppery to reddish green or clear green, often variegated; flowers, about 2.5 cm long, axillary, solitary, borne on long pubescent peduncles; calyx, deeply 5-lobed; corolla, much larger than calyx, tubular, with 5 subequal, rounded lobes spreading to about 2 cm in diameter, tube red on upper surface, yellow with red spots on lower surface and within, the limb orange-red, the 3 lower lobes the longest; fruit, a 2-valved capsule; seeds, ellipsoid, smooth, brown. Pot plant. 5,6.

Saintpaulia ionantha Wendl. "African violet", "Saintpaulia"

Recent introduction. Trop. E. Africa. Rare. Stemless perennial pubescent herb; leaves, 3.5 to 8 cm long and wide, long-petiolate, alternate to subopposite, suborbicular to oblong-ovate, succulent, velvety, edges scalloped, often purplish beneath, forming a rosette or broad tuft of leaves at the base; petioles, pilose; inflorescences, axillary, 2- to 10-flowered cymose peduncles, rising above the leaves; calyx, deeply 5-lobed, the lobes linear or lanceolate, erect; corolla, 2 to 3.5 cm across, rotate to broadly campanulate, much longer than the calyx, the tube short, the limb 5-lobed, 2-lipped, the upper lip 2-lobed and shorter, color variable depending on the cultivar, white or pink to violet, dark purple or blue; fruit, about 7 mm long, longer than the calyx, a narrow-oblong to subglobose capsule, dehiscing by decay of the pericarp; seeds, ellipsoid. Pot plant. 5,6.

GOODENIACEAE (Naupaka Family)

Scaevola taccada (Gaertn.) Roxb. "scaevola", "saltbush", "half-flower"; "beach naupaka"(Hawaii)
emet, emed, emit (B)(N); te mao (K); gasu, gahu (T)
syns. *S. sericea* var. *taccada* Makino; *S. frutescens* sensu auct. non (Mill.) Krause; *S. frutescens* var. *sericea* (Forst.f.) Merr. (nom. nud.); *S. koenigii* Vahl; *S. lobelia* Murr.; *Lobelia taccada* Gaertn.; *L. koenigii* (Vahl) Wight

Indigenous. Trop. Asia to Hawaii. Very abundant. Erect freely branching, spreading, somewhat succulent, soft-wooded, pithy-stemmed glabrous to pubescent shrub, up to about 2 m high, with leaves spiralled or crowded near the ends of the branches; leaves, 8 to 26 cm long and 3 to 12 cm wide, alternate, obovate to oblong-spathulate, apex rounded (obtuse) or emarginate, base cuneate-decurrent, margins somewhat wavy or obscurely toothed or crenate, glabrous or somewhat puberulent, slightly fleshy, light bright green, the midrib sometimes faintly purplish, venation obscure; petiole, short, up to 15 mm long, broad, winged by decurrent blade margins with a basal tuft of sulky white hairs in the leaf axil; inflorescence, a fragrant axillary forking 3- to 9-flowered cymose cluster, 2 to 5 cm long, the peduncles 0.5 to 2 cm long; calyx, 5 to 12 mm long including acute lobes, 5 to 10 mm long; corolla, 12 to 22 mm long, the tube, 10 to 15 mm long, white to greenish or purplish, the limb, 5 to 10 mm long, spreading, white or pale green without, and purple-veined or brown-bordered, the lobes with membranaceous, sometimes fimbriate or erose margins, asymmetrical, appearing to be split in two with only half the petals remaining; fruit, 10 to 18 mm in diameter when fresh, drying to 7 to 13 mm, 2-celled, subglobose, bluntly costate, fleshy, white; seeds, 1 or 2. Abundant in strand vegetation; dominant species and one of first colonizers on strip-mined areas. Wood considered good for smoking (cooking) fish and the black noddy bird (an important delicacy at feasts); hollow sticks used as "guns" to shoot gum balls (*egato*) and small balls carved from pandanus; inner bark used in the past to make headbands which resembled noddy-bird feathers and which were worn for traditional dances; leaves used to wrap food in and to cover the earth oven (*eom*, *eyom)*; *Scaevola* and *Guettarda speciosa* (*iut*) flowers the first flowers smelled by returning sailors; flowers used in garlands and either added directly, or boiled with coconut oil to scent it; leaves crushed to yield a juice to retards loss of hair and cure rashes; inner bark scraped to yield medicine for abscesses or boils, and white ripened fruit squeezed into eyes as a "pre-eye-drops" cure for conjunctivitis. 2, 3(58622, 58761), 5(30), 6, 7(27801).

HERNANDIACEAE (Hernandia Family)

Hernandia nymphaeifolia (Presl.) Kubitzki "lantern tree"
etiu, yetiu, etsiw (N); te nimareburebu, te bingibing (K); puka, puka vaka (T)
syns. *H. sonora* L.; *H. peltata* Meissn.; *H. ovigera* senus auct. non L.; *Biasolettia nymphaeifolia* Presl

Indigenous. Trop. Asia to Pacific Is. Rare. Medium to large tree, up to 20 m high, with a shortly buttressed trunk and smooth grayish, slightly fissured bark; leaves, 12 to 40 cm long and 10 to 30 cm wide, alternate, rounded-ovate, acute-acuminate, subpeltate to peltate near base, glabrous, softly leathery, medium green (the ventral insertion of the petiole usually red), palmately 5- to 9-nerved from petiole; petiole, 5 to 17 cm long; inflorescence, a densely-flowered axillary and terminal long-stalked, tomentose cymose panicle of numerous, unisexual but monoecious, white to yellowish-white flowers, 12 to 30 cm long; involucre, green to whitish or pinkish, slightly fleshy, subtended by 4 bracteoles; each cyme composed of 3 pedicellate white to pale green flowers, the 2 laterals males, the center one female; male flowers, about 7 mm long, 3-merous; female flowers, 4-merous; style up to 5 mm long; fruit, about 2.5 cm in diameter, broadly obovoid-subcompressed, nut-like, brown, nearly smooth, somewhat ribbed, enclosed in an enlarged, fleshy, white or grayish to reddish succulent balloon-like vesicle with a circumscissile opening; seed 1. Tree on or near base of escarpment. Very light wood, which is sometimes found in the form of driftwood, used for canoe outriggers, pull-floats for fishermen to tie fish to, and corks for bottles; fruit rubbed against rock to burn each other in traditional games. 5(10), 6, 7(27819).

LAMIACEAE OR LABIATAE (Mint Family)

Coleus amboinicus Lour. "Indian borage"
syns. *Plectranthus amboinicus* (Lour.) Spreng.; *Coleus aromaticus* Benth.

Recent introduction. Africa and India to Indonesia. Rare. Very aromatic, densely pubescent, somewhat succulent, low sprawling or ascending perennial herb, up to 1 m high, with sub-quadrangular to subterete stems; leaves 2 to 11 cm long and 1.5 to 9 cm wide, opposite, broadly ovate to suborbicular, acute to broadly rounded (obtusish), base cuneate or rounded to truncate, coarsely crenate to dentate (toothed), succulent, finely pubescent on both sides, fragile; petioles 1 to 5 cm long, densely pubescent; inflorescence, a long simple (unbranched) terminal spicate panicle up to 50 cm or longer bearing numerous (up to 30 or more) whorls of flowers on short pedicels at intervals of about 1 to 2 cm; bracts, 3 to 4 mm long; pedicels slender, hirsute, up to 5 mm long; calyx 1.5 to 4 mm long, campanulate, hirsute and glandular, the upper lip erect, broadly ovate-oblong, the other teeth narrow, very acute; corolla, 7 to 12 mm long, pale blue or violet to pink, the tube 3 to 4 mm long, declinate, expanding distally, pubescent without, the upper lip to 4.5 by 3 mm, erect, puberulent, the lower lip to 5 to 6 by 4 mm, concave; fruit, about 0.5 by 0.7 mm, a nutlet, smooth, pale brown. Pot plant at Location and at Indian residence at Meneng Terrace. Leaves used as a spice in curries and medicinally. 6(211), 7.

Coleus pumilus Blanco "creeping coleus"
syn. *C. repens* Gurke

Recent introduction. W. Africa. Occasional. Pot plant. 2(59673, 58781), 5, 6.

Mentha piperita L. "mint", "peppermint"
syn. *M.* × *piperita* L. (*M. aquatica* L. × *M. spicata* L.)

Recent introduction. Europe. Rare. Strongly-scented erect to sprawling rhizomatous perennial herb, the stems 4-angled, glabrous to sparsely pubescent, often purplish; leaves, 1 to 6 cm long and 1 to 3.5 cm wide, opposite, lanceolate-elliptic to oblong-ovate, ovate or suborbicular, somewhat rugose, sharply acute to apiculate, cuneate to rounded or cordate at base, serrate at margin, pubescent to glabrous; petioles, 3 to 6 mm long; inflorescence, a terminal spikelet at stem tips with flowers arranged in whorls (verticils) which are congested terminally and more distantly-spaced basally, mostly glabrous except on calyces; calyx, 3 to 4 mm long, tubular, purplish and dotted with oil glands, the teeth subequal, ciliate, narrowly acuminate, much shorter than calyx tube at anthesis; corolla, 4 to 6 mm long, pale violet, glabrous or puberulent, the tube exserted; stamens 4, small, included; fruit, about 0.75 mm long, a brown nutlet. Pot herb planted in old oil drum on Command Ridge and at Indian residence at Meneng Terrace. 6, 7.

Ocimum basilicum L. "basil", "sweet basil"
dementsi (N); te marou (K); mili (T)

Pre-World War II introduction. Africa to Pacific Is. (Paleotropics). Occasional. Freely-branching aromatic perennial herb or subshrub, often cultivated as an annual, up 80 cm or higher, the stems 4-angled, the branchlets glabrous to hispid; leaves, 2 to 8 cm long and 1 to 3 cm wide, opposite, elliptic-lanceolate to ovate and oblong, acute, base cuneate to attenuate, entire or obscurely dentate, glabrous to scattered-pubescent; petioles, up to 2 cm long, slender; inflorescences, terminal racemes, 10 to 15 cm or longer, at stem tips bearing many short-pedicellate, 6-flowered whorls (verticils) at intervals; bracts, petiolate, green to rich purple, the bracteoles, 2 to 6 mm long; calyx, 2 to 3 mm long at anthesis, enlarging to 5 to 9 mm long in fruit, bilabiate, 10-nerved, with long hairs inside, greenish, purplish-tinged; corolla, 7 to 9 mm long, tube 3.5 mm long, upper lip 4-toothed, lower lip entire, white, glabrous to hispid; fruit, of 4 nutlets, 1.5 to 2.5 mm long, obovoid or ellipsoid, brown or blackish, pitted, swelling in water and becoming slimy. Planted in home gardens; common in I Kiribati and Tuvaluan gardens at

Location. Fragrant flowers and leaves used in garlands and for scenting coconut oil. 2, 3, 5(141), 6, 7(22305).

Ocimum sanctum L. "sacred basil", tulsi (Hindi)
demere (N)?; te marou (K)
syn. *O. tenuiflorum* L.

Pre-World War II introduction. Trop. Asia, now Pantropical. Rare. Erect, aromatic, much-branched herb or subshrub up to 1 m high, the branchlets soft-pubescent; leaves, 3 to 7.5 cm long and 1 to 2.8 cm wide, elliptic to elliptic-oblong or rhomboidal, obtuse to acute, base cuneate to attenuate, margin entire or remotely serrate, upper bract-like leaves ovate to cordate, green to grayish-purple, pubescent on both surfaces but especially on nerves beneath; petioles, up to 2.5 cm long; inflorescences, slender racemes at stem tips, 8 to 10 cm long, bearing whorls (verticils) of flowers at intervals; bracteoles, 2 to 3 mm long, ovate, acuminate, ciliate; pedicels, up to 4.5 mm long; calyx, 2.5 to 3.5 mm long at the anthesis, enlarging to 5 mm in fruit, often purplish, glabrous within except occasionally puberulent near the base of upper lobe, the upper lip suborbicular, reflexed, short-apiculate, the lower lip longer than the upper lip, the teeth 4, lanceolate; corolla, 3 to 5 mm long, the tube 1.5 to 2 mm long, upper lip with rounded lobes, lower lip entire, purplish to pale pink or white; stamens 4; fruit, 0.8 to 1.5 mm long, nutlets, subglobose-compressed or broadly ellipsoid, purple-green to brown, smooth to minutely pitted. Planted ornamental. Fragrant flowers and leaves used in garlands and headbands and for scenting coconut oil. 5, 6, 7.

Plectranthus oertendahlii Fries "Swedish ivy", "prostrate coleus"

Recent introduction. S. Africa. Rare. Prostrate or trailing, tender or somewhat succulent, perennial herb, up to 50 cm high, with creeping reddish stems; leaves, suborbicular, velvety, bronze-green with silver along the veins and purplish beneath; inflorescences, erect or ascending racemes or panicles, 10 to 15 cm long, bearing whorls (verticils) of flowers at intervals; corolla, 2-lipped, pink. Pot plant. 3(58673, 58781), 5, 6.

Plectranthus scutellarioides (L.) R. Br. "painted nettle", "coleus", "painted-leaf plant"
syns. *Coleus scutellarioides* (L.) Benth. and *C. blumei* Benth.; *Ocimum scutellarioides* L.; *Solenostemon scutellarioides* (L.) Codd

Recent introduction. Malaysia. Occasional. Erect or ascending, tender or somewhat succulent, aromatic brown-pubescent perennial herb up to 1.5 m high, the stems 4-angled and branches glabrous to pubescent; leaves, opposite, 4 to 17 cm long and 3 to 10 cm wide, broadly ovate to ovate-cordate, acute to acuminate, base truncate to rounded or cuneate and attenuate, crenate, doubly crenate to laciniate, scabrid to subglabrous, variegated, highly ornamental, variously colored, green, red, purple, yellow or white; petioles, 1 to 8 cm long, slender; inflorescences, erect terminal racemes or panicles, 5 to 40 cm long, bearing whorls (verticils) at intervals; bracts, 4 by 5 mm, ovate, long-acuminate, deciduous; pedicels, 3 to 4 mm long; calyx, 2 to 4 mm long and 2 to 3 mm wide, enlarging to 7 mm long in fruit, bilabiate, obliquely campanulate, pubescent and gland-dotted, 10-nerved; corolla, 8 to 18 mm, long, infundibular, blue to purple or mauve, the tube, about 5 mm long, paler, puberulent, abruptly decurved, the upper lip about 1.5 mm long, erect, the lower lip deeply concave, up to 6 mm long; stamens 4; fruit, nutlets, 0.75 to 1.2 mm long, lenticular to broadly ovoid or subglobose, brown, smooth, glossy. Planted ornamental and pot plant. 5, 6, 7.

LAURACEAE (Laurel Family)

Cassytha filiformis L. "beach dodder", "giant dodder","devil's twine"
denuwanini, denuwenini, eduwinini (B)(N); te ntanini (K); fetai (T)

Indigenous. Pantropical. Abundant. Slender, filiform, branching, twining or climbing light green to yellowish-green or yellowish-orange, glabrous parasitic herb, up to 3 to 8 m long, attaching to host plants by means of sucker-like haustoria, often forming sense, tangled mats; leaves, alternate, spirally arranged, reduced to minute scales; inflorescences, erect solitary pedunculate spike-like clusters, 1.5 to 5 cm long, borne in the axils of minute bracts; rachis, rather thick, glabrous, finely brown-hairy; bracts and bracteoles ovate-circular; flowers, bisexual, the perianth greenish-white to yellowish-white, somewhat fleshy, tepals 6, white, the 3 outer tepals, connate, broadly ovate-circular, about 0.75 mm across, the 3 inner ones broadly ovate, glabrous, 2 to 2.5 mm long; stamens 9; staminodes, few, yellow; fruit, 4 to 7.5 mm in diameter, subglobose, white when mature, enclosed in a fleshy perianth tube, 1-seeded; seed with a membranaceous or coriaceous testa. Parasite on other plants, found generally on natural vegetation at all elevations. Entire plant used as garlands and headbands; plant used for "black magic" by I Kiribati and other islanders, a practice occasionally copied by Nauruans; tender tips used at times in the past for scenting coconut oil; fruit eaten by children in the past. 2(23.5), 3(58590), 4(163N), 5(6), 6, 7, 8(9566).

Persea americana Mill. "avocado", "avocado pear", "alligator pear"
syns. *Laurus persea* L.; *Persea gratissima* Gaertn.f.

Recent introduction. Mexico. Rare. Medium to large evergreen tree, up to 12 m or taller; leaves, 7 to 30 cm long and 2.5 to 20 cm wide, alternate and spirally arranged, elliptic, ovate-oblong or obovate-oblong, acute-acuminate, chartaceous to somewhat coriaceous, glaucous beneath, downy when young, nerves alternate, pinnate, prominent; petioles, 1.5 to 5 cm long; inflorescences, axillary many-flowered downy panicles crowded near the ends of branches; peduncles and pedicels, yellowish-green, pubescent; flowers, bisexual, somewhat fragrant, subtended by lanceolate deciduous hairy brown bracts, 4 mm long; the perianth of 6 tepals, 10 to 15 mm in diameter, greenish to yellowish white, short-pedicellate; stamens 9, in 3 whorls, the staminodes, conspicuous, orange to brown; pedicels cylindric or enlarged and fleshy when in fruit; fruit, 7 to 25 cm long and 5 to 12 cm in diameter, subglobose to pear-shaped (pyriform) fleshy, 1-seeded drupe, skin light-green to purplish, flesh light-green to yellow-green, of butter-like consistency, edible; seed, single, subglobose, up to 5 cm in diameter, with 2 brown seed coats and 2 fleshy, whitish or pink cotyledons. Seedling planted in garden at Meneng Terrace. 5.

LECYTHIDACEAE (Brazilnut Family)

Barringtonia asiatica (L.) Kurz "fish-poison tree", "barringtonia"
kwenbabai, kwenababai, eijinut (B)(N); te baireati (K); futu (T)
syns. *Mammea asiatica* L.; *Barringtonia speciosa* Forst.; *B. butonica* Forst.

Indigenous. Indo-Pacific. Occasional. Large, spreading, round-crowned tree, 10 to 20 m high, with gray bark and rather stout branches; leaves, 15 to 50 cm long and 8 to 24 cm wide, alternate, clustered toward the ends of branches, obovate or oblong-obovate, obtuse or slightly emarginate, base cuneate, subcoriaceous, glabrous, glossy-green, subsessile; petioles, 1 to 5 cm long; inflorescences, terminal more or less erect racemes, 2 to 15 cm long and 15 cm broad; pedicels, 2 to 9 cm long; calyx, 2-lobed, sepals, 2 to 4 by 2 to 3 cm, concave, obtuse, persistent on fruit; corolla, 4-parted, sweetly fragrant, petals, about 4 to 8 cm long and 2.5 to 4.5 cm wide at anthesis, elliptic to ovate, white, early deciduous; stamens numerous, 4 to 12 cm long, white at base, pink- or red-tinged distally, anthers yellow; style, 6 to 15 cm long, white at base, pink- or red-tinged distally; fruit, 8 to 12 cm long and broad, 4-angled, 1-seeded, pyramidal or subturbinate, exterior fibrous, crowned by calyx (2 large persistent sepals), pendent and heavy when ripe, buoyant; seed, 4 to 5 cm long and 2.5 to 4 cm wide, ovoid or ellipsoid. Spontaneous or planted on coastal strip, often in home gardens; larger concentrations on escarpment leading to plateau above Anibare Bay. Wood a favoured timber and fuelwood for cooking toddy syrup (*kamwaerara*); fruit possibly used to poison fish in the past. Fruit commonly used as a fish poison or stupefacient elsewhere in the Pacific. 1(48.R), 2, 3(58665), 5(36), 6, 7.

LYTHRACEAE (Lythrum Family)

Lagerstroemia indica L. "crape myrtle"

Recent introduction. S. China. Rare. Glabrous, deciduous shrub or small tree, 2 to 5 m high, with 4-angled branchlets; leaves, 3 to 10 cm long and 2 to 5 cm wide, alternate, elliptic to oblong-subobovate, obtuse to acute, subsessile; inflorescences, terminal or axillary panicles, 5 to 20 cm long, bearing clusters of flowers, each about 2.5 to 3 cm across; calyx, 6-lobed, campanulate, glabrous; petals 6, 12 to 15 mm long, ovate-suborbicular, wrinkled, clawed, scentless, white, pink or lavender to rich purple or blue; stamens about 15 to 40; fruit, about 0.5 to 1 cm long, ovoid, capsular; seeds, winged. Planted ornamental on Command Ridge. 3(58712), 5, 6.

MALPIGHIACEAE (Malpighia Family)

Stigmaphyllon ciliatum (Lam.) Juss."Brazilian golden vine", "golden cup", "orchid vine"

Recent introduction. W. Indies to Brazil. Rare. Slender, woody vine; leaves, 2.5 to 8 cm long and nearly as wide, cordate, glabrous with pubescent margins; inflorescences, axillary racemose clusters of 3 to 7 flowers, each about 3.7 cm in diameter; sepals 5; petals 5, bright yellow, free, stalked at base, unequal, wavy, orchid-like; stamens 10, unequal, only 6 bearing anthers; styles 3; fruit, 3-parted, each part with a broad wing about 2.5 cm long. Planted ornamental climber. 3(58725), 6.

Tristellateia australasiae Rich. "bagnit"
syn. *Tristellateia australis* Rich.

Recent introduction. Malaysia and Australia. Occasional. Glabrous, long woody climber with stems dotted with raised lenticels; leaves, 2 to 12 cm long, opposite or verticillate, ovate, acute or obtuse, base rounded or subcordate with 2 glands, glabrous, rather pale green; petiole, 5 to 20 mm long; inflorescences, terminal racemes at branch tips bearing 12 or more flowers, each nearly 2.5 cm in diameter; sepals 5; petals 5, bright yellow, 4 of them slightly falcate, equal, each about 1 cm long excluding the 2 mm long pinkish-orange claw; stamens, usually 10 of unequal length, yellow turning red; style 1, curved, undivided; fruit, samaroid, with a lateral wing with 5 to 8 slender flattened lobes each up to about 1 cm long. Planted ornamental climber. 5, 6(179, 205), 7.

MALVACEAE (Mallow Family)

Abutilon asiaticum (L.) Sweet var. **supraviride** Fosb.
ekaura, inen ekaura (N); te kaura ni Banaba (K)

Indigenous. S. E. Asia to the Pacific Is. Occasional. Erect velvety-pubescent subshrub, 0.5 to 2 m high; leaves, 5 to 12 cm long, alternate, suborbicular-ovate cordate at base, coarsely crenate-serrate or lobed, palmately-nerved, downy gray-green, long-petiolate; flowers, 1.5 to 2.5 cm across, axillary, solitary, on long pedicels, 4 to 7 cm long; calyx 5-lobed; corolla, 1.5 to 2.5 cm across, petals 5, about 1 cm long or longer, imbricate, deltoid-obovate, orange-yellow; fruit, circular, a capsular schizocarp of 11 to 20 radiating carpels, hirsute, brown when dry, each carpel flattened, somewhat boat-shaped, apiculate by the short persistent style-remnant, about 8 mm long; seeds, reniform, stellate-pubescent. Found in waste places and ruderal habitats along coastal strip, especially near the Ijuw-Anibare boundary, and among pioneering weeds in topsoil in areas recently cleared for phosphate mining. Tender meristem used to scent coconut oil; flowers used in garlands and headbands. 2, 3(58807, 58805), 4(107N), 5(107), 6, 7(22306).

Gossypium barbadense L. "sea-island cotton", "cotton"
duwoduwo (N); te baubau (K)
syns. *G. brasiliense* Macf.; *G. peruvianum* Cav.

Pre-World War I introduction. Trop. America. Extinct? Erect branching shrub, up to 3 m or higher; leaves, 7 to 13 cm long, alternate, rotund to ovate, cordate, deeply palmately 3 to 5 (rarely 7)-lobed or laciniate, glabrous with short, fugacious hairs, long-petiolate; stipules foliaceous, lanceolate or ovate, auriculate; inflorescences, terminal or on short axillary branches, solitary or 2 to 4-flowered racemes; bracteoles of epicalyx 3, much longer than the calyx, with cordate base and a deeply incised or laciniate apical lobe; top of pedicel with or without glands below the bracteoles; corolla, 5 to 8 cm across, obovately 5-petaled, petals, about 5 to 8 cm long, yellow, becoming streaked with red or purple on fading, usually with a basal reddish or purplish spot; fruit, a 3-valved ovoid, leathery, pitted capsule dotted with black oil glands; seeds, numerous, ovoid, black, covered with fine, long, pure white easily-removed woolly fibers or hairs (cotton). Collected by Burges in 1935, but not seen by subsequent collectors. Grown by Nauruans in the past for the cotton which was used to stuff mattresses and pillows. The Nauruan name for cotton is the same as for kapok. 2.

Hibiscus esculentus L. "okra", "gumbo", lady's finger"; bindi (Fiji Hindi)
syn. *Abelmoschus esculentus* (L.) Moench.

Recent introduction. Asia. Coarse, erect suffruticose, annual herb, 1 to 3 m high, with green or red-tinged stems; leaves, 10 to 25 cm long and 10 to 35 cm wide, alternate, broadly cordate, palmately 3- to 7 lobed, serrate, hirsute, pale green beneath; petioles, 15 to 35 cm long, hispid, often red-tinged; flowers, solitary, axillary; peduncle about 2 cm long; epicalyx of up to 10 narrow bracteoles, up to 1.5 cm long, usually falling before fruit reaches maturity; calyx completely fused as flower develops, splitting longitudinally as flower opens, falling with the corolla after anthesis, 2 to 3 cm long; petals 5, yellow with crimson spot on claw, obovate, 5 to 7 cm long; staminal column united to base of petals, 2 to 3 cm long, with numerous stamens; stigmas small, 5 to 9, deep red; fruit, 10 to 30 cm long and 2 to 3 cm across, a pyramidal-oblong, beaked capsule, longitudinally furrowed, hirsute or glabrous, dehiscing longitudinally when ripe; seeds, 5 mm in diameter, dark green to brown, rounded, tuberculate.

Hibiscus manihot L. "bush spinach", "edible hibiscus"; "bush hibiscus spinach"; "pele" (Polynesia); mbele (bele in Fiji); nambere (K); pele (T); kabis, slippery kabis (SI)
syn. *Abelmoschus manihot* (L.) Medik

Recent introduction. S. E. Asia. Occasional. Erect, perennial, often suffruticose woody herb or subshrub, 1.5 to 3 m or higher, with young stems, petioles and pedicels glabrous or short-hairy, often accompanied by longer hairs; leaves, 10 to 60 cm by 5 to 60 cm, alternate, extremely variable in shape, orbicular to ovate-oblong, base cordate, either contracted into an elongated-triangular acumen from a broad base or palmately 3 to 7-lobed (or 3 to 7-fid) to subentire, lobes or segments triangular-ovate, oblong-lanceolate, obovate-spathulate or linear, entire, dentate or serrate, pellucid-dotted, more or less crenate, glabrous or pubescent; petiole, 2 to 50 cm long; stipules, 2 to 8 cm long, filiform, caducous, flanked by paired, variable lobed or entire leaflets, 2 to 6 cm long; inflorescences, axillary, solitary, on pedicels, 1 to 5 cm long; bracteoles of epicalyx, 4 to 6 (-8), 1 to 3 cm long and 0.5 to 1 cm broad, ovate to oblong, not rarely coherent in pairs, pubescent on both sides; petals 3, 5 to 8 cm by 3 to 6 cm, yellow with purple centers; fruit, 3.5 to 6 cm long and 2 to 2.5 cm broad, capsular, pentagonous, with 5 prominent costas, concave between the costas, loculicidally dehiscent; seeds, many, about 3 to 4 mm long, subglobose, asymmetrical, dark brown, pubescent. Food plant in gardens at Location and Topside Workshop and occasionally in other home gardens. Nutritious slippery green leaves cooked as a green vegetable by Solomon Islanders, Tuvaluans, I-Kiribati and Fijians. Along with taro leaves, one of the two most important leafy green vegetables in the Pacific Is. 5, 6(105), 7.

Hibiscus mutabilis L. "changeable rose mallow", "changeable rose", "variable rose"
dorot ("the rose")(N)

Recent introduction. S. China. Rare. Large, downy pubescent shrub, up to 5 m tall, with both simple and stellate hairs; leaves, 10 to 25 cm long and broad, alternate, orbicular, cordate, 3 to 7-lobed, long-acuminate, 5 to 11-nerved, dark green above and light green and tomentose beneath; petioles, 2 to 8 cm long; inflorescences, axillary (occasionally terminal), usually single but sometimes double; pedicels, 7 to 10 cm long, accrescent, articulate; epicalyx, 6-segmented, well-developed, persistent, segments about 2 cm long, linear-lanceolate; calyx, 5 to 7 cm across, deeply divided, 5-lobed, lobes 2 to 3.5 cm long, abruptly widened above the base; corolla, 8 to 12 cm across, opening white changing to pink, many-petaled, petals 4 to 5 cm long; fruit, about 2.5 cm wide, subglobose, capsular, 5-locular, setose-lanate; seeds, reniform, tomentose, the hairs 2 to 4 mm long, spreading to subspreading. Planted ornamental along road to Meneng Terrace. 5(157), 7.

Hibiscus rosa-sinensis L. "hibiscus", "red hibiscus"
dorot ("the rose")(N); te roti ("the rose")(K); aute (T)

Pre-World War II introduction. Trop. Asia. Common. Many branching, glabrous shrub, up to 1 to 4 m tall, with erect to drooping branches; leaves, about 6 to 15 cm long and up to 12 cm wide, alternate, variable, ovate-elliptical, acute or acuminate, crenate-serrate, subcordate, obtuse or subacute, green on both sides, palmately 5-nerved; petioles, up to 5 cm long; inflorescences, axillary, near the ends of branches on elongate pedicels, 1.5 to 7.5 cm long; epicalyx of 5 or more ovate- to linear-lanceolate bracts 5 to 18 mm long; calyx, green, 5-lobed for about half its length, persistent; corolla, mostly 8 to 12 cm across, single or in some forms double, campanulate or broadly funnelform, petals entire, showy, usually bright red, but also pink, yellow, light-orange or white; staminal tube slightly longer than the corolla, often nodding or pendulous, crimson; fruit, capsular, ovoid-rounded, 5-valved, 15-seeded (or less); seeds, subglobose, rarely seen. Planted ornamental and hedge plant; flowers used in garlands and for decoration. One of the commonest and most widespread of all ornamental plants in tropical regions. 3(58791), 5(126), 6, 7.

Hibiscus schizopetalus (Mast.) Hook.f. "coral hibiscus", "dragon flower"
dorot (N)

Recent introduction. E. Africa. Rare. Glabrous shrub, 2 to 4 m high, very much like *H. rosa-sinensis*; leaves, alternate, ovate-elliptical, acute, dentate; inflorescences, solitary, pendulous on long pedicels at the ends of slender, drooping branches; pedicels, 8 to 10 cm long; segments of epicalyx 1 to 2 mm long; calyx irregularly 2- to 4-lobed, sometimes spathaceous; corolla, deeply dissected (laciniate), reflexed, petals pink-and-white to coral-red, sometimes with white or yellow margins; staminal tube about twice as long as petals, slender, flaccid, red, curved at the tip. Planted ornamental. 3(58770), 5(125), 6.

Hibiscus tiliaceus L. "beach hibiscus", hibiscus tree", "hau" (Hawaii)
ekwane (N); te kiaiai, te rao (K); fou, fau (T)
syns. *Pariti tiliaceus* (L.) A. St. Hil.; *P. tiliaceum* Britt.; *Paritium tiliaceum* (L.) A. St. Hil.

Indigenous. Pantropical. Very abundant. A small, dense, broad-crowned, often scrambling tree, 3 to 10 (rarely 15 to 18) m high, intricately branched when mature, with many spreading low branches from a short trunk; youngest branches gray-pubescent, older ones glabrate with grayish rather smooth very fibrous and mucilaginous bark and bast fiber; leaves, up to 15 or 20 cm long and nearly as wide, round-ovate, abruptly acuminate, base deeply cordate, velvety pubescent when young, glabrate and dark green above, grayish-white stellate-tomentose beneath and slightly glaucous, palmately 7- to 9-nerved with linear basal glands dorsally; petioles, up to 12 or 15 cm long; stipules, 2 to 4 cm long, broadly attached, ultimately leaving annular scars; inflorescences, terminal or axillary, solitary or in few-flowered open cymes or panicles; epicalyx conspicuous, shorter than calyx, with 8 to 12 deltoid, acute segments (bracts); pedicels 1 to 3 cm long; calyx 5-lobed; corolla, about 10 cm across, cupular-campanulate, yellow with a maroon-purple eye, aging (after falling) to salmon red; staminal tube shorter than corolla, yellow; style rich purple distally; fruit, 1 to 2.5 cm long and 2 cm wide, ovoid globose, capsular, 5-celled, pubescent, grayish-brown, splitting at top when mature; seeds, generally 15, glabrous, brownish black. In thickets and forest on escarpment surrounding plateau and on inner and outer edges of coastal strip. Timber used for house construction and considered good for canoe outriggers, poles for noddy bird nets, and the best wood for the construction of frigate bird nesting platforms (*eteo*, *etea*); very soft pieces of wood rubbed together in the past to make fire by friction in the procedure known as *ikumo*; inner bark (bast fiber) used to make white fiber, which after stripping off outer bark and soaking in mud and sea water, is used to make skirts (*ridi*), special hula skirts (*ingung*), and baskets (*ebwer*, *eber*); fibre used for straining coconut cream and for lashing house rafters; leaves used for parceling pig and other foods for cooking in the earth oven (*eyom*, *eom*); leaves cooked with water as a cure for diarrhea. 1(22.R), 2, 3(58747), 4(169N), 5(28), 6, 7.

Hibiscus ornamental hybrids "hybrid hibiscus"

Recent introduction. Rare. Origin? Variable shrubs, up to 2 m or higher; leaves smooth to rough; flowers, single or double; bracts, few to several; calyx of single forms 5-lobed, showy, more or less campanulate; staminal column more or less covered with stamens surrounding all but the tip of a longer 5-lobed style; fruit a 5-valved capsule containing 15 or more seeds. Planted ornamentals. 3, 5, 6, 7.

Malvastrum coromandelianum (L.) Garcke "false mallow"

syns. *M. tricuspidatum* A. Gray; *Malva coromandeliana* L; *Malva tricuspidata* R. Br.

Recent introduction. C. America to S. United States. Common. Tough-stemmed, woody-rooted, widely-branching annual herb or subshrub up to 1 m high (usually less); stems, pubescent with 4-rayed hairs; leaves, 2 to 6 cm long and 1 to 2.5 cm wide, alternate, ovate to ovate-elliptic or ovate-lanceolate, acute or obtuse, serrate, appressed-pubescent, 3-nerved from the base, midrib branched upward; petioles, 1.5 to 4 cm long, slender; stipules, 0.5 to 1 cm or more long, lanceolate to very narrow; inflorescences, axillary, solitary or finally appearing in short axillary and terminal clusters; peduncles, about 5 mm or longer; epicalyx of 3 free narrow subulate bracts; calyx, deeply 5-lobed, the sepals ovate, acute, pubescent; corolla, about 1.2 to 2 cm across, broadly campanulate, 5-petaled, opening after mid-day, finally falling with the staminal tube; petals slightly unequally bilobed at apex, yellow to salmon-orange; staminal column shorter than the corolla, divided at apex into numerous filaments; fruit, about 6 mm across, a discoid (wheelshaped) schizocarp breaking up at maturity into 10 one-seeded segments (mericarps), each about 3 mm long, with a few stiff hairs and 2 stubby points on the convex side; seeds, 1.5 mm long, obliquely reniform, black with a dull surface. Weed in settled areas, roadsides and ruderal sites. 3(58694, 58728, 58766), 5, 6(207), 7, 8.

Malvaviscus arboreus Cav. var. **penduliflorus** (Moc. & Sesse ex DC.) Schery

"sleeping hibiscus", "Turk's cap"

syns. *M. penduliflorus* Moc. & Sesse ex DC.; *M. conzatti* Greenm.; *M. grandiflorus* Hort. non H.B.K.

Recent introduction. Trop. America. Occasional. A shrub, 1 to 3 m high, with fibrous bark; leaves, 7 cm to 20 cm long and up to 10 cm wide, alternate, narrowly ovate to ovate-oblong or ovate-lanceolate, acute to obtusely acuminate, base broad cuneate to rounded, serrate; petioles, usually 5 to 12 cm long, puberulent; stipules, about 7 mm long, linear; flowers, solitary, axillary, pendulous, hibiscus-like; pedicels, 4 to 6 cm long or longer, slender, pubescent; epicalyx of usually 6 to 7 linear oblong bracts, about 1 to 1.5 cm long, apex obtuse, margins ciliate; calyx, 5-lobed, exceeding bracts of epicalyx by up to 1 cm; corolla, about 4 to 7 cm long, 5-petaled, bright red (occasionally pink), petals, unequally obovate, slightly keeled, flattened at apex, base suricular, remaining rolled, overlapping and closed; staminal tube slightly exserted, slender, reddish or pale pink with dull purple anthers; fruit, a 5-seeded schizocarp, globose, fleshy, red. Planted ornamental. 5(124), 6.

Sida acuta Burm.f. "spiny-headed sida", "broom weed"
"coffee bush" (N)
syns. *S. carpinifolia* L.f.; *S. glomerata* Cav.

Recent introduction. Pantropical. Common. Low, freely-branching perennial subshrub, up to 1 m tall, with slender stems and a strong taproot; leaves, 1.5 to 7.5 cm long and 0.5 to 2 cm wide, alternate, lanceolate or linear-lanceolate, acute, obtuse, cordulate or rounded at base, sharply serrate, yellowish-green, more or less stellate-pubescent or glabrous beneath, palmately 3-nerved from base, pinnately nerved above the base, midrib branched upward; petioles, 3 to 5 cm long; stipules linear-acute or linear-subulate, up to 12 mm long; inflorescences, solitary or paired, axillary or sometimes terminal; pedicels, 2 to 10 cm long; calyx, about 5 mm across, 5-lobed, lobes pointed; corolla, about 4 to 15 mm across, 5-petaled, petals united at base, obovate, rotate, yellow; stamens numerous, fused into a column (monadelphous); fruit, 4 to 5 mm broad, a 6 to 10-carpellate schizocarp, carpels 2-awned, grooved dorsally; seeds, about 1.5 to 2 mm long, rounded-wedge-shaped, dark reddish-brown. Weed on coastal strip, along roadside, and in and near thickets. Two forms, a narrow ovate-lanceolate-leaved form (22303) and a broader-leaved form (96) exist. 3(58615, 58649, 58806), 5(23, 96), 6, 7(22303), 8(9558, 9582).

Sida fallax Walp. "ilima" (Hawaii)
ekaura, idibin ekaura (N); te kaura (K)

Indigenous. Indo-Pacific. Rare. Small downy, often almost prostrate, shrub, up to 50 cm high; leaves, about 2 to 4 cm long and 1 to 3 cm wide, alternate, oblong or cordate, acute or obtuse, serrate or scalloped-edged, glaucous, downy; petioles, about 1 to 2 cm long ??; flowers, axillary or terminal, solitary or 2 or 3 near ends of branch tips; pedicels, 2 to 5 cm long, slender ??; calyx, about half as large as corolla, 10-ribbed, downy; corolla, about 2 to 2.5 cm across, 5-petaled, yellow to rich orange, reddish near the center; stamens numerous, fused into a column (monadelphous); fruit, a wheel-like, 7- to 12-carpellate schizocarp with 1-seeded, short-awned seed cases or carpels; seeds ??. Found in ruderal habitats on coastal strip and in areas cleared recently for phosphate mining. Unopened flower buds used, after soaking in coconut oil to retard their opening and make them last, to make headbands and necklaces worn by dancers and sportsmen during special occasions; dried and treated leaves used by I Kiribati, in Kiribati, as a very strong fertilizer and mulch in ceremonial giant swamp taro (*Cyrtosperma chamissonis*) gardens. 1(5.R), 2(7.5), 5(108), 6(160, 162).

Sida rhombifolia L. "broomweed", "broom plant", "Cuba jute", "Paddy's lucerne"
"coffee bush", itsi (tea) (N)

Recent introduction. Pantropical. Common. Tough-stemmed, much-branching, erect, stellate-pubescent shrub, 30 cm to 1.5 m high; leaves, 1.5 to 8 cm long and 0.7 to

2.5 cm wide, alternate, elliptic or rhombic-ovate to subspatulate or lanceolate, acute to obtusish, base cuneate to very narrowly obtuse at petiole, serrate near apex, somewhat glaucous-green above, pale beneath, glabrous above, densely stellate-pubescent beneath; petioles, 2 to 6 mm long (rarely longer); stipules 3 to 10 mm long, narrow; flowers, solitary or occasionally paired in axils; pedicels 1 to 5 cm long, slender; calyx, about 15 mm wide, 5-lobed, lobes deltoid-apiculate; corolla, about 6 to 18 mm wide, 5-petaled, petals free, obovate, unequally bilobed, rotate, yellow to pale orange; stamens numerous, fused into a column (monadelphous); fruit, about 8 mm in diameter, an 8- to 10 (rarely 12)-carpellate schizocarp, carpels about 3 to 4.5 mm long, deltoid, apiculate, stellate pubescent dorsally, with 2 sharp awns, about 1 mm long at apex; seeds, 1 per mericarp, about 2 mm long, rounded wedge-shaped or almost pyramidal-triangular, dark brown or black. Weed of roadsides, waste places and semi-shaded areas. Tea made from leaves during World War II; leaves boiled in water used to treat blisters. 3(58621), 4(138N), 5, 6, 7, 8(9575).

Sida spinosa L. var. **angustifolia** (Lam.). Griseb. "prickly sida"

Recent introduction. Pantropical. Occasional. Soft pubescent herb, up to 1 m high, the young stems covered with minute soft hairs; leaves, 2.5 to 5 cm long and 0.4 to 2 cm wide, alternate, ovate-lanceolate, or oblong, acute, base rounded, obtuse or subcordulate, serrate; petiole, up to 2 cm or longer, slender; stipules, small, pointed, one at base and 2 lateral, usually curved downward; flowers solitary or in axillary or terminal paniculate clusters of 2 or 3; corolla, about 1 cm across, 5-petaled, light yellow; fruit, an ovoid 5-carpellate schizocarp, carpels 2-beaked; seeds, triangular, smooth, dark brown. Weed in waste places. 4, 6.

Thespesia populnea (L.) Sol. ex Correa "milo" (Hawaii, Polynesia)
itira, itirya (N); te bingibing (?)(K); milo (T)
syns. *Hibiscus populneus* L. (at least in part); *H. bacciferus* Forst.f.; *Malvaviscus populneus* (L.) Gaertn.

Indigenous. Paleotropics. Occasional. Medium tree, 3 to 15 m (rarely 20 m)high, with a fairly stout trunk, rough corrugated bark, dense round crown, and glabrous branches; branch tips silvery brown lepidote or scurfy, glabrescent; leaves, 5 to 15 cm long and almost as broad, alternate, rather crowded, ovate, base cordate with an open sinus, acuminate, entire or rarely somewhat lobed, green above, only slightly paler beneath, glabrous, slightly fleshy-coriaceous, glossy, usually at right angles to petiole, the tip pointing down, midrib yellowish, palmately 7- to 7-nerved; petioles, 3 to 12 cm long; inflorescences, solitary, axillary; pedicels, about half as long as the petioles, stout; epicalyx, 3 to 5-bracteate, bracts, 4 to 17 mm long, oblong to lanceolate, caducous; calyx, about 18 mm in diameter, rim- or disc-like, unlobed or scarcely toothed, persistent; corolla, 8 to 10 cm across, 5-petaled, campanulate, rather persistent, pale yellow with a maroon or reddish center of "eye", fading to purple or pinkish-purple; staminal column fused (monadelphous), shorter than corolla, cylindric, toothed at apex, pale yellow; stigmas yellow; fruit, about 2 to 4.5 cm across, depressed-pentagonal-globose, usually 4- to 5-celled, coriaceous-woody, glabrous, green becoming purplish or brown at maturity, with a yellowish gum, indehiscent, irregularly crumbling upon aging, calyx persistent at base; seeds, 4 per cell, usually 7 to 8 mm long, ovoid to obovoid, glabrous or silky pubescent (villous). Growing along edges of mangroves in Anetan; planted on golf course. Specimens (73.R) have leaves scarcely cordate, almost subtruncate at base, as in *Thespesia populneodes*, but have seeds villous on angles, as in *T. populnea*. Considered the best wood for house construction, woodcarving, furniture and canoe outriggers; wood also used in traditional stick games. 1(73.R), 2, 3(58745), 4(165N), 5(57), 6, 7(27821).

MELIACEAE (Mahogany Family)

Melia azedarach L. "Indian lilac", "China berry", "Persian lilac", "pride of India"
gadong, gadung (N)

Pre-World War I introduction. Trop. Asia. Common. Small to medium tree, 3 to 12 m (rarely 15 m) high, with wide-spreading branches and coarse weak wood; leaves, up to 50 cm or longer, alternate, bipinnate, with 3 to 7 pairs of leaflets, the lowest pinnae sometimes once more divided (thus partly tripinnate); leaflets, 3 to 9 cm long and 1 to 3 cm wide, opposite, oblong-ovate or lanceolate, acute to acuminate, base somewhat inequilaterally acute, serrate, glabrous; petiolules, up to 8 mm long; inflorescences, axillary, open, many-flowered panicles, 10 to 30 cm long; calyx, 5- to 6-lobed, puberulent; corolla, nearly 2 cm across, 5 (or 6)-petaled, the petals about 8 mm long, oblanceolate, purple to lavender or nearly white, fragrant; staminal tube cylindric, as long as petals, toothed, lilac, anthers 10; fruit, about 13 to 20 mm long, 3- to 8-locular, a subglobose to ellipsoid, fleshy, yellow drupe, the endocarp thick, bony; seeds, 1 (or 2) per locule, laterally compressed, the testa crustaceous. Planted ornamental and spontaneous on coastal strip, in strip-mined area on plateau, near the Topside Oval, and on escarpment slopes near phosphate processing plant. 2, 3(58732), 4(122N), 5(74), 6, 7.

Sandoricum koetjape (Burm.f.) Merr. "santol" (Philippines)
syns. S. *indicum* Cav.; *Melia koetjape* (Burm.f.) Merr.

Recent introduction. Malesia. Extinct? Medium to rather bulky, somewhat deciduous tree, up to 12 m or higher, with velvety-pubescent young branchlets and brown to gray smooth or slightly flaky bark; leaves, spiralled, trifoliate; leaflets, 10 to 20 cm long, oblong-ovate, acute, rounded at base, slightly asymmetric or not, velvety-pubescent or leathery, withering yellow or red; inflorescences in many-flowered axillary panicles, 10 to 20 cm long; calyx, 5-lobed, pubescent; corolla, 5-petaled, the petals about 1 cm long, linear, yellowish, fragrant; stamen tube elongate, anthers 10, stigma 5-lobed; fruit, 8 to 10 cm across, a globose, fleshy drupe with velvety-pubescent skin, usually 5-celled, 1 seed to each cell; pulp, brownish-white, acid, edible; seeds, large, inedible. Small recently planted seedling growing in Filipino home garden at Location in 1980. No longer present in 1981. 5.

MORACEAE (Mulberry Family)

Artocarpus altilis (Park.) Fosb. "breadfruit"
deme (N); te mai (K); mei (T)
syns. *A. incisus* (Thunb.) L.f.; *A. communis* Forst.

Aboriginal introduction. Malayo-Pacific. Common. Medium to large, round-topped tree, 10 to 20 m or higher, with thick milky sap; leaves, 30 to 60 cm (rarely up to 1 m) long and 20 to 40 (rarely up to 65 cm) cm wide, alternate, deeply pinnately 5- to 7-lobed or -incised, lobes long-acuminate, oblong, acute, or in some varieties entire or shallowly divided with 2 or 4 short triangular lobes, base broadly cuneate or obtuse, dark green above, paler beneath, thick-coriaceous, glabrous above, sometimes hairy on the nerves beneath or on both surfaces; midrib raised strongly beneath; petioles, 3 to 5 cm long, stout; stipules, 10 to 25 cm long, dorsally pilose; male inflorescences, 7 to 30 cm long and 1.5 to 4 cm wide, solitary, axillary, dense, yellow, somewhat spongy, cylindri-clavate (somewhat club-shaped), drooping spikelike clusters on stout peduncles 3 to 8 cm long; female inflorescences, solitary, axillary, globose to rounded-oblong or ellipsoid headlike clusters, 8 to 10 cm long and 5 to 7 cm wide, which develop into fruits, stiffly upright on stout peduncles 4 to 8 cm long; fruit, a syncarp, 10 to 30 cm in diameter, globose or rounded-oblong, weighing up to 6 kg, studded with slightly conic or pyramidal, hexagonal carpel apices, yellowish-green to brownish; inner flesh yellowish-white to creamy, usually seedless, but sometimes with seeds, about 2.5 cm long. Planted staple tree crop on coastal strip. Fruit cooked as a staple food; sap (*denda*) used as an adhesive for caulking canoes and a chewing gum; leaves used for wrapping food for cooking, for parcelization of fresh food, and as plates; medicine for curing ear aches made by crushing juice out of tender meristems. Two main cultivars of *A. altilis* are *deme* and *modenewe* or *modenawe* ("modern way"). Important staple food in Kiribati, Tuvalu. and other atoll countries, and an important supplementary staple in other areas of the Pacific. 2, 3(58753), 5, 6, 7.

Artocarpus heterophyllus Lam. "jakfruit", "jackfruit"
te mai rekereke (K)
syns. *A. integrifolia* sensu L.f.; *A. integer* sensu (Thunb.) Merr.

Pre-World War II introduction. Indomalaysia. Rare. Medium tree, 10 to 20 m high, with thick milky sap and young twigs with many long, rigid hairs which are often hooked at the apex; leaves, 5 to 25 cm long and 3 to 12 cm wide, alternate, oval or oblong, entire (sometimes 3-lobed on young trees), acuminate, acute or obtuse, base cuneate or obtuse, non-decurrent, dark-green, coriaceous, with stiff hairs; petioles, about 3.5 cm long; stipules, 1.5 to 8.5 cm long; male inflorescences, axillary or terminal spikelike clusters, 2.5 to 10 cm long and 1 to 3 cm in diameter, ellipsoid-clavate, terete, yellow or greenish yellow; female inflorescences, in globose or oblong heads which turn into fruit and which are borne on the trunk or older branches (cauliflorous or ramiflorous); fruit stalk 7 to 12 cm long; fruit, a syncarp, usually 30 to 40 cm long but occasionally up to 60 to 90 cm long and about half as wide, oblong cylindric, golden yellow to yellow-green, weighing up to 20 kg, rind studded with hexagonal bluntly conic carpel apices; inner flesh pulpy, waxy, whitish-yellow, acid or sweetish or fetid when over-ripe; seeds, 2 to 3 cm long, rounded, brown, enclosed in a slippery pulpy jacket. Planted fruit tree reported present by Burges in 1933; young tree seen in Topside Workshop food gardens in 1987. Ripe fruit eaten; immature fruit cooked as a supplementary staple in curries by Indians. *A. integrifolia* and *A. integer* are incorrect botanical names for the jakfruit and according to Corner (in *Gard. Bull. Straits Settlem.* 10:56-81, 1939), *A. integer* refers to a separate species, the champedak which is not present in Nauru, and *A. integrifolia* is an illegitimate name (Smith, 1981). 2,6.

Artocarpus mariannensis Trec. "Marianas breadfruit"
damenkamor (N); te mai kora (K); matua mei (T)

Aboriginal introduction? Micronesia. Occasional. Tree similar to *A. altilis*; leaves smaller, 10 to 30 cm long, half as wide, broadly obovate to broadly elliptic, acute to acuminate, entire to variously lobed in the upper part, but cutting usually not more than halfway to the midrib, usually less, with some leaves often quite entire, base cuneate, glabrous and somewhat shiny above, brown hairs on the veins and midrib beneath; petiole, up to 4.5 cm long, usually half this length; male spike, up to about 8 to 10 cm long; fruit, rather small, shortly cylindric, usually with several large seeds and somewhat scanty pulp. Planted staple fruit tree. Same uses as for *A. altilis*, but fruit of *A. mariannensis* eaten raw and cooked. 3(58755), 5, 6, 7.

Ficus benghalensis L. "banyan", "Indian banyan", "east Indian fig", "Vada tree"

Recent introduction. India. Occasional. Large spreading tree, up to 20 m or higher and often several times as wide, with milky latex and massive pillar roots, descending from branches, which extend the tree laterally, sometimes almost indefinitely;

leaves, 10 to 30 cm long and 5 to 20 cm wide, elliptic to ovate, obtuse, base usually cordate, glabrous (downy when young), leathery, with intercostal venation, the lateral nerves in 5 to 7 distinctly spaced pairs, the basal nerves elongate in 2 to 4 pairs; petioles, 1.5 to 7 cm long, not articulate to lamina; male inflorescences disperse; female inflorescences similar to fig (gall); fruit, a fig about 14 to 25 mm in diameter, axillary, paired, sessile or the body pedicellate, depressed-globose, orange-red, edible, the basal bracts well-developed, 10 to 14 by 3 to 7 mm; seeds, small, smooth. Planted ornamental tree on coastal strip; common on golf course. 3(58749), 5(53), 6, 7.

Ficus elastica Roxb. "Indian rubber tree", " rubber plant", "Indian rubber fig"

Recent introduction. India to Nepal and Malaya, perhaps southward to Java. Occasional. A large spreading, fast-growing banyan tree, up to 35 m high (usually much smaller as an ornamental), with smooth gray bark, copious aerial roots and milky latex; leaves, 10 to 40 cm long and 4 to 22 cm wide, elliptic to subobovate, short-acuminate, thick, stiff, leathery, glabrous, dark-green and shiny above, paler beneath, primary lateral nerves usually in 15 to 22 pairs, the secondary lateral nerves almost as prominent as the primary, leaves in bud enclosed in pointed, rolled, rosy, caducous sheaths; petioles, 4 to 12 cm long, not articulate to lamina; stipules large and conspicuous, pink to red; male flowers, disperse; figs, up to 12 by 9 mm, in pairs, short-ellipsoid or oblong, greenish-yellow, with a short thick peduncle usually 3 to 5 mm long and 4 to 6 mm thick, the basal bracts 3, early caducous. Planted ornamental tree or house plant in its juvenile form. 5, 6, 7.

Ficus prolixa Forst.f. var. **carolinensis** (Warb.) Fosb. "native banyan"
eaeo, eyayo, yayo (N)

Indigenous. Micronesia. Very abundant. Medium to large tree, 2 to 20 m high, with many aerial roots descending from branches; leaves, 8 to 16 cm long and 6 to 8 cm wide, alternate elliptic-oblong or oblanceolate, short acuminate, base cordate or subcordate, glabrous, primary nerves in 5 to 10 pairs; petioles, 0.8 to 3 cm long; male inflorescences ostiolar and disperse; figs, 5 to 10 mm in diameter, axillary, mostly solitary, subglobose, ripening white to pink and purple-black, with 3 slightly coherent rounded basal bracts, sessile or borne on peduncles up to 3 mm long. Common on plateau in areas of unmined forest, in older strip-mined areas, and on the escarpment and coastal strip, primarily on coral-limestone pinnacles and outcrops. *F. prolixa* seems to be one of the only species capable of long-term colonization of residual pinnacles in strip-mined areas and could become dominant in the disclimax vegetation. Berry-like fruit (*moduru*) eaten cooked and mixed with boiled sap (toddy or *karawai*) from the coconut flower spathe (*kamerara*) to make a dish known as *dedangan* or *dedengan* which can keep for two to four weeks, and, if cooked and dried in the sun, will keep for years if stored in a dry place; sap used as chewing gum (*ikumi*, *kumi*). 1, 3(58663), 5(19), 6, 7.

Ficus tinctoria Forst.f. var. **neo-ebudarum** (Summerh.) Fosb. "Dyer's fig", "native fig" debero (N); te bero (K); felo (T)

Recent introduction. S. E. Asia to Polynesia and Micronesia. Rare. Small dioecious tree, up to 8 m high, commonly with long aerial roots or prop-roots; leaves, about 8 to 15 cm long and 5 to 8 cm wide, ovate, with a slightly asymmetric base, dark green withering to a bright yellow with purplish veins, lateral nerves in 3 to 9 pairs; tepals, white; figs, about 12 mm in diameter, globose, yellowish turning dull reddish, borne on peduncles about 10 mm long. Planted food tree in Rev. J. Aigimea's garden. Fruit eaten cooked; fruit also cooked and mashed and mixed with boiled coconut syrup (*kamirara*, *kamerara*) to make a pudding (*dedengan*). Plant introduced from Kiribati, where it is a supplementary staple in many areas and a major staple in the drier islands of southern Kiribati. Use learned by some Nauruans from I-Kiribati, but recipe essentially the same as used by Nauruans for *F. prolixa*. 5(104), 6, 7(27808).

Ficus sp.

Recent introduction. Planted ornamental. Rare. 5 (197).

MORINGACEAE (Moringa Family)

Moringa oleifera Lam. "horseradish tree", "drumstick tree", "saijan", "seijan" (Hindi), malunggay (P)
syns. *Guilandina moringa* L.; *M. moringa* (L.) Millsp.; *M. pterygosperma* Gaertn.

Recent introduction. India. Occasional to common. Small soft-wooded tree up to 10 m high, with thick stems, corky, gummy bark and pungent roots; leaves, 20 to 60 cm long, alternate, bi-tripinnate, the pinnae and leaflets opposite; leaflets, 1 to 3 cm long and 5 to 18 mm wide, oval to obovate, sometimes faintly notches, somewhat grayish-green; inflorescences, shorter than the leaves, axillary, many-flowered, paniculate; calyx, 5-lobed, lobes imbricate, subequal, spreading or reflexed, white; corolla, about 1.5 to 2.5 cm across, 5-petaled, petals imbricate, shortly connate at base, unequal, the lowermost the largest, erect, the other reflexed, white, greenish proximally, fragrant; stamens 10, 5 with yellow anthers, perfect, epipetalous, the filaments free; fruit, 15 to 4 cm long, a 3-valved, pendent, podlike capsule, elongated, beaked, subtorulose, the valves thick, spongy with 9 blunt ribs; seeds, many, about 10 mm in diameter, 3-angled, winged at angles. Food plant in Indian home gardens on Meneng Terrace and in Filipino Gardens at Location. Nutritious leaves, fruit, and flowers cooked as vegetables by resident Filipino and Indian families. Very common food tree planted by Indians in Fiji. 5, 6, 7.

MYRTACEAE (Myrtle Family)

Eucalyptus sp. "eucalyptus", "gum tree"

Recent introduction. Australia. Rare. Tree with peeling bark; leaves, aromatic; flowers, petals absent, with numerous showy stamens; fruit, a woody capsule, opening by slits; seeds, small and numerous. Planted ornamental tree in Nauruan houseyard garden. 6.

Pimenta dioica (L.) Merr. "allspice"
syn. *P. officinalis* Lindl.; *Myrtus pimenta* L.; *M. dioica* L.

Recent introduction. C. America and W. Indies. Rare. Small to medium tree, 6 to 12 m high, with nearly smooth silvery-brown bark and brittle wood; leaves, 5 to 20 cm long and 2 to 8 cm wide, opposite, narrowly elliptic to elliptic-oblong, bluntly acute, obtuse to rounded at base, thick, coriaceous, glabrous, dark green above and paler and gland-dotted beneath, pinnately veined, mid-rib impressed above and prominent below, highly aromatic; petioles, usually 1 to 1.5 cm long; inflorescences, many-flowered, subterminal axillary (in axils of the upper leaves) cymose panicles, 5 to 15 cm long; pedicels, about 1 cm long, pubescent, with small brownish bracteoles; calyx, 4-sepaled campanulate with spreading persistent lobes about 2 mm long; corolla, about 8 to 10 mm in diameter, 4-petaled, petals, about 4 mm long, rounded, reflexed, white, spreading, caducous; stamens numerous, free; fruit, 5 to 7 mm in diameter, a small subglobose berry, dark purple when mature, with sweet pulpy mesocarp; seeds, usually 2, subglobose with a spiral embryo. Planted ornamental seedling in home garden. 6.

Psidium guajava L. "guava"
kuwawa (N); tekuwawa (K); kuava (T)
syn. *P. pomiferum* L.

Recent introduction? Trop. America. Common. Shrub or small, shallow-rooted tree, 2 to 10 m high, with smooth green, light reddish-brown or copper-colored bark, wide-spreading branches, and pubescent 4-angled or -winged young branches, often producing suckers from roots near base of trunk; leaves 5 to 15 cm long and 3 to 7 cm wide, opposite, ovate-elliptic or oblong-elliptic, acute-acuminate, base obtuse to rounded, dull green, pubescent beneath, often rather brittle, lateral veins 7 to 20 per side, slightly sunken above, prominent below; petioles, 2 to 10 mm long; inflorescences, axillary, solitary or in 2- to 3-flowered cymes; peduncle, about 1 to 2 cm long, pubescent; calyx, 4- to 6-lobed, campanulate, splitting irregularly, lobes 1 to 1.5 cm long, reflexed, pubescent, persistent; corolla, about 2.5 to 3 cm across, petals 4 or 5, elliptic to obovate, slightly concave, reflexed, white, slightly fragrant, fugaceous; stamens, numerous (about

200 to 250), white, about as long as petals, with yellow anthers; style, 1.5 to 2 cm long, filiform, greenish-yellow, exserted above stamens; fruit, 3 to 12 cm long, globose, ovoid or pyriform, surmounted with remnants of calyx lobes, shining pale green, whitish yellow or faintly pink when ripe, pulpy; pulp, granular-juicy, sweet-sour, light pink to reddish-pink or cream-colored, aromatic; seeds, many, 3 to 5 mm long, bony, reniform, yellowish to light brown, embedded in pulp. Occasionally planted or protected in home gardens; spontaneous on coastal strip and locally abundant in unmined forest on plateau and in mined areas. Wood an excellent firewood and makes good fishing poles; leaves used to treat diarrhea; ripe fruit eaten and made into jams. 3(58650, 58767), 4(105N), 5(94), 6, 7, 8.

Syzygium malaccense (L.) Merr. & Perry "Malay apple", "mountain apple"
apolo Solomona ("Solomon Is. apple")(T)
syns. *Eugenia malaccensis* L.; *Carophyllus malaccensis* (L.) Stokes; *Jambosa malaccensis* (L.) DC.

Recent introduction. S. E. Asia. Rare. Medium tree, 6 to 15 m tall; leaves, 10 to 38 cm long and 5 to 22 cm wide; opposite, elliptic to oblong-obovate, bluntly acuminate, base obtuse to acute, then abruptly decurrent on petiole, glossy, glabrous, paler beneath, obscurely punctate, thick-coriaceous, pinnately nerved, lateral nerves submarginally loop-connected 4 to 7 mm from margin; petiole, 8 to 15 mm long, stout, in young leaves reddish; inflorescences, dense few-flowered cymes, about 5 cm long, on defoliate older branches and on trunk; pedicels, 1 cm long or less; calyx tube, 1.5 to 2 cm long, turbinate, 4-lobed, lobes rounded, wider than long; corolla, 4 to 7 cm in diameter across expanded stamens, petals 4, 8 to 18 mm long, obovate, concave, red, fugaceous; stamens, many (about 125), 1 to 3.5 cm long, erect, red to vivid crimson-pink; anthers, small yellowish; style, nearly 2 cm long, dark red; fruit, about 6 to 8 cm long, obovoid or pyriform, crowned by inflexed calyx-lobes, glossy and slightly waxy in appearance, crisp-succulent, light green maturing to red or greenish-white or striped or mottled, usually 1-seeded; flesh, white, watery; seeds, about 2 cm across. Planted fruit tree seedling in Tuvaluan garden at Location. Common aboriginal introduction throughout most of high-island Melanesia and Polynesia, where the fruit is eaten. 5, 6.

NYMPHAEACEAE (Waterlily Family)

Nymphaea sp. "water lily"

Recent introduction. E. and S. Africa and Madagascar. Rare. Aquatic perennial herb with submerged rhizomes; leaves, peltate, floating, long-petiolate, arising from the rhizome; flowers, cup-like, solitary, regular, bisexual; calyx, 4-sepaled, the sepals, nearly free, intergrading into the petals; corolla, many-petaled, petals, overlapping, showy, variously colored from rich blue, pink, yellow to creamy-white; stamens, numerous, anthers introrse, opening by slits; carpels united into a multilocular ovary bearing a flat radiate stigma; seeds, hard, operculate, arillate. Planted ornamental in water tanks and in small household fish ponds. 3(58684), 4, 5(251).

NYCTAGINACEAE (Four-o'clock Family)

Bougainvillea glabra Choisy "bougainvillea", "red bougainvillea"
tsita, tsitta (N); te akanta (K); akanta (T)

Recent introduction. Brazil. Stout, woody scrambling or climbing vinelike shrub, with spiny, but less thorny than *B. spectabilis*; leaves, alternate, elliptic, acute at both ends, sparsely puberulent on both surfaces; inflorescences, axillary, nearly 2.5 cm long, in threes within 3 involucral bracts; bracts, ovate, commonly red, but variable in color, persistent; perianth 5-lobed, swollen, 5-angled below constriction, yellow to yellowish-white; fruit, 7 to 13 mm long, a glabrous anthocarp. Occasional. Planted ornamental. Flowers used by I-Kiribati in garlands. 3(58726), 5, 6, 7.

Bougainvillea spectabilis Willd. "bougainvillea", "purple bougainvillea"
tsita, tsitta (N); te akanta (K)

Recent introduction. Brazil or Peru. Occasional. Stout, woody scrambling or climbing vinelike shrub with stout axillary spines and the young growth finely pubescent; leaves, alternate, ovate, acute at both ends, tomentose beneath and often above; inflorescences, axillary, nearly 2.5 cm long, in threes within 3 involucral bracts; bracts, ovate, rich purplish-magenta to rosy pink, less commonly orange, pale yellow or white, veiny, persistent; perianth 5-lobed, tubular, indistinctly angled, yellow to yellowish white; stamens usually 8, unequal; fruit, 11 to 14 mm long, a 5-angled anthocarp, densely pilose, not sticky. Planted ornamental. Flowers used by I Kiribati in garlands. 5, 6, 7.

Mirabilis jalapa L. "four-o'clock", "marvel of Peru", "false jalap"
teoua, teowa (N); te aoaaua, te awaava (K)

Recent introduction? Mexico. Occasional. Erect, glabrous, somewhat succulent annual herb, up to 1 m tall, with tuberous roots; leaves, 5 to 10 cm long, opposite, ovate-lanceolate, apex long attenuate-acuminate, base broadly cordate; petioles up to 2.5 cm long; inflorescences, bisexual, in terminal clusters; perianth, 2.5 to 5 cm long, 5-parted, funnel- or trumpet-shaped, red, purple, yellow or various, fragrant, opening late in the afternoon; stamens, 5; fruit, 8 mm long, an anthocarp, hard, ribbed, black, not prickly or sticky. Planted ornamental; spontaneous in some places on coastal strip. Flowers used in garlands. 3(58784), 5, 6, 7.

Pisonia grandis R. Br. "pisonia"
yangis, yangys, yangits (N); te buka (K); puka, puka vai (T)
syns. *P. alba* Span.

Indigenous. Indopacific. Uncommon. Medium to large, soft-wooded tree with a stocky trunk and brittle, often wind-broken, branches; leaves, up to 20 cm or longer and 10 cm wide, opposite, elliptic or ovate, obtuse to acutish, base acute, thin, pale green, glabrous, pubescent along the midrib beneath, with numerous lateral veins; petiole, up to 5 cm or longer; inflorescences, small, in terminal cymose clusters; perianth 4- to 6-lobed, fragrant; stamens 5 to 13, unequal; style present; fruit, about 1 cm long, an anthocarp, fusiform or short-cylindric, with rows of short spines, glandular, very sticky. Tree in unmined plateau forest bordering escarpment above Anibare Bay and on unmined residual rocky limestone outcrops. Very brittle wood used in past as an inferior fuel; most important roosting habitat for noddy birds which are an important ceremonial food. 6, 7.

OLEACEAE (Olive Family)

Jasminum multiflorum (Burm.f.) Andr. "jasmine", "star jasmine"
rimone (N)
syns. *Nyctanthes multiflora* Burm.f.; *J. pubescens* Willd.

Recent introduction. India. Rare. Pubescent spreading, sometimes climbing shrub, 1 to 2 m high, with copiously pilose or tomentose branchlets; leaves, 2 to 6 cm long and 1.5 to 4 cm wide, opposite, ovate, acute, rounded or truncate to subcordate or cordate at base, pubescent on both surfaces or sometimes glabrate above; petiole, short; inflorescences, short, compact terminal clusters; calyx, 4- to 8-lobed, lobes, 8 to 18 mm long, subulate, densely pubescent with spreading yellowish hairs 8 to 18 mm long; corolla, about 2.5 cm across, tube 19 to 28 mm long, 4- to 9- lobed, lobes, 12 to 20 mm long, acute, white, tube greenish, fragrant to odorless; fruit, a berry, 2-lobed, 2-locular and 2-seeded. Planted ornamental. 5, 6.

Jasminum sambac (L.) Ait. "jasmine", "Arabian jasmine", "pikake" (Hawaii)
rimone (N); te bitati (K); pitasi (T); sampagita (P)
syn. *Nyctanthes sambac* L.

Pre-World War II introduction. India. Common. Pubescent, or somewhat downy, scrambling or sometimes climbing (scandent) shrub, up to 1 m or higher, with angular branchlets; leaves, 2 to 10 cm long and 1.5 to 6 cm wide, opposite, elliptic to ovate, acute or obtuse, base rounded or cuneate, nearly glabrous, with evident pinnate nerves, blades with axillary hair tufts beneath; petiole, short, arched, pubescent; inflorescences in few-flowered axillary clusters; calyx, about 2.5 cm across, 4- to 10-lobed, lobes about 6 to 7 mm long, linear, ciliate or glabrous; corolla, tubular, often double, tube about 15 mm long, the lobes, oblong to nearly orbicular, obtuse, as long as tube, white, fragrant; fruit a berry. Planted ornamental, especially in I-Kiribati and Tuvaluan gardens at Location; also in Nauruan gardens. Flowers used in garlands and for scenting oil. 3(58719), 5(18), 6, 7.

ONAGRACEAE (Evening Primrose Family)

Ludwigia octovalvis (Jacq.) Raven "swamp primrose", "willow primrose"
te mam (K); titania? (T)
syns. *Jussiaea suffruticosa* L.; *Oenothera octovalvis* Jacq.

Recent introduction. Pantropical. Rare. Erect, coarse, slender, branching perennial herb, 50 cm to 2 m high, with sparingly to densely pubescent and longitudinally-grooved stems which are somewhat woody at the base; leaves, 3 to 15 cm long and 0.5 to 2.8 cm wide, alternate, linear-lanceolate to ovate, acuminate or acute, base cuneate to acute, with 11 to 20 pairs of lateral nerves; petioles, up to 1 cm long; inflorescences, solitary, axillary, 2.5 to 3 cm across, borne on short pedicels, about 1.2 cm long with 2 small bracts near top; calyx, 4-lobed, lobes, 6 to 15 mm long and 1 to 7.5 mm wide, ovate-lanceolate to linear, persistent, sometimes red-tinged; corolla, 4-petaled, tubular, tube linear, about 2 cm long, petals, 5 to 17 mm long and 4 to 17 mm wide, broadly obovate or cuneate, emarginate (notched), yellow, caducous; stamens 8, 1 to 4 mm long (excluding anthers), alternately unequal; fruit, 1.7 to 6.5 cm long and up to 5 to 7 mm wide, a longitudinally 8- to 10-ribbed cylindrical 4-celled capsule with sepals persistent at apex, late dehiscent along the sides; seeds, 0.6 to 0.75 mm long, several-rowed in each cell, free, not embedded in endocarp. Weed in swampy area bordering mangroves in Meneng. 4 (150).

OXALIDACEAE (Wood Sorrel Family)

Averrhoa bilimbi L. "belimbi"

Recent introduction. Malaya to India. Rare. Small tree, 3 to 10 m high; leaves, up to 60 cm long, odd-pinnate with 15 to 41 pairs of leaflets; leaflets, 3 to 11 cm long and 1.5 to 3 cm wide, oblanceolate, acute-acuminate, a few proximal ones smaller than the distal leaflets; inflorescences, cauliflorous or ramiflorous, borne in fascicles on branches or trunk; calyx, 5-sepaled, sepals imbricate, yellowish-red to purple; corolla, 5-petaled, petals, 1 to 2 cm long, dark red, glabrous within, not cohesive; stamens 10, all with anthers; fruit, 5 to 10 cm long and 2 to 5 cm across, oblong-cylindric (cucumber-shaped), smooth, subterete, faintly 5-angled, yellowish-green, acid, crisp; seeds, 6 to 8 mm long and 4 to 6 mm across, embedded in pulp, exarillate. Three large trees planted near Indian homes on Meneng Terrace. Fruit eaten ripe; green and ripe fruit made into pickles by Indian families. 7.

Oxalis corniculata L. "yellow wood-sorrel", "creeping wood-sorrel"
syn. *O. repens* Thunb.

Pre-World War I introduction; reported by Schumann & Lauterbach (1901) as collected by Finsch. Paleotropical and paleosubtropical; now cosmopolitan. Rare. Procumbent, creeping, freely-branching, pubescent perennial herb, ascending to 10 to 20 cm high or decumbent, with several stems radiating from the main root, the individual stems rooting at the nodes and rarely exceeding 50 cm in length; leaves, usually less than 2.5 cm across, alternate, palmately trifoliate, clover-like, the terminal leaflet much larger than the lateral leaflets; leaflets, 4 to 20 mm long and wide, obocordate, deeply notched at apex, base obtuse, nearly pubescent; stipules, up to 3 mm long, united to base at petiole, inconspicuous; petioles, 1 to 8 cm long; inflorescences, 1- to 6-flowered umbels on axillary peduncles, 2 to 7 cm long; pedicels, 4 to 15 mm long, slender; bracts and bracteoles, 0.5 to 3 mm long, deltoid-linear; calyx, 5-sepaled, sepals, 2.5 to 6 mm long, lanceolate to narrowly ovate; corolla, 5-petaled, petals, 4 to 8 mm long, oblanceolate, yellow; stamens 10, in two series; fruit, 5 to 20 mm long and 2 to 4 mm across, an oblong, 5-locular, 5-angled, acute-tipped, pubescent capsule, opening by longitudinal valves; seeds, 5 to 10 per locule, each about 1.5 mm long, compressed, cross-ridged or wrinkled, brown. Weed at MQ 40 Command Ridge. 1, 6(163).

PASSIFLORACEAE (Passion Flower Family)

Passiflora coccinea Aubl. "scarlet passion flower"

Recent introduction. Trop. America. Rare. Climbing, tendril-bearing vine; leaves, up to 15 cm or longer, simple, ovate, toothed, woolly beneath; petioles, purplish, with no glands or 2 at base; inflorescences with striking scarlet petals, yeilowish on reverse, with filaments white at proximally, shading through pink to purple distally; fruit, about 5 cm in diameter, orange or yellow with green lines and spots, edible. Planted ornamental. 6.

Passiflora edulis Sims "passionfruit"

Recent introduction. Trop. America. Rare. Vigorous woody perennial climbing vine, up to 15 m long, with glabrous, grooved stems and axillary, spirally coiled tendrils; leaves, 10 to 15 cm by 12 to 25 cm, alternate, broadly ovate in outline, deeply palmately 3-lobed, lobes ovate-oblong, sharply acute to acuminate, sinus rounded, base cordate, serrate; petioles, 2 to 5 cm long, usually glabrous, grooved on upper surface, with 2 conspicuous glands near base of blade; stipules, about 1 cm long, lanceolate; inflorescences, axillary, 7 to 10 cm in diameter; peduncle, 2 to 5 cm long, triangular; bracts 3, 1 to 3 long and 1 to 2 cm wide, near apex of peduncle, leafy, ovate to lanceolate, serrate-glandular; calyx, 5-lobed, tubular at base, sepals, 2 to 3 cm long and 1 to 2 cm wide, ovate-oblong, spreading, reflexed, white above, yellowish-green below, spongy, fleshy, with thorn-like appendage near tip and 0 to 4 glands on margins; corolla, 5-petaled, petals, 2.5 to 3 cm long and 0.5 to 1 cm wide, elliptic, free, white, alternating with calyx, inserted on throat of calyx; corona of 2 outer rows of wavy, threadlike, radiating filaments, 2 to 3 cm long, white distally and purple or pink proximally, with several rows of short, purple-tipped papillae; stamens 5, filaments united in a tube around gynophore for about 1 cm then widely parted for 1 cm; anthers, 1 to 1.5 cm long, versatile, transverse, 2-celled, pale yellow, hanging downwards below level of ovary; fruit, 4 to 6 cm long, subglobose or ellipsoid, yellow or purple depending on the variety or form, rind hard, endocarp white; seeds, many, about 5 by 3 mm, compressed, testa blackish, 3-toothed at base, attached to peg-like funiculi on the ovary wall and surrounded by yellowish-orange, aromatic pulpy and juicy aril with a tart but pleasing flavor; seeds, pulpy aril and juice edible. Two small seedlings in home garden. Supplementary food plant in many parts of the Pacific and currently or formally an important cash crop in Niue, Fiji, W. Samoa, Hawaii and Papua New Guinea. 6.

Passiflora foetida L. var. **hispida** (DC.) Killip "stinking passion flower", "love-in-a-mist" oatamo, watamo (N); te biku (K)
syn. *P. hispida* DC. ex Triana & Planch.

Pre-World War II introduction. Trop. America. Occasional. Creeping or climbing perennial herbaceous vine, 1.5 to 5 m long, with weak, densely long-hispid, longitudinally-grooved stems, axillary coiled tendrils and fetid (bad smelling) foliage; leaves, 4 to 12 cm long and almost equally wide, simple, ovate or ovate-cordate in outline; palmately 3-lobed, the lobing shallow to halfway to the mid-vein, lobe apices acute, base subcordate, margins unevenly dentate or entire, both surfaces hispid-hirsute; petioles, 2 to 6 cm long, pubescent; stipules, laciniate, the divisions filiform; inflorescences, 2.5 to 5 cm across, solitary, axillary; pedicels 2 to 7 cm long; involucral bracts prominently 2- or 3-bipinnatifid; calyx, 5-lobed, tubular, sepals oblong, mucronate, inside white; corolla, 5-petaled, petals, 1.5 to 2.5 cm long, oblong, white; stamens 5, pale green, surrounded by a ring-like corona of filaments, 9 to 15 mm long, white distally and purple to rich-blue proximally; fruit, 1.5 to 2.5 cm in diameter, subglobose to ovoid, yellowish-orange to red-orange, often with faint greenish vertical lines, leathery, thin-walled, surrounded by pinnatifid involucral bracts, tardily dehiscent; seeds, many, surrounded by scanty, slimy, sweetly-tart yellowish-orange pulpy aril, edible. Weed, generally on plateau, but also on escarpment and coastal strip, along roadsides and in ruderal habitats. Scanty pulpy aril and seeds eaten by children. 2, 3(58592), 4(117N), 5(54), 6, 7, 8(9581).

PIPERACEAE (Pepper Family)

Peperomia obtusifolia (L.) A. Dietr. "jade plant", "baby rubber plant"
syn. *Piper obtusifolia* L.

Recent introduction. W. Indies and Florida. Rare. Erect or decumbent, spreading, branching, succulent perennial herb, up to 20 cm high, with reddish stems; leaves, 3 to 10 cm long and 2 to 6 cm wide, alternate, oval to inverted-ovate, obtuse, apex sometimes notched, base decurrent to cuneate, glabrous, shiny, dark green above pale below, succulent; petioles, 1 to 3 cm long, reddish; inflorescences, erect spikes, 5 to 15 cm or longer, green, bearing minute sessile flowers; stamens 2. Pot plant. 3(58691), 6, 7.

Peperomia pellucida (L.) HBK. "peperomia"
syns. *P. pellucidum* L.; *P. lineata* Miq. ex Yuncker

Recent introduction. Trop. America. Rare. Pale, erect or reclining, fleshy, glabrous, weak-stemmed perennial herb, 15 to 30 cm high, with branched stems; leaves, 1 to 3.5 long, alternate, ovate-cordate, acute to acuminate, base rounded to cordate or cordate-truncate, glabrous, shiny above dull beneath; petioles, 3 to 12 mm long; inflorescences, slender leaf-opposed or terminal spikes, 2 to 5 cm long, bearing minute, well-separated green sessile flowers; calyx and corolla absent; stamens 2; ovary subtended by a minute bract; fruit, less than 1 mm in diameter, a green globose, rostellate (beaked) drupe with longitudinal ribs, containing a single warty seed. Weed of pot plants in homes. 5(7), 6, 8.

POLYGALACEAE (Polygala Family)

Polygala paniculata L.

Recent introduction. Trop. America. Rare. Slender, erect, profusely-branching annual herb, 10 to 60 cm tall, with glandular-pubescent stems and a tuberous, yellow, strongly aromatic tap-root with the scent of peppermint or wintergreen; leaves, 1 to 2.5 cm long and 2 to 4 mm wide, linear-lanceolate, in whorls of 5 caducous leaves below and spirally arranged above; inflorescences, slender terminal racemes, 2 to 15 cm long, bearing numerous crowded small flowers, 2 to 3 mm long; calyx, 5-parted, the two inner sepals resembling wings and much larger than the others and resembling petals; corolla, 3-petaled, the upper pair rather narrow, the lower (keel) boat-shaped; petals and inner sepals at first white, becoming purplish or pinkish with age; stamens 8; fruit, about 2 to 3 mm long, oblong, glabrous, not winged; seeds, about 1.5 mm long, oval-oblong, black with tiny white hairs and a 2-lobed whitish caruncle. Weed along Topside running track and in other waste places. 5, 6(203), 7.

POLYGONACEAE (Buckwheat Family)

Antigonon leptopus Hook. & Arn. "Mexican creeper", "mountain rose", "confederate vine", "chain of love", "love vine", "hearts on a chain", "coral vine"

Recent introduction. Mexico. Occasional. Perennial herbaceous climbing to scrambling vine with slender glabrous stems, axillary tendrils and tuberous roots; leaves, 5 to 12 cm long, alternate, broadly ovate, cordate, apiculate to acuminate, net-veined, wrinkled and wavy-edged; petioles, 1 to 5 cm long; inflorescences, long, slender, loose, 6- to 15-flowered racemes which end in branched tendrils; pedicels about 1 cm long; flowers about 13 mm long; tepals 5, rose pink or white with a darker center, becoming membranous, greenish, reticulate-veined; fruit, up to 1.5 cm long, a triangular, brownish achene; seed, longitudinally grooved. Planted ornamental and spontaneous in waste places and ruderal habitats. 3(58679), 5(59), 6, 7, 8(9562).

Coccoloba uvifera (L.) Jacq. "sea grape"
syn. *Polygonum uvifera* L.

Recent introduction. Trop. America. Rare. Small glabrous tree, up to 8 m or higher, with thick branchlets and spreading branches; leaves, 10 to 20 cm across, usually broader than long, alternate, suborbicular, cordate, firm, coriaceous, glossy, glabrous, the midrib and lateral nerves reddish; inflorescences, erect spike-like racemes, about 15 cm long; individual flowers with 5 tepals, 8 stamens and 3 styles, greenish-yellow, fragrant; fruit, about 1 cm across, a subglobose or pyriform, reddish berry-like drupe, sweetish-acidic, astringent, edible. Planted ornamental near Buada Lagoon. 3(58787), 6.

PORTULACACEAE (Purslane Family)

Portulaca grandiflora Hook. "portulaca", "purslane", "pigface"

Recent introduction. Brazil. Rare. Decumbent, succulent, annual herb, up to 15 cm high, with tufts of white silky hairs at the nodes and just below the flowers; leaves, 12 to 35 mm long and 1 to 4 mm wide, narrowly cylindric or subterete; inflorescences, terminal; calyx, 2-lobed, sepals, 5 to 12 mm long, connate; corolla, 2 to 3 cm across, 4- to 6-petaled, petals, 12 to 30 mm long, pink, red, yellowish, white or striped; stamens, many (40 to 75); fruit, about 5 mm in diameter, a membranous capsule, circumscissile (dehiscent by a hemispherical lid). Planted ornamental. 3(58659), 5, 6, 7.

Portulaca oleracea L. "pig weed", "purslane", "wild purslane"
debois, doboiy (N); te boi (K); katuli (T)

Pre-World War II introduction. Europe. Occasional. Prostrate, spreading, fleshy, glabrous herb, up to 30 cm high, branching at base with branches sometimes reddish; leaves, 4 to 30 mm long and 3 to 12 mm wide, alternate or clustered at branch ends, obovate, spathulate or oblong-cuneate, obtuse to slightly notched, base cuneate, fleshy, flattened, dull green or reddish, subsessile; inflorescences, terminal, sessile, few-flowered; calyx, 2-lobed, sepals connate; corolla, usually 5-petaled, petals yellow, withering early; stamens 7 to 15; fruit, about 4 mm long, a membranous capsule, circumscissile (dehiscent by a hemispherical lid); seeds, numerous, small, black, slightly roughened. Weed in gardens and waste places, especially in sandy, hydromorphic soils of the shores of Buada Lagoon. Cooked leaves and stems eaten after pounding and mixing with coconut flower spathe syrup (*kamerara*); important famine food during World War II; plants fed to pigs; leaves and stems boiled with water being used to cure scabies. 3(58624, 58734), 5(4), 6, 7, 8.

RHAMNACEAE (Buckthorn Family)

Colubrina asiatica (L.) Brongn. "soapbush", "hoop withe"
ewongup (N)
syns. *Ceanothus asiaticus* L.; *Ceanothus capsularis* Forst.f.

Indigenous. Paleotropical. Common. Sprawling or climbing, much-branched shrub or small tree, 1 to 5 m high; leaves, mostly 4 to 11 cm long and 1 to 6.5 cm wide, alternate, ovate, acuminate, base rounded or subcordate, finely crenate-dentate, glossy green, nearly glabrous, palmately 3-to 5-nerved, the midrib branched upward; petioles, 1 to 3 cm long; inflorescences, small, axillary short-pedunculate, 3- to 7-flowered, compact, cymose clusters; peduncles less than 3 mm long; pedicels, about 3 mm long, slender; calyx, 5-sepaled, sepals acute, white to pale or dull yellow; corolla, 5-petaled, petals hoodlike, green to yellowish-green or whitish; stamens 5, less than 1 mm long; disc, broad, saucer-like, greenish-yellow to yellow-orange; fruit, 6 to 8 mm in diameter, depressed-globose, 3-celled, green or brown; seeds 3 (1 per cell), nearly 5 mm long, dark brown or black. Found in forests on plateau and on cliffs and slopes and at base of escarpment. Rolled leaves used with flowers of other species in garlands. A traditional source of soap in other Pacific islands, although not reportedly used for this purpose on Nauru. 2, 3(58641), 4(113N), 5(69), 6, 7.

RHIZOPHORACEAE (Mangrove Family)

Bruguiera gymnorrhiza (L.) Lam. "brown mangrove"

etum, etam (N); te tongo, te tongo buangui (K)

syns. *Rhizophora gymnorhiza* L.; *R. conjugata* L.; *Bruguiera gymnorhiza* Savigny; *B. rheedii* Bl.; *B. eriopetala* W. & Arn.; *B. conjugata* (L.) Merr.

Indigenous. Indopacific. Occasional. Medium tree, 3 to 15 m tall (in Nauru rarely over 4 m), with an inconspicuously buttressed trunk, knee-like pneumatophores, dark fissured trunk bark, and smooth-barked slightly nodose stems; leaves, 9 to 20 cm long and 4 to 9 cm wide, opposite, elliptic-oblong, acute-acuminate at both ends, base decurrent, thick-coriaceous, quite glabrous, somewhat glossy dark green; petioles, up to 4 cm or longer; stipules, to 3.5 cm long, linear-lanceolate, reddish, sheathing the new leaves, caducous; inflorescences, solitary, axillary, somewhat nodding, up to 3 or 4.5 cm across, on pedicels 1 cm long; calyx, 10- to 14-lobed, firm, glossy red to dull yellow or yellow-green, lobes, about 1.5 cm long, slender-subulate or very narrowly-lanceolate, as long as tube; corolla, 10- to 14-petaled, petals 3 to 5 cm long, narrowly oblong, notched at apex, white fading to brown, each lobe bristly; stamens, many (or as few as 20), about 1 cm long; anthers, 4 to 5 mm long, linear; pollen dirty white; styles nearly 2 cm long, pale green; fruit, 2 cm long and 1.5 cm thick, turbinate, crowned by calyx limb; seed germinating on tree to form an elongated, somewhat extruded, cylindric radicle, reaching 15 to 25 cm long before falling. Localized in system of brackish lakes or lagoons near base of escarpment in Meneng, Anabar and Anetan District (lake in Anabar known as Araro); reportedly present in Buada Lagoon in the past. Strong wood excellent for house construction; pre-germinated seed (fruit) eaten cooked, after scraping, drying in the sun and then boiling; the Nauruan delicacy known as *etum* or *etam*, is prepared by mixing the grated pre-germinated seed with coconut milk and then baking; skin of seed used to prepare a black dye for traditional skirts (*ridi*). 2, 3(58746), 4(167N), 5(103), 6, 7.

ROSACEAE (Rose Family)

Filipendula rubra (J. Hill) B.L. Rob. "queen of the prairies"

Recent introduction. Central U.S. Hardy, clump-forming, perennial herb, up to 60 cm high; leaves, compound, up to 20 cm or longer; inflorescences, large, feather-like, compact, many-flowered, irregular panicles, 15 to 30 cm wide, bearing many small peach-pink flowers. Rare. Planted ornamental. 6.

Rosa damascena Mill. "damask rose"
dorot ("the rose")(N); te roti ("the rose")(K)

Recent introduction. W. Asia. Occasional. Erect, robust, aculeate shrub, up to 2 m high, with stems bearing numerous prickles or small thorns; leaves, pinnate, with 5 to 9 leaflets; leaflets, 7 by 5 cm, ovate-oblong, puberulent beneath on the midrib; inflorescences, clustered, 6- to 12-flowered corymbs, with bristly pedicels and receptacles; calyx, 5-sepaled, imbricate in bud; corolla, 5-petaled (sometimes more), red or pink, fragrant; stamens and ovaries numerous; hypanthium pilose within; fruit, a 1-seeded achene included by the fleshy, colored fruitlike hypanthium. Planted ornamental. 5(80), 6.

RUBIACEAE (Coffee Family)

Aidia cochinensis Lour.
enga, enguh (N)
syns. *Randia cochinchinensis* (Lour.) Merr.; *R. racemosa* (Cav.) F.-Vill.; *Stylocoryna racemosa* Cav.; *Randia graeffei* Reinecke; *Stylocoryna densiflora* (Wall.) Miq.; *Randia densiflora* (Wall.) Benth.

Indigenous. Trop. Asia to Pacific Is. Rare, possibly extinct. Small, glabrous tree or shrub, 1 to 2 m high, with smooth stems; leaves, 9 to 18 cm long and 3 to 6 cm wide, opposite, oblong-lanceolate to elliptic-ovate, acute or acuminate, base acute-decurrent or attenuate, thinly coriaceous, rather glossy, pinnately nerved; petioles, 0.5 to 2 cm long, ridged by decurrent leaf-blade margins; stipules, small, connate; inflorescences, axillary, rather dense, many-flowered, rather richly-branched, short-pedunculate, cymose clusters, up to 4 to 6 cm or longer, but not longer than the adjacent leaf, glabrous or minutely puberulent; bracts shortly deltoid; calyx, short, 5 (rarely 4-)-toothed; corolla, usually 5-lobed, tube and lobes about equally long, about 1.5 by 3 mm, creamy-white, throat pubescent; stamens 4 to 5 , inserted on corolla tube; anthers, linear, exserted, nearly as long as corolla lobes; style, rather thick, exserted, 7.5 mm long; fruit, 5 to 9 mm long, globose, reddish to purplish, edible, with several to many seeds, crowned by calyx remnant. Rare shrub with edible fruits in escarpment forest. Ripe fruit eaten, especially by children. 2(K9), 6(165).

Gardenia augusta (L.) Merr. "gardenia"
syns. *Varneria augusta* L.; *Gardenia florida* L.; *G. jasminoides* Ellis; *G. radicans* Thunb.

Recent introduction. China. Rare. Erect shrub, 1 to 2 m or higher; leaves, 4 to 12 cm long, and 1 to 4 cm wide, opposite, ovate, oblong-lanceolate or elliptic obovate, acute or somewhat acuminate, decurrent at base on short petiole, somewhat glossy, dark green; petioles, 1 to 8 mm long, winged by decurrent leaf-blade margins; stipules, often split nearly to base with a single unilateral lobe, but sometimes bilobed; inflorescences, axillary, solitary; calyx 5- to 7-winged, terminated by linear-lanceolate spurs, 15 to 30 mm long and 1.5 to 6 mm wide; corolla, 6 to 8 cm across, 6-petaled (double cultivars with additional petals), tube 5 to 9 cm long, white aging yellow-brown, very sweetly fragrant; stamens 5 to 11; fruit, 2 to 3 cm long, ovoid, 5- to 6- ribbed, crowned by calyx, many-seeded. Planted ornamental. 6, 7.

Gardenia taitensis DC. "Tahitian gardenia", tiare Tahiti (Tahiti)
te tiare (K); tiale, siale (T)

Recent introduction. Pacific Is. Rare. Large shrub to small tree, up to 5 m tall; leaves, 6 to 18 cm long and 3 to 10 cm wide, opposite, elliptic-obovate, obtusely short-pointed, base cuneate, somewhat glossy or shiny, bright green, prominently pinnately nerved, midrib very prominent; petiole, winged by decurrent leaf-blade margins, the petiole bases of leaf-pairs joined together by stipules; petioles, usually less than 5 mm long; stipules, connate, bilobed; inflorescences, solitary, in upper leaf axils; calyx, prominently 4-lobed, lobes 11 to 30 cm long and 2 to 8 mm wide, lanceolate; corolla, 4 to 8 cm across, 4- to 8-petaled, petals, up to about 3 or 4 cm long, spreading from a tubular base, about equalling tube, bright white, very fragrant; fruit, about 2 to 2.5 cm in diameter, globose, longitudinally ridged. Planted ornamental in Tuvaluan garden at Location. Fragrant flowers used in garlands and to scent coconut oil. 6, 7.

Gardenia sp. "Professor Pucci gardenia"

Recent introduction. Origin. Rare. Planted ornamental. 6.

Guettarda speciosa L. "guettarda"
iut, yut (N); te uri (K); pua, puapua, uli (T)

Indigenous. Trop. Asia to the Pacific Is. Small spreading tree, 4 to 15 m high, with thick branchlets; leaves, 10 to 25 cm long and 6 to 18 cm wide, opposite, broad-obovate, acute-subacuminate to obtuse, rounded or emarginate, base obtuse to subcordate, rather dark green above, paler and usually puberulent beneath, with 7 to 10 pairs of prominent lateral nerves; petioles, 2.5 to 4 cm long, pubescent, leaving large scars on the twigs when they fall; stipules, small, ovate, leaf-like, at nodes between leaf-pair petiole bases; inflorescences, compact, forked, many-flowered cymose clusters on axillary peduncles, 5 to 10 cm long, usually forming after leaf-fall; calyx, about 1 cm long, cupulate, truncate, pubescent; corolla, tubular, 2.5 to 5 cm long and 2 to 3 cm across the limb, 5- to 6-petaled, dull or yellowish white, fragrant, villous within; flowers dimorphic, some with short styles not reaching the anthers, others with exserted styles; fruit, 2 to 3 cm in diameter, a woody, depressed-globose, 4- to 9-chambered drupe with a circular rim at apex, whitish, pinkish or green when ripe, faintly ribbed, usually 4- to 6-seeded. Occasional in woods and thickets on coastal strip, but less common in forest on plateau near escarpment; common in regrowth in older strip-mined areas; planted in home gardens. Straight pieces of timber make excellent house rafters and used for canoe parts and handicrafts; bark scraped and mixed with other plant extracts, eg., *Scaevola taccada* (*emet*) and *Cordia subcordata* (eongo) to produce a medicine for beriberi; leaves used to parcel food and as plates; flowers used in garlands and decorations, often after soaking in coconut oil; flowers considered the best for scenting coconut oil; juice from flowers used as a deodorant; flowers and young leaves soaked in water to make a love potion, which is drunk by women and which when sweating, makes men go crazy (reportedly learned from I-Kiribati); juice of flowers mixed with coconut juice used to keep hair healthy. 2, 3(58759), 5(70), 6, 7(27806).

Hedyotis corymbosa (L.) Lam.
syn. *Oldenlandia corymbosa* L.

Recent introduction. Pantropical. Rare. Much-branched, annual herb, up to 20 cm high, with slender ascending or erect, bluntly 4-angled stems; leaves, 1 to 4 cm long and 1.5 to 8 mm wide, opposite, linear-oblong or narrowly elliptic, acute at both ends, blade pale beneath, midrib prominent, chartaceous, subsessile or petiole very short; stipules fused to petioles; inflorescences, 2- to 8-flowered axillary cymes which are shorter than the leaves; pedicels, 4 to 8 mm long, slender; calyx, about 2 mm long, 4-lobed, not exceeding ovary; corolla, about 2 mm long, white or faintly pinkish-purplish; stamens inserted just above the base of the tube; fruit, about 2 mm by 2 mm, a 2-celled capsule, exalate, flattened at apex, slightly laterally compressed, with several seeds per cell, dehiscent by valves at apex. Weed in waste places and ruderal habitats. 4(140N), 5(143), 6, 8(9560).

Ixora casei Hance "ixora"
te katuru, te katiru (K); suni (T)
syns. *I. duffii* Baine; *I. duffii* T. Moore; *I. carolinensis* Hosok.; *I. confertiflora* Val. non Merr.; *I. volkensii* Hosok.; *I. pulcherrima* Volk.

Recent introduction. Caroline Is. (Southeast Asia?). Occasional. Large shrub, up to 3 m or higher; leaves, up to 30 cm long, opposite, narrow-oblong, acute, dark-green glossy, glabrous, short-petiolate; stipules, interpetiolar, entire, acuminate; inflorescences, many-flowered, terminal cymose clusters, about 20 cm in diameter, not at all fragrant; calyx, tiny, 4-toothed; corolla, about 5 cm long, tubular, 4-lobed, lobes, ovate, more or less acute, spreading, twisted spirally in bud, deep vermilion-red to scarlet; stamens 4; fruit (rare), a 2-seeded, berry-like drupe. Planted ornamental in Nauru, but reportedly wild in Palau, Chuuk (Truk) and Pohnpei (Ponape) and Kosrae (Kusaie). 3(58707), 5, 6, 7.

Ixora coccinea L. "ixora", "flame of the woods"
syn. *I. fraseri* Hort. ex Grant

Recent introduction. Southeast Asia. Occasional. Small shrub, up to 2.5 m high; leaves, 3 to 10 cm long and 2 to 5 cm wide, opposite, oblong-obovate or subcordate and slightly amplexicaul, obtuse, coriaceous, sessile; inflorescences, dense terminal corymbose clusters; calyx, 4-toothed, puberulent; corolla, up to 5 cm long, tubular, 4-lobed, lobes 10 to 15 mm long, ovate-lanceolate, acute, red, orange-pink or yellow; stigmas, 3 to 4 mm long, red; fruit, a 2-seeded berry-like drupe. Planted ornamental. 5, 6(202).

Ixora sp. "ixora"

Recent introduction. Rare. Planted ornamental. 5, 6(196).

Morinda citrifolia L. var. **citrifolia** "beach mulberry", "Indian mulberry"
deneno (N); te non (K); nonu (T)
syn. *M. indica* L.

Indigenous. Trop. Asia and Australia to S.E. Polynesia. Common. Shrub or small tree, up to 6 m or higher, with quadrangular branchlets; leaves, 15 to 30 cm long and 6 to 18 cm wide, opposite, broadly elliptic or slightly obovate, acute or obtuse, dark green, glossy, pubescent when young; petioles, 1 to 2 cm long, narrowly ridged by decurrent leaf-blade margins; stipules, interpetiolar, sheathing, large, connate, deltoid, sometimes bifid; inflorescences, axillary, solitary, fleshy, headlike clusters, up to 2.5 cm long, irregularly subglobose on peduncles, 2 to 3 cm long; calyx, truncate; corolla, about 1 cm long, pilose in the throat, usually with 5 acute lobes about 5 mm long, pure white; anthers included or slightly exserted; style about 1.5 cm long; fruit, 4 to 12 cm long, a globose-ovoid, fleshy, compound drupe (syncarp) containing 1-seeded pyrenes, somewhat waxy, shiny, creamy to yellowish-white; flesh, strongly fetid and gelatinous, but edible when ripe; seed, bony. Common to abundant on coastal strip, often protected or planted around homes and in waste areas; occasional in plateau forest and in older strip-mined areas. Plants kept around homes to ward off evil spirits; small pieces cut up and rubbed on hands, face, etc., to ward off evil spirits; roots ground to provide a yellow dye; ripe fruit eaten raw, but far more common eaten in the past; fruit cooked and mixed with coconut syrup to make pudding (*dedangan*); fruit and branches cooked to eliminate evil smells, especially after war; roots and branches crushed and squeezed to cure rashes, fruit and roots ground and cooked to cure headaches, tender leaves heated up with coconut oil and used as a poultice to suck puss out of boils (*ibir*, *ibur*), raw fruit ground and drank as a cure for diabetes, and fruit cooked and used as a cure for dysentery. Plant also a very important medicinal and multi-use plant in Kiribati and Tuvalu. In Kiribati, where there have been recent outbreaks of vitamin A-deficiency-induced nightblindness among young children, programs encouraging mothers to feed children the cooked leaves of vitamin A-rich *M. citrifolia* have reportedly improved the situation. 2, 3(58754), 5(98), 6, 7(27807).

Mussaenda erythrophylla Schum. & Thonn. "red mussaenda"

Recent introduction. Trop. Africa. Rare. Shrub or liana, 2 to 4 m high, often with drooping or climbing branches and copiously pilose branchlets; leaves, 5 to 12 cm long and 3 to 8 cm wide, oval-ovate to almost cordate (when young), acuminate, base obtuse to slightly decurrent, copiously pilose, prominently veined; petioles, 1 to 6 cm long; stipules, interpetiolar; inflorescences, terminal, several-flowered, branched, corymbose cymes; calyx, 5-lobed, one of the lobes (rarely 2) enlarged, petal-like, up to 9 cm long and 6.5 cm wide, ovate-lanceolate, lax-pendant, bright red above and somewhat paler beneath, palmately veined, pubescent, the other lobes, up to about 1 cm long and 2 mm wide, narrowly linear-lanceolate, caducous, bright red, calyx tube reddish-pubescent; corolla, about 2.5 cm long, tubular, 5-lobed, red-pubescent outside with tube white or pale-yellow within distally; stamens 5, included; fruit, a berry with numerous minute seeds; Planted ornamental. 6(195).

Mussaenda frondosa L. "mussaenda"
syn. *M. sericea* Bl.

Recent introduction. Trop. Africa and Madagascar to S. Asia. Rare. Erect shrub, up to 4 m or higher, with drooping or rambling branches; leaves, 5 to 18 cm long and 3 to 7 cm wide, opposite, ovate to lanceolate, acuminate, base obtuse, rounded or decurrent, puberulent; petioles, 1 to 3 cm long; stipules, concealing a band of hairs, caducous; inflorescences, terminal corymbose cymes; bracts and bracteoles caducous; calyx 5-lobed, one of the lobes (rarely more) enlarged, petal-like, foliaceous, colored, white or pink; corolla, mostly 2 to 3 cm long, tubular, 5-lobed, dark-yellow to orange; stamens 5, included, anthers normal but always devoid of pollen in "female", long-styled flowers; fruit, 1 to 1.5 cm long, a berry, ellipsoid, truncate at base, black when ripe, seeds, numerous, reticulate. Planted ornamental. 6(248).

Pentas bussei K. Kr. "red pentas", "red star cluster"

Recent introduction. Trop. Africa? Rare. Planted ornamental. 3(58675), 6.

Pentas lanceolata (Forssk.) K. Schum. "pentas", "Lady Fletcher", "Egyptian star cluster"
syns. *Ophiorrhiza lanceolata* Forsk.; *Pentas carnea* Benth.

Recent introduction. Trop. Africa, Madagascar, Comorro Islands and Arabian Peninsula. Occasional. Erect, pubescent, sometimes straggling, perennial herb or subshrub, up to 80 cm high; leaves, 2.5 to 15 cm long, opposite, ovate, acute to acuminate, pubescent; inflorescences, up to 7.5 cm across, terminal, open, headlike, corymbose clusters; corolla, long-tubular, commonly 5-lobed, lobes, acute, mauve or rich purple to pink and white, with a white-bearded throat; fruit, about 4 mm long, obovoid, capsular with minute seeds. Planted ornamental. 3(58689), 5, 6(233,166), 7.

Spermacoce assurgens R. & P. "buttonweed"
syns. *S. suffrutescens* Jacq.; *Borreria laevis* sensu auct. plur. non (Lam.) Griseb.

Recent introduction. S. Asia. Uncommon. Decumbent or ascending, perennial herb, up to 40 cm high, with slender, wiry, somewhat angled stems and slightly woody and branching near the base; leaves, 2 to 6 cm long and about 0.5 to 2 cm wide, elliptic-lanceolate, sharply acuminate, base cuneate, pinnately nerved, nerves prominent, scabrid near margin but otherwise glabrous, subsessile; stipules, connate, with filamentous processes, interpetiolar, fused to the leaf-stalks; inflorescences, in axillary verticillate headlike clusters; calyx, small, 4-lobed, lobes ovate; corolla, 1.5 to 3.5 mm long, infundibular, 4-lobed, lobes, spreading, white or pink-tinged; stamens 4, exserted from the corolla, with white filaments and pale blue or bluish-tinged anthers; style, pink and white-tinged; fruit, 1 to 4 mm long, 2-seeded, enclosed in calyx, finally splitting; seeds, 1.5 to 2 mm long, oblong, brown, transversely ridged, still clasped by the half-calyx with part of the septum. Weed in waste places and houseyard gardens. 5(2), 6.

Tarenna sambucina (Forst.f.) Dur. ex Drake
syns. *Coffea sambucina* Forst.f.; *Stylocoryna sambucina* (Forst.f.) A. Gray; *Tarenna glabra* Merr.

Indigenous? New Caledonia to S.E. Polynesia and Micronesia. Extinct? Small glabrous or minutely puberulent shrub or small tree, 1.5 to 12 m high, with 4-angled young branches; leaves, 10 to 20 cm long and 5 to 9 cm wide, opposite, narrowly-elliptic or ovate-elliptic, acute at both ends, attenuate to petiole, membranaceous or thin-coriaceous, lateral nerves usually 7 or 8 pairs; petioles, 1 to 4 cm long; stipules, interpetiolar, deltoid, entire, persistent; inflorescences, terminal, many-flowered corymbose cymes; calyx, about 2 cm long, 5-lobed; corolla, 6 mm long, funnelform, creamy-white turning yellowish, villous within, fragrant; stamens 5; style exserted 3.5 mm long, anthers white, the style greenish to white; fruit, 5 to 6 mm in diameter, a globose berry, green turning purplish-black; seeds, about 8, each 2 mm long, 4-sided. Reported present by Burges in 1935, but not collected since. 2.

RUTACEAE (Rue Family)

Citrus aurantifolia (Christm.) Swingle "lime"
derem, deraim (N); te raim (K); laim, tipolo (T)
syn. *Limonia aurantifolia* Christm.

Pre-World War II introduction. Malesia. Occasional. Small, much-branched tree, 2 to 6 m high, with copious short, stiff, sharp spines; leaves, 4 to 10 cm long and 4 to 6 cm wide, alternate, usually ovate-elliptic but variable in different cultivars, margins somewhat crenulate; petioles, 5 to 18 mm long and 1.5 to 6 mm wide, spathulate, narrowly-winged, leaflike, articulate with leaf blades; inflorescences, axillary, 1- to 7-flowered, produced over an extended period, 2 to 2.5 cm in diameter; corolla, small, 4- to 5-parted, 8 to 12 mm long and 2.5 to 4 mm wide, white to pale pink; stamens 20 to 25; ovary 9- to 12-locular; fruit, 2.5 to 6 cm in diameter, ovoid to subglobose, green to yellowish when ripe depending on the cultivar; peel, thin, 1 to 3 mm thick, glandular, adherent; pulp greenish, juicy, very acid but pleasantly fragrant in some cultivars; seeds, small, oval, flattened angular, pale yellow or whitish. Planted fruit tree. Juice of fruit used to marinate raw fish and to make drinks. 3(58695), 5, 6(221), 7.

Citrus limon (L.) Burm.f. "lemon"
te remen, te remon (K); moli, laim (T
syns. *C. medica* var. *limon* L.; *C. limonum* Risso; *C. limonia* Osbeck

Pre-World War II introduction. E. Asia. Rare. Small tree or shrub, 2 to 9 m high, with stout, stiff spines; leaves, 5 to 10 cm long and 3 to 6 cm wide, alternate, long-ovate, acute, serrate; petioles, 0.5 to 1 cm long, very narrowly winged or margined, cordate, clearly articulate with leaf blades; inflorescences, axillary, solitary or few, 3.8 to 5 cm in diameter; corolla, usually 5-parted, petals white within but pinkish or purplish-tinged outside and when in bud; stamens 20 to 40; ovary 8- to 10-locular; fruits, 5 to 12 cm long, ovoid or ellipsoid, 8- to 10-locular, with a broad apical papilla or nipple; peel, about 5 mm thick, adherent, prominently gland-dotted, slightly rough, green to bright yellow when ripe depending on the cultivar; pulp, pale yellow, juicy, sour; seeds, ovoid, white. Planted fruit tree. Reportedly more abundant in the past. Juice used to marinate raw fish and to make drinks. 5, 6, 7.

Citrus reticulata Blanco "tangerine", "mandarin orange"
syns. *C. deliciosa* Ten.; *C. nobilis* Lour. var.

Recent introduction. Rare. E. Asia. Small, usually spiny tree, 3 to 8 m high; leaves, 4 to 8 cm long and 1.5 to 4.5 cm long, alternate, ovate or elliptic to lanceolate, usually crenate, dark shining green above, yellowish-green beneath; petioles, 5 to 15 mm long and 1.5 to 3 mm wide, alternate, narrowly winged or margined, 1.5 to 3 mm wide across the wings, clearly articulate with leaf blades; inflorescences, axillary, small 1.5 to 2.5 cm in diameter; corolla, usually 5-parted, petals, white; stamens about 20; ovary 10- to 15-locular; fruit, 5 to 8 cm in diameter, depressed-globose to subglobose, greenish with yellowish patches to bright orange; peel, thin, loose, separating easily from the segments; pulp, orange, sweet, juicy; seeds, small. Immature planted fruit tree. 5, 6.

Citrus sinensis (L.) Osbeck "orange", "sweet orange"
te aoranti (K)
syn. *C. aurantium* var. *sinensis* L.

Recent introduction. S. Asia. Rare. Small to medium tree, 4 to 12 m high, often with stout spines; leaves, 5 to 15 cm long and 2 to 8 cm wide, alternate, ovate to oval-elliptic, glabrous, dark green above, sometimes slightly serrate; petioles, 1 to 2.5 cm long and 3 to 5 mm wide, winged, clearly articulate with leaf blades; inflorescences, axillary, solitary or in small racemes, 2 to 3 cm in diameter; corolla, usually 5-parted, petals white, fragrant; stamens 20 to 25, united into groups; ovary 10-to 14- locular; style slender with globose stigma, soon deciduous; fruit, 4 to 12 cm in diameter, subglobose, greenish-yellow or orange, juicy, edible; peel up to 5 mm thick, tightly adherent to segments; pulp, yellow-orange to dark orange, juicy, slightly acidic, sweet; seeds, none to many, obovoid, white. Immature planted fruit tree; reportedly more common in past and planted by the Japanese during World War II. 6, 7.

Murraya paniculata (L.) Jack "mock orange"," orange jessamine", "orange jasmine"
syns. *Chalcas paniculata* L.; *Murraya exotica* L.

Recent introduction. Trop. Asia, Malesia and Australia. Rare. A shrub to small tree, 1 to 8 m high, but usually kept under 3 m by pruning; leaves, alternate, pinnate; leaflets, 3 to 7, usually 5, 3 to 10 cm long and 2 to 4 cm wide, ovate to subobovate, glossy, thin-coriaceous, nitid; petiolules, very short; inflorescences, 1- to 8-flowered, compact paniculate clusters; calyx, 5-parted, deeply-lobed, sepals basally somewhat united; corolla, 5-parted, petals, usually 10 to 15 mm long and 3 to 6 mm wide, imbricate, pure white, fragrant; stamens 10, the filaments 6 to 12 mm long, the style 5 to 9 mm long; ovary 2-locular, styles with capitate stigma; fruit, 1 to 1.3 cm long, an ovoid to ellipsoid reddish-orange berry; seeds, 1 to 2, villous. Planted ornamental and pot plant at Location. 6(184), 7.

SAPINDACEAE (Soapberry Family)

Dodonaea viscosa (L.) Jacq. "native hop bush"
eteweo, eteweau (N)
syns. *Ptelea viscosa* L.

Indigenous. Pantropical. Common. Shrub or small tree, 0.5 to 6 m high, with angular branchlets and slightly sticky resinous exudate; leaves, 5 to 12 cm long and 1 to 3 cm wide, alternate, narrowly lanceolate or oblanceolate, acute at both ends, long-attenuate at base, margins somewhat wavy, firm to somewhat coriaceous, olive green above, paler beneath, somewhat viscid appearing varnished, subsessile; petioles, 1 to 2 mm long, winged; inflorescences, in short, lax terminal or axillary panicles about half as long as the leaves, individual flowers about 4 mm across, greenish-yellow; calyx, 5-parted; petals none; disk, small or obsolete; stamens, usually 8, distinct; fruit, 15 to 20 mm in diameter, inflated, papery, reddish or orange to brown, 2- to 4-winged (lobed) capsule, the wings membranous, veiny, glabrous; seeds, 1 or 2 per lobe, black, with a spiral embryo. Common in scrub and occasional in plateau forest; occasional in revegetated older mined areas. Strong but flexible trunks and branches used for fishing rods and for frames for flying-fish and noddy nets; leaves occasionally used to scent coconut oil. 2, 3(58598, 58637), 5(73), 6, 7, 8(9578).

Nephelium litchi Camb. "lychee", "lychee nut"
syn. *Litchi chinensis* Sonn.

Recent introduction. S. China. Rare. Small to medium tree, up to 10 m high, with a heavy trunk, spreading crown and thick foliage; leaves, paripinnate with 2 to 4 pairs of leaflets; leaflets, 8 to 15 cm long and 3 to 4 cm wide, elliptic-oblong, coriaceous, glossy; inflorescences, large terminal panicles; individual flowers, small, pale greenish-yellow; calyx, 5-parted; petals none; disk, annular; stamens 6 to 10; fruit, 3 to 3.5 cm in diameter, pendent in loose clusters, covered with small pyramidal tubercles, usually bright red to purplish when ripe; pulp-like aril, white, translucent, fleshy, somewhat gelatinous, juicy, sweet, fragrant, edible, with a grapelike consistency; seed, dark brown, covered by aril. Planted fruit tree seedling. 6.

SAPOTACEAE (Sapodilla Family)

Chrysophyllum cainito L. "star apple", "cainito"

Recent introduction. W. Indies. Rare. Medium tree, 5 to 12 m high, with puberulent, golden-brown young branchlets and white latex; leaves, 8 to 20 cm long and 3 to 9 cm wide, alternate, 2-ranked, elliptic to elliptic-oblong, sharply acute or obtuse, base acute, coriaceous, pinnately nerved, lateral veins very slender, shiny, dark-green above, densely silky-pubescent and golden-brown beneath; petiole, 1 to 2 cm long; inflorescences, axillary, often many-flowered, pedicellate to sessile clusters; calyx, 5 (4 to 6)-parted, spirally arranged; corolla, usually exserted from calyx, 3 to 5 mm long, tubular, 5 (4 to 11)-lobed, lobes equal to or longer than tube, purplish-white; stamens, as many as corolla lobes, inserted; fruit, 5 to 12 cm in diameter, subglobose to ovoid, smooth, with light green to purple skin; pulp, white, sweet, often juicy, edible; seeds, 4 to 8, hard, obliquely obovoid, compressed, with a broad lateral scar, glossy, brown, embedded in a star-like arrangement in the pulp. Planted fruit tree seedling. 6.

SAXIFRAGACEAE (Saxifrage Family)

Saxifraga sarmentosum L.f."mother of millions", "mother of thousands", "roving sailor", "strawberry geranium"
syn. *S. stolonifera* ?? authority

Recent introduction. E. Asia. Rare. Tufted perennial herb, up to 30 cm high, with many slender, strawberry-like, branching red runners upon which numerous new plants are formed; leaves, 2.5 to 10 cm in diameter, rounded, cordate, scalloped or dentate, softly-pubescent, green and white- or silvery-veined or variegated above and pale green, suffused with red or pink beneath; inflorescences, erect, loose, long-stalked, spikelike clusters, up to 15 to 50 cm high; corolla, 5-petaled, star-like, 2 petals about 12 mm long which far exceed the other 3, irregularly-shaped, white to flesh-pink; stamens 10. Pot plant. 4 (144).

SCROPHULARIACEAE (Snapdragon Family)

Angelonia angustifolia Benth. "angelonia", "monkey face"
syns. *A. gardneri* auct. non Hook.; *A. salicarifolia* auct. non H. & B.

Recent introduction. Trop. America. Occasional. Erect perennial herb, up to about 60 cm high; leaves, up to 7.5 or 9 cm long and 1 cm wide, opposite or verticillate (or distal one alternate), narrow-oblong or lanceolate, minutely glandular-serrulate to subentire, sessile or subsessile; inflorescences, axillary, solitary or paired, slender-pedicellate; calyx, deeply 5-lobed; corolla, 1.5 to 2 cm across, short-tubular, 2-lipped, the limb widely cupuliform, about 2 cm across, short-spurred, 5-lobed, 4 broad and flat, the lower one cupuliform in the lower half, the throat broadened into a sac-like cup, blue or purplish; stamens 4, borne on the dorsal side of the cupuliform part of the corolla, the filaments short, thick; fruit, a globose or ellipsoid, 2-valved capsule, rarely indehiscent. Planted ornamental. 3(58723), 5, 7.

Angelonia biflora Benth. "angelonia"

Recent introduction. Trop. America. Rare. Erect perennial herb, up to 1 m high; very similar to *A. angustifolia*, except that it is slightly taller and has a slightly larger and paler, often white, corolla. According to Smith (1991), it is questionable whether these two taxa constitute separate species. 6(256). Planted ornamental

Bacopa procumbens (Mill.) Greenm.
syns. *Erinus procumbens* Mill.); *Herpestris chamaedryoides* HBK.; *Bacopa chamaedryoides* (HBK.) Wettst.

Recent introduction. Trop. America. Suberect, perennial herb, with quadrangular glabrous stems, rooting at the nodes; leaves, 1 to 2.5 cm long and 6 to 12 mm wide, opposite, elliptic or shortly ovate-elliptic, crenulate-serrulate; inflorescences, axillary, usually solitary; pedicels, 4 to 6 mm long, extending in fruit to 18 mm; calyx 5-parted, upper segment broadest; corolla, slightly longer than the calyx, subregular, cylindric-tubular, 5-lobed, yellow; stamens, 5; fruit, a 2-valved capsule, enclosed by the calyx. Weed in lawns and disturbed places. 2 (58813).

Russelia equisetiformis Schlecht. & Cham. "firecracker flower", "coral plant"
dokaibangi, dugaibangi, dogaibwangi (N); te kaibaun (K)
syn. *R. juncea* Zucc.

Recent introduction. Mexico. Occasional. Shrub or subshrub, up to 1.5 m high, with long, straggling, longitudinally-ridged, whorled or drooping green branches or stems; leaves, up to 2 cm long and 1.5 cm wide, ovate, dentate, whorled in groups of 5 to 8 on main stem, but more often, reduced to minute, opposite, linear, awl-shaped scales on branches; inflorescences, narrow, terminal, loose, drooping paniculate cymes; pedicels about 1 cm long; calyx 5-parted; corolla, 1.5 to 2.5 cm long, long-tubular, with a small 5-lobed limb, lobes about 3 mm long, bright red, nodding; stamens 4, inserted; fruit, about 5 mm long, globose or broadly ellipsoid, 4-valved, rostrate; seeds, many, oblong. Planted ornamental. 3(58678), 4(157N), 5, 6(213), 7.

Russelia sarmentosa Jacq.

Recent introduction. Mexico. Rare. Shrub or subshrub, up to 1.5 m high; leaves, ovate to triangular, in whorls; inflorescences, in clusters of 30 to 40 individual flowers; calyx 5-parted nearly to base; corolla, tubular, 5-lobed, scarlet; stamens 4, inserted; fruit, globose or broadly ellipsoid, 4-valved, rostrate; seeds, many, oblong. Planted ornamental. 3 (58795).

Scoparia dulcis L.

Recent introduction. Trop. America. Rare. Branched, subligneous, perennial herb, 20 to 80 cm high, with wiry, angular-ribbed stems; leaves, 3 to 4 cm long and 1 to 1.5 cm wide, opposite or whorled in threes, narrowly elliptic, oblong-obovate or oblanceolate, subsessile, distally serrulate or serrate, gland-dotted beneath; inflorescences, axillary, solitary, pedicellate; calyx 4-lobed nearly to base, lobes, imbricate; corolla, 5 to 8 mm across, 4-lobed nearly to base, the lobes spreading, subequal, obtuse, white to pale blue or pale purple with a darker center, pubescent within; stamens 4, subequal, greenish; stigma, slender; ovary green; fruit, an ovoid or subglobose, 2-valved capsule; seeds, many, tuberculate or scrobiculate. Weed of waste places. 6(159), 8(9557).

SOLANACEAE (Nightshade Family)

Capsicum annuum L. var. **annuum** "chilli pepper", "red pepper"
epeba (N); te beneka (K); tili, polo feuu (T)

Recent introduction. Trop. America. Erect, glabrous, annual or short-lived, much-branched perennial herb or subshrub, up about 1 m high; leaves, 1.5 to 12 cm long and 0.5 to 7.5 cm wide, alternate, broadly lanceolate to ovate-elliptic or acute-acuminate, base cuneate or acute, thin, subglabrous; petioles, 0.5 to 2.5 cm long; inflorescences, usually solitary or paired, terminal, pendulous, but because of the form of branching appear somewhat axillary; pedicels, up to 1 or 1.5 cm long, usually 1 per node after first flowering; calyx, about 2 mm long, campanulate, shortly 5-dentate, 10-ribbed, persistent, usually enlarging to enclose the base of the fruit; corolla, 0.8 to 2 cm in diameter, rotate-campanulate with a very short tube, deeply 5- to 6-parted, white, sometimes with a greenish or bluish tinge; stamens, 5 to 6, inserted near base of corolla, anthers bluish or purplish drying green, dehiscing longitudinally, style simple, white or purple; fruit, 3 to 6 cm long and 2 to 3 cm wide, oblong to subglobose, somewhat irregularly shaped, wrinkled or twisted, a many-seeded pendent berry, with a leathery skin, green turning bright red when ripe, indehiscent, hot-spicy, pungent; seeds, 2 to 4 mm long, suborbicular, compressed, pale yellow. Planted spice plant in expatriate garden at Meneng Terrace. Fruit used to spice food. 6, 7.

Capsicum annuum L. var. **grossum** (L.) Sendtn. "bell pepper", "sweet pepper", "sweet capsicum", "paprika", "pimento" pepa (T)
syn. *C. grossum* L.; *C. dulce* Hort. ex Dun.

Recent introduction. Trop. America. Rare. Similar to *C. annuum* L. var. *annuum*, but bearing a larger, oblong to linear, almost quadrangular, or sometimes broadly ellipsoid-acuminate fruit, 6 to 14 cm long and 5 to 10 cm across, green to bright red or occasionally yellow, partially hollow, usually sweet and non-pungent. Food plant in Topside workshop gardens. Fruit eaten raw in salads and cooked as a green vegetable. 5, 6.

Capsicum frutescens L. "tabasco", "bird chilli", "perennial chilli"
epeba (N); te beneka (K); tili, polo feuu (T)
C. minimum Roxb.

Pre-World War II introduction. Trop. America. Rare. Coarse, perennial, suffrutescent, much-branched subshrub, 0.6 to 2 m high, leaves, 2 to 9 cm long and 1 to 4 cm wide, alternate, ovate-elliptical to ovate-lanceolate, acute-acuminate, base acute or obtuse, entire or slightly undulate, glabrous or slightly pubescent; petioles 1 to 3 cm long; inflorescences, terminal and axillary, commonly paired, sometimes more, long-pedicellate; pedicels, 1 to 2.5 cm long, 2 (rarely 3) per node after first flowering; calyx, 2.5 to 3 mm long, tubular, shortly 5-dentate, persistent, usually enlarging to enclose the base of the fruit; corolla, 1 to 1.5 cm in diameter, deeply 5-lobed, white to greenish-white or purplish-white; stamens 5, anthers purple; fruit, 1 to 1.5 cm long and about 5 mm across, ellipsoid-lanceolate, ellipsoid-ovoid or subconic, an erect, many-seeded berry, with a leathery skin, green or greenish-yellow turning bright red when ripe, indehiscent, hot-spicy, pungent; seeds, 2 to 3 mm long, suborbicular, compressed, pale yellow. Planted or protected in Tuvaluan garden at Location and in Topside Workshop gardens. Reportedly much more common in the past. Fruit used to spice foods. 6.

Cestrum nocturnum L. "night cestrum", "night flowering cestrum", "night-flowering or night-blooming jasmine", "lady of the night" fafine o te po (T)

Recent introduction. W. Indies. Rare. Erect, glabrous shrub, 2 to 5 m high; leaves, 7 to 20 cm long, spiralled, ovate-oblong to lanceolate-elliptic, petiolate; inflorescences, cymose racemes longer than petioles; calyx, about one-third as long as the corolla, 5-toothed, green, persistent; corolla, 1.5 to 2.5 cm long, tubular, 5-lobed, narrowed at throat, widened at apex, with a small spreading limb, lobes, 5 to 6 mm long, obtuse to subacute, erect or spreading, greenish-yellow, pale-yellow or cream-white, extremely fragrant, mostly at night; stamens 5, included, puberulent at base; fruit, 6 to 10 mm long, a subglobose berry, white, 1- to 3-seeded. Planted ornamental. 5(15), 6.

Datura metel L. "datura", "cornucopia", "jimson weed"
syn. *D. fastuosa* L.

Recent introduction. S.E. Asia. Rare. Erect herb or subshrub, 1 to 2 m high; leaves, 4 to 25 cm long and 2 to 20 cm wide, narrowly ovate to angular-ovate, acute, base oblique, sinuate-repand to sinuately-lobed, major lobes 2 or 3 per side, glabrous to slightly puberulent; petiole, 1 to 16 cm long; inflorescences, solitary, terminal, single or double (or triple); pedicels, 8 to 15 mm long, erect or nodding; calyx, 3 to 9 cm long, tubular, with 5 (-9) conspicuous longitudinal veins, usually 5-lobed, lobes 8 to 25 mm long, circumscissile after the anthesis; corolla, commonly 12 to 18 cm long, often double or triple, tubular, trumpet-like, 5-lobed, the lobes with acumens 1 to 2.5 cm long, purple without, pale lavender to white within; stamens 5, at apex of tube, anthers 1 to 2 cm long; style, 10 to 14 mm long; fruit, 3 to 4 cm in diameter, a capsule, deflexed, subglobose, prickly or spiny with 100 to 200 conical tubercules, each 2 to 5 mm long, irregularly dehiscent; seeds, 4 to 5 mm long, many, compressed, yellow-brown. Planted ornamental. 6.

Nicotiana tabacum L. "tobacco"
te kaibake (K)

Pre-World War I introduction. Trop. America. Rare. Coarse, erect herb up to 2 m or higher; leaves, 30 to 60 cm long, spiralled, the lowest ones forming a rosette, oblong-ovate to lanceolate, acute, sometimes shortly-decurrent on stem, surfaces pubescent, subsessile; inflorescences in terminal racemose panicles, pubescent; calyx, 1 to 2 cm long, tubular-campanulate, 5-lobed, accrescent, puberulent; corolla, 3 to 5 cm long, tubular, 5-lobed, lobes, ovate, puberulent, pink to red; stamens 5, included or slightly exserted, filaments puberulent at base; ovary glabrous; fruit, 15 to 17 mm long, a brown capsule with persistent calyx at base; seeds, numerous, minute, subreniform, tuberculate. Planted in home gardens; reportedly more common in the past. Leaves dried and cured for smoking. 3, 5, 6.

Physalis angulata L. "cape gooseberry", "bladderberry", "ground cherry"
watamo, oatamo (N); te baraki (K); pini (T)

Pre-World War II introduction. Trop. America. Common. Erect, nearly glabrous, branching annual herb, up to 80 cm or higher, with hollow angular-ribbed stems; leaves, 3 to 14 cm long and 2.5 to 9 cm wide, alternate, ovate to oblong-lanceolate, acute-acuminate to obtuse, base obtuse or acute (somewhat asymmetrical), irregularly toothed or sinuate-entire, very short-puberulent on both sides; petioles, 2 to 11 cm long; inflorescences, axillary, pedicellate; pedicels, 0.7 to 1.5 cm long, slender, enlarging to 2.5 cm in fruit; calyx, 3 to 6 mm long, enlarging to 2 to 4 cm long in fruit, short-puberulent; corolla, 0.6 to 1 cm long, pale-yellow, yellowish-green near base, partly puberulent externally; stamens 5, 2.5 to 4 mm long, capitate; anthers, 1 to 2.5 mm long, blue; style, 4 to 5 mm long; fruit, 1 to 1.6 cm in diameter, subglobose or ellipsoid, fleshy, enclosed in an inflated, balloon-like, ovoid calyx, up to about 3 cm long, with an apical opening; seeds, about 1.7 mm long, flat, reniform, yellowish. Weed in low ground near Buada Lagoon, on road fill in currently mined areas, and in disturbed soil and dumps on coastal strip. Ripe fruit eaten by children. 2, 3(58645, 58768), 4(130N), 5(14), 6, 7(22321), 8(9541).

Physalis lagascae R. & S. "ground cherry", "wild cape gooseberry", "bubble fruit"
watamo, oatamo (N); te baraki(K); pini (T)
syn. *P. minima* L.

Recent introduction. Trop. America. Rare. Low, much-branched, somewhat sprawling annual herb; leaves, 1.5 to 6 cm long and 1 to 3 cm wide, mostly alternate, oval-ovate, acute at both ends, margin entire or somewhat wavy, spreading pilose on both surfaces; petioles, 0.5 to 3 cm long, slender; inflorescences, solitary, axillary; pedicels, 2 to 5 mm long, enlarging to 9 mm in fruit; calyx, short-spreading-pilose without, glabrescent, green, inflated, enclosing but free from fruit; corolla, 4 to 6 mm across, yellow, with a darker center with 5 very distinct brownish blotches; fruits, 5 to 7 mm in diameter, berrylike, sessile, enclosed in a papery, inflated, bag-like calyx, 12 to 25 mm long, ovoid acuminate, prominently 5-angled. Weed in low ground near Buada Lagoon. 3(58646).

Solanum lycopersicum L. var. **lycopersicum** "tomato"
te tomato (K); tomato (T)
syns. *Lycopersicon esculentum* Mill.; *L. lycopersicum* (L.) Karst.

Pre-World War II introduction. Trop. America. Rare. Erect, pilose, glandular herb, 0.5 to 2 m high, with capitate hairs on the younger parts, slightly succulent, solid green stems, which sometimes becoming prostrate and spreading, a strong tap-root, and a distinctive strong odor; leaves, 10 to 30 cm long and 6 to 20 cm wide, spirally arranged, pinnate or bipinnate, with a terminal leaflet and equal or unequal smaller lateral leaflets alternating with larger leaflets; petiole, 3 to 6 cm long; larger leaflets (major pinnae) 7 to 9, 5 to 10 cm long, opposite and/or alternate, usually irregularly toothed or incised, sometimes pinnatifid, puberulent; inflorescences, extra axillary (opposite or between the leaf axils), 4- to 12-flowered racemes, the individual flowers, about 2 cm in diameter, pendent; pedicels, 1 to 2 cm long; calyx, 5- to 8-lobed, sepals, about 1 cm long, slender, persistent, enlarging in fruit; corolla, about 1 cm long, rotate, 5- to 8-lobed, lobes, lanceolate, stellate, later reflexed, yellow; stamens, 5 to 8 or 10; anthers, 5 mm long, apical appendage 2 mm; ovary glabrous; fruit, 2 to 12 cm in diameter, subglobose, usually depressed at both ends, a 3 to 12-celled berry, bright red or yellowish when ripe, juicy, edible; seeds, many, 3 to 5 mm long and 2 to 4 mm wide, reniform, compressed, silvery-pubescent, light brown or yellowish. Food plant at Location and in expatriate home gardens; spontaneous in waste heaps. 5, .

Solanum melongena L. "egg plant", "aubergine", "brinjal"

Recent introduction. S. Asia. Rare. Erect, stellate-tomentose, weakly-perennial, branching herb or subshrub, 0.5 to 1.5 m high, the stems sometimes prickly and all parts covered with a gray tomentum; leaves, 6 to 25 cm long and 4 to 15 cm wide, alternate, ovate to elliptic oblong, obtuse to acute, base obtuse to subcordate, usually shallowly sinuately 2- to 4-lobed, both surfaces densely or sparingly stellate-tomentose; petioles, 1 to 10 cm long; inflorescences, solitary or 2- to 5-flowered cymes, opposite to subopposite the leaf axils, the lower flowers bisexual the upper ones male; pedicels, 1 to 3 cm long, elongating and enlarging in fruit; calyx, about 2 cm long, narrowly 5- to 7-lobed, lobes, 1 to 1.5 cm long, acuminate, enlarging and sometimes splitting in fruit, stellate-hairy, persistent; corolla, 3 to 5 cm in diameter, 5- to 6-lobed, campanulate, lobes about the length of the tube, broadly-triangular, incurved, hairy beneath, glabrous within, pale violet to purplish-violet; stamens, 5 to 6, about 1 cm long, free erect, yellow, with short filaments; anthers, 5 to 8 mm long, yellow; fruit, 5 to 30 cm long and 3 to 8 cm across, pendent, highly variable in shape depending on the cultivar, subglobose, oblong, cylindric or obovoid or pyriform, a fleshy berry with leathery skin, smooth, shiny, purple-black to purple, white, yellowish or striped; seeds, many, compressed, pale yellow or light brown, Food plant in home gardens. 5, 6.

Solanum tuberosum L. "potato", "Irish potato"

Recent introduction. S. America-Andes Mts. Rare. Branched, sprawling annual herb, up to 1 m high, with a mass of fine, fibrous, adventitious roots and swollen stem tubers borne on underground stolons; leaves, 10 to 25 cm long, pinnate, with small interjected leaflets between larger leaflets (main pinnae); larger leaflets, 5 to 9, ovate; inflorescences, leaf-opposed, few-flowered cymose panicles; peduncles, 5 to 10 cm long; calyx lobes, 5 to 8 mm long, lanceolate; corolla, about 2 cm in diameter, subrotate, white or pale violet to purple or bluish; fruit, 1.5 to 2 cm in diameter, subglobose, a small inedible berry; seeds, suborbicular to subreniform, green or yellowish. Immature food plant at Location. 5, 6, 7.

STERCULIACEAE (Cocoa Family)

Waltheria indica L. "waltheria"
syns. *W. americana* L.; *W. elliptica* Cav.

Recent introduction. Pantropical. Occasional. Downy perennial subshrub, 0.3 to 1 m high, with erect, branched tomentose stems and woody near base; leaves, 1 to 6 cm long and 0.5 to 3 cm wide, alternate, ovate-oblong, crenate or serrate, velvety-pubescent with mixed stellate and simple hairs, prominently veined; petioles, about 1 to 1.5 cm long; stipules, narrow, caducous; inflorescences, axillary, dense cymose clusters;

peduncles, up to 4 cm long; bracts 3, linear, caducous; calyx, about 6 mm long, 5-lobed; corolla, slightly longer than calyx, 5-lobed, clawed, yellowish-orange to yellow, persistent; stamens 5, connate at base; ovary, 1-celled, sessile; fruit, a 2-valved capsule; seeds 1, rarely 2, exalate. Weed in waste places, vacant lots and ruderal habitats on coastal strip. 3(58668), 4(112N), 5(5, 109a), 6, 7(22301), 8(9599).

SURIANACEAE

Suriana maritima L.
gie", gie cool? (T)

Indigenous. Pantropical. Rare. Shrub or small tree with pubescent young growth, 1 to 4 m high, often dwarfed and wind-trimmed when exposed to salt spray; leaves, 1.5 to 3 cm long and 2 to 6 mm wide, alternate, crowded, narrowly obovate-oblong or linear-spathulate, acute, base decurrent, very short-petiolate; inflorescences, axillary racemose clusters; bracts, green, persistent; calyx, 5-lobed, persistent; corolla, 5-lobed, petals, about 8 mm long, imbricate, yellow; stamens 10; fruit, a 5-parted, 5-angled capsule, pubescent, brownish, enclosed in persistent calyx, Rare coastal plant. 7(27820)

TILIACEAE (Linden Family)

Muntingia calabura L. "Panama cherry", "Panama berry"
bin (bean)(N)

Recent introduction. Trop. America. Occasional. Small pubescent tree, 3 to 12 m high, with tiered, slightly drooping branches; leaves, 5 to 10 cm long and 2 to 3.5 cm wide, alternate, crowded, oblong-acuminate, obliquely subcordate, strongly asymmetrical, thin, serrulate, sticky-pubescent, soon wilting; stipules, about 5 mm long, linear, paired, unequal, caducous; inflorescences, supra-axillary, 1 or few-flowered clusters; pedicels, about 2 to 3 cm long; calyx, 5 (rarely 6 or 7)-parted, sepals, about 1 cm long, lanceolate-caudate, tomentose-hirsute; corolla, 5-parted, petals about 12 to 13 mm long, broadly spathulate-deltoid, white or pink-tinged; stamens about 75, yellow; filaments, about 6 mm long, slender, distinct, white; anthers, small, rounded, yellow; fruit, 1 to 1.5 cm in diameter, subglobose, berry-like (baccate), 5-celled, light-red to yellowish, sweet, juicy, edible; seeds, many, about 0.5 mm long, elliptic, grayish-yellow, embedded in pulp. Planted ornamental fruit tree; naturalised and spreading in strip-mined areas in interior Baiti District. Ripe fruit eaten as a snack food, primarily by children. 3(58752), 4(139N), 5(91), 6, 7.

Triumfetta procumbens Forst.f. "beach burr"

ikiau, ikiow, igiau, giau (B)(N); te kiaou (K); tolotolo, kiaou *(T)*

syn. *T. fabreana* Gaud.

Indigenous. Paleotropics. Rare. Pubescent prostrate subshrub with long-trailing, densely-stellate pubescent branches up to 3 m long; leaves, 1.5 to 6 cm long and nearly as wide, alternate, broadly ovate to suborbicular or shallowly 3-lobed, rounded to obtuse, base rounded to subcordate, crenate-serrate, densely stellate-woolly beneath, palmately 5- to 7-nerved; petioles, up to 6 cm long; inflorescences, axillary, pedunculate, subumbellate clusters; calyx, 5-lobed, with a cornate protuberance at tip; corolla, 10 to 12 mm across, 5-parted, petals bright yellow; stamens, numerous and distinct; fruit, 6 to 12 mm in diameter, subglobose, spiny, burr-like, stellate-pubescent. Growing along coastal strip and in open areas in coastal thickets. Probably incorrectly reported as *T. semitriloba* Jacq. by Burgess in 1935. Juice from crushed leaves used medicinally to cure filariasis and fever, to retard hair from falling out, and for a gelatinous post-natal medicine which is drunk by mothers to help rid them of afterbirth; crushed leaves and stems also mixed with toddy (*kerawai*) and used as poultices on boils. 1, 2, 4(111N), 5(109), 6, 7(27803).

URTICACEAE (Nettle Family)

Laportea ruderalis (Forst.f.) Chew

luna, aluna, pakisikisi (T)

syns. *Urtica ruderalis* Forst.f.; *Fleurya ruderalis* (Forst.f.) Gaud. ex Wedd.; *Schykowskya ruderalis* (Forst.f.) Endl.; *Boehmeria paniculata* Gaud.; *Fleurya paniculata* Gaud.

Indigenous. Malayo-Pacific. Rare. Erect, un- or few-branched, slightly fleshy, glabrous herb, up to 40 cm high; leaves, 1.5 to 8 cm long and 1 to 4 cm long, alternate, obtuse, obtuse or acute, base truncate or subcordate, coarsely crenate; petiole, as long as blade; inflorescences, axillary, pedicellate, in open paniculate clusters, shorter than petiole; male flowers, 4-rarely, 3- or 5-merous; female flowers, 4-merous, perianth with unequal lobes; fruit, obliquely ovate, an achene partly enclosed in the persistent perianth. Growing in shady areas near caves and in moist habitats at the base of the limestone escarpment. 5(99), 6, 7(27809).

Pellionia sp.

Recent introduction. Trop. Asia. Small, creeping, succulent, perennial herb; leaves, 2.5 to 7 cm long, oval, attractive, variegated with combinations of purple, light green, bronzy-green or gray depending on the species and cultivar; inflorescences, inconspicuous, greenish. Pot plant. 6.

Pilea cardieri Gagn. & Guill. "aluminum plant"

Recent introduction. Vietnam. Occasional. Erect, branching, somewhat succulent when young, perennial herb, up to 40 cm high, with somewhat 4-angled stems and swollen internodes; leaves, up to 9 cm long and 5 cm wide, ovate, paired, dentate near apex, dark-green with silvery blotches above, light green beneath; petioles, 2 to 3 cm long; inflorescences, axillary, long-pedicellate, globose clusters; perianth segments, dull white or slightly pink-tinged. Pot plant. 5, 6.

Pilea microphylla (L.) Liebm. "artillery plant"
syns. *Parietaria microphylla* L.; *Pilea muscosa* Lindl.

Recent introduction. Trop. America. Occasional. Low, delicate, much-branched, succulent, glabrous, perennial herb, up to 30 cm high, with tender greenish or purplish stems; leaves, 3 to 6 mm long and 1 to 2 mm wide, opposite, 2-ranked, crowded, elliptic to spathulate or obovate; inflorescences, axillary, cymose clusters; individual flowers, minute, unisexual, minute, greenish, sometimes red-tinged; female flowers, 3-tepaled, tepals, unequal; stamens, opening explosively. Weed in pot plants and under planted ornamentals. 3(58713), 5(8), 6, 7.

Pilea nummularifolia (Sw.) Wedd. "creeping Charlie"

Recent introduction. Tropical America. Occasional. Creeping perennial herb, up to 20 cm high, rooting at the nodes; leaves, up to 2.5 cm in diameter, oval, crenate, succulent, pubescent, 3-veined from base; inflorescences, rose-red. Pot plant; ground cover in shaded areas. 5, 6.

VERBENACEAE (Verbena Family)

Clerodendrum inerme L. var. **oceanicum** A. Gray "beach privet"
eamwiye, eamwije, eyamwiye, eyamwije (N); te inato (K); inato (T)
syns. *Volkameria inermis* L.; *Clerodendrum nereifolium* Wal.; *C. commersonii* (Poir.) Spreng.

Indigenous. Indomalaysia, Australia and the Pacific Is. Common. Erect, trailing or scrambling, sometimes shrubby, glabrous perennial, up to 5 m high; leaves, 3 to 13 cm long and 1 to 7 cm wide, opposite, or sometimes in whorls of 3, elliptic to obovate or narrowly lanceolate, short-acuminate or cuspidate to somewhat blunt, base acute, glabrate, thinly fleshy, pinnately nerved, dotted beneath with a few sunken glands basally; petiole, 0.4 to 2 cm long, slender, leaf scars prominently somewhat raised; inflorescences, axillary, supra-axillary or pseudoterminal, 3- to 12-flowered cymose clusters; peduncle, 1 to 4 cm long, slender, subglabrate; pedicels, 3 to 6 mm long; bracteoles, small, few; calyx, 4 to 6 mm long, campanulate, subtruncate and minutely 5-denticulate, enlarging somewhat as fruit matures; corolla, up to 3.5 cm long, hypocrateriform or slender-tubular, 5-lobed, lobes, 5 to 8 mm long, ovate, subequal, somewhat expanded distally, bluntly acute at apex, glabrous white or pinkish along tube, fragrant; stamens 4, 1 cm long, exserted, inrolled in bud, filaments red, purple or pinkish; anthers, yellow; style, exserted to 20 mm, purple to rich pink distally, paler proximally; fruit, about 1 to 1.5 cm in diameter, obovoid, drupaceous, separating into four 1-seeded nutlets, yellow-green to dark-brown, turning black at maturity, subtended by a indurate, striate-venose calyx; seeds, oblong. Abundant on limestone cliffs and pinnacles, forming luxuriant curtains near edge of escarpment and on parts of coastal strip in Anetan District; occasionally a planted ornamental. Fragrant flowers used in garlands; leaves reportedly pounded and used as a cure for leprosy in the past (cure reportedly received in a dream). 2, 3(58664), 4(103N, 166N), 5, 6, 7(27817).

Clerodendrum paniculatum L. "pagoda flower"

Recent introduction. E. Trop. Asia. Rare. Perennial shrub, up to 1 to 2 m high, with medullose to hollow, bluntly quadrangular branchlets, the nodes with a broad band of hairs; leaves, 4 to 15 (-40) by 7 to 20 (-38) cm, opposite, broadly ovate, prominently 3 to-7-lobed or the uppermost ones entire, base cordate, the lobes acute to short-acuminate and remotely dentate to crenate or entire, thin chartaceous to membranaceous, minutely strigillose to glabrous above, squamose with peltate scales beneath; inflorescences, axillary or terminal, many-flowered panicles, up to 45 cm long and broad; pedicels, 4 to 15 mm long, filiform, reddish; calyx, 3 to 5 mm long, campanulate, deeply-divided, red to orange-red; corolla, hypocrateriform or narrow-tubular, the tube, up to 2 cm long, slender, the limb spreading to 1 cm across, orange-red to vivid scarlet (rarely white), puberulent; stamens and style exserted 2.5 to 3.5 cm beyond corolla throat; fruit, drupaceous, greenish-blue to black at maturity. Planted ornamental. 5, 6(235), 7.

Clerodendrum thomsoniae Balf.f. "bleeding heart"

Recent introduction. W. Africa. Rare. Perennial shrub or climbing vine, up to 3 m or higher, with slender, distally 4-angled and terete proximal branchlets and twining older branches; leaves, 5 to 15 cm long and 2.5 to 7 cm wide, elliptic to elliptic-ovate, acute to short-acuminate, base subcordate to subacute or rounded, glabrate on both surfaces or puberulent on venation; petioles, 8 to 30 mm long; inflorescences, terminal or distally axillary, cymose clusters, to 12 by 15 cm; peduncles, 2.5 to 6.5 cm long, slender; pedicels, 7 to 16 mm long, slender; calyx, 2 to 2.7 cm long, deeply 4- to 5-lobed, lobes sharply acute, pale yellow-green, becoming white or pinkish in flower, red-violet in fruit, prominently veined; corolla, 2.2 cm long, hypocrateriform or tubular, the tube, 1.5 to 2.5 cm long, slender, greenish-red, 5-lobed, lobes up to 1 cm long, deep red to scarlet or crimson distally, the limb spreading or reflexed, to 2 cm broad; stamens and style, long-exserted, pale green; fruit, a drupe, glossy, black, with a brilliant red aril uniting the 4 pyrenes; seeds, 4, nutlets. Planted ornamental. 3(58794), 5, 6, 7(27817).

Duranta repens L. "golden dewdrops", "golden eardrops"
D. erecta L.; *D. plumieri* Jacq.

Recent introduction. Trop. America. Rare. Erect perennial shrub or small tree, up to 4 m or higher, with slender, arching, drooping or trailing branchlets and sometimes bearing axillary or suppressed spines; leaves, 1.5 to 7 cm long and 0.5 to 4 cm wide, opposite or in whorls of 3, elliptic or ovate, rarely elliptic-obovate, obtuse to acute to acuminate or apiculate, base cuneate, entire or distally serrate, usually thin-textured, glabrate on both surfaces; petioles, 1 to 8 mm long, slender; inflorescences, axillary or terminal, erect or recurved, loose, many-flowered paniculate clusters or racemes, 5 to 30 cm long; pedicels, 1 to 5 mm long; bracteoles, minute or occasionally subfoliaceous; calyx, 3 to 4.5 mm long at anthesis, tubular, angular, minutely toothed or subulate; corolla, about 8 mm long, surpassing calyx by about 2 to 5 mm, tubular, 5-lobed, 7 to 14 mm across the limb, pale purple to bluish-purple, 2 slightly smaller lobes with a purple stripe and 3 slightly larger plain lobes, fragrant, puberulent on both surfaces; stamens 4; fruit, 6 to 12 mm in diameter, a globose, 8-seeded drupe, juicy, yellow to orange, enclosed by the enlarged, curved-beaked, yellowish calyx. Planted ornamental. 5, 6, 7.

Lantana camara L. var. **aculeata** (L.) Mold. "lantana"
magiroa (N); te kai buaka (K); kaipuaka (T)

Pre-World War II introduction. Trop. America. Occasional. Erect or rambling, more or less pungent-odorous, perennial shrub, 1 to 5 m high, the stems and branches usually armed with short, recurved prickles; leaves, 2 to 12 cm long and 2 to 6 cm wide, opposite, decussate or whorled, ovate to oblong-ovate, acute to short-acuminate, base abruptly rounded and cuneate, crenate-serrate, stiff chartaceous, reticulate-rugose and scabrous above, downy or hispid,below, pinnately nerved, spicy pungent if rubbed; petioles 0.7 to 2 cm long; inflorescences, axillary, crowded, hemispherical, many-flowered, corymbose heads, 2 to 4 cm across; peduncle, 2 to 9 cm long, slender; bracteoles, 4 to 9 mm long and 1 to 1.5 cm wide, oblong to lanceolate, acute to subulate at apex; calyx, about 3 mm long, 2-lobed, inconspicuous; corolla, 10 to 12 mm long, tubular or hypocrateriform, 4 to 5-lobed, 5 to 8 mm across the limb, pubescent internally, white, pink, orange and red with a darker eye, the youngest flowers central, pale, the older flowers orange, the oldest ones red (or white); stamens 4; fruit, 3 to 4 mm in diameter, a fleshy, slightly juicy drupe, purple-black; seeds 1, a 2-celled pyrene with an air cavity between the cells. Planted ornamental; naturalized in ruderal sites and in unmined open plateau forest; occasional in older revegetated strip-mined sites. Flowers used in garlands. The first Nauruan to plant lantana was reportedly a woman by the name of Magiroa who stole it from a garden of an expatriate British Phosphate Company employee, hence the Nauruan name. 2, 3(58599, 58798), 4(101N), 5(42), 6, 7, 8(9563).

Lantana camara L. var. "drap d'or" "cloth of gold lantana"

Recent introduction. Trop. America. Rare. Cultivar with single-colored yellow flowers. Planted ornamental. 3, 6.

Premna serratifolia L. "premna"

idibiner, idibinerr (N); te ango (K); aloalo, valovalo, te ango (T)

syns. *P. obtusifolia* R. Br.; *P. gaudichaudii* Schauer; *P. mariannarum* Gaud. ex Schauer; *P. integrifolia* L.; *P. taitensis* Schauer; *P. corymbosa* (Burm.f.) Rottl. & Willd.; *P. alba* Lam.; *P. angustifolia* Lam.; *P. paulobarbata* Lam.

Indigenous. Indopacific. Common. Small, nearly glabrous shrub or small tree, up to 5 m or higher, with minutely puberulent youngest branches; leaves, 2 to 15 cm long and 1 to 9 cm wide, opposite, elliptic to oblong-ovate or suborbicular, subacuminate to blunt, sometimes short-mucronate, base rounded or obtuse to subcordate, chartaceous, shiny, usually ventrally concave, glabrate or minutely puberulent dorsally on nerves, 4 to 7 pairs of lateral nerves; petioles 0.5 to 6 cm long; inflorescences, terminal, sometimes also axillary, richly-branched, many-flowered, corymbose clusters, 3 to 10 cm or more across; peduncles, up to 2 cm long; pedicels, up to 1 mm long; bracts, to 5 mm long, paired at each node, subulate to narrowly lanceolate, persistent; calyx, 1.5 to 2 mm long at anthesis, cupular, bilabiate, minutely 4- to 5-toothed or subtruncate, minutely puberulent on both surfaces; corolla, 2.5 to 4 mm long, tubular or short-hypocrateriform to subrotate, tube up to 2.5 cm long, 4- to 5-lobed, somewhat bilabiate, the longest lobe to 1.5 cm long, greenish; stamens 4 or rarely 5, 1.2 to 2.4 mm long, 2 longer, 2 shorter, very slightly exserted or included; fruit, 2 to 4 mm across, subglobose, glabrous, green turning purple-black at maturity. Common tree on coastal strip and in escarpment forest; common in home gardens. Timber used for house rafters in the past; wood considered to be among the best firewood for cooking pandanus; leaves boiled with coconut oil to scent it; flowers used in garlands; young leaves used as poultices to help wounds heal. 1(49.R), 2(8.5), 3(58597, 58633), 5, 6, 7(27810).

Stachytarpheta jamaicensis (L.) Vahl "Jamaica vervain", "blue rat's tail"

edidubai, edidubaiy (N); te uti ("lice")(K)

syns. *Verbena jamaicensis* L.; *Stachytarpheta indica* (L.) Vahl

Pre-World War II introduction. Trop. America. Extinct? Erect, sparsely-branching perennial subshrub, up to about 1 m high; leaves, 4 to 11 cm long and 2.5 to 5 cm wide, opposite, elliptic-oblong, acute or subobtuse, distally crenate-serrate, decurrent on the petiole, flat, pale, somewhat glossy, silvery- or irridescent-green, lateral nerves not prominent dorsally; inflorescences, erect, elongated purplish spikes, 15 to 40 cm long; individual flowers, axillary to a bract, a few opening at a time, evanescent and soon caducous, sessile; bracts, 4 to 5 mm long, with a scarious margin; calyx, dorsally compressed, 4- to 5-toothed; corolla, 5 to 10 mm long and 4 to 12 mm wide tubular, 5-lobed, pubescent internally, pale violet to purple or whitish; fertile stamens 2, included; fruit, 4 to 5 mm long, 2-segmented, enclosed in the calyx. Weed reported present by Burges in 1935, but not reported since. 2.

Stachytarpheta urticifolia Sims "blue rat tail", "false verbena"
edidubai, edidubaiy (N); te uti ("lice")(K)
syn. *Cymburus urticifolius* Salisb.

Pre World War II introduction. Trop. America. Common. Erect, sparsely-branching perennial subshrub, 0.5 to 1.5 m high; leaves, 4 to 12 cm long and 2 to 7.5 cm wide, opposite, decussate, ovate-elliptic or ovate, acute or subobtuse, base cuneate-decurrent, distally crenate-serrate, leaf teeth ciliate, rich green, subglossy, pinnately nerved, lateral nerves prominent dorsally, bullate (convex between the veins); inflorescences, erect, elongated, greenish spikes, 14 to 50 cm long, bearing numerous flowers in groove-like depressions on the rachis; peduncle up to 3 cm long; individual flowers, axillary to a bract, a few opening at a time, evanescent and soon caducous, sessile; bracts, 4 to 7 mm long, erect, lanceolate, aristate at apex; calyx, 5 to 7 mm long, dorsally compressed, 4- to 5-toothed; corolla, up to 8 mm long, tubular, 5-lobed, pubescent internally, medium violet to dark blue-violet; fertile stamens 2, included, white; style, white; fruit, 2-segmented pyrene, enclosed in a persistent calyx. Common weed in waste places and ruderal habitats, especially along roadsides. Mature dried black fruits reportedly eaten by some children. 3(58632), 4(109N), 5(12), 6, 7, 8(9543).

Vitex negundo L. var. **bicolor** (Willd.) H.J. Lam "blue vitex"
dagaidu, dogaidu (N); te kaitu? (K)
syn. *V. trifolia* L. var. *bicolor* (Willd.) Mold.

Indigenous. E. Africa to the Pacific Is. Occasional. Erect, aromatic, freely-branching shrub or small tree, 1.5 to 8 m high, with 4-angled puberulent branches; leaves, opposite, 3- to 5- (rarely 7-) foliate; leaflets, oblong-elliptic to ovate-lanceolate, acute to subacuminate, the central one longest, up to 11 cm and 3 cm wide, with petiolules up to 1 to 2 cm long, the other leaflets smaller on shorter petiolules, pinnately nerved, dark above, densely white-tomentose beneath, aromatic; petioles, 2.5 to 6 cm long; inflorescences, terminal or axillary, narrow, branching, puberulent, paniculate clusters; calyx, about 3 mm long, 5-toothed, gray-puberulent; corolla, about 4 mm long, bilabiate, 5-lobed, blue-violet, puberulent; filaments and style blue to purple; fruit, 5 to 6 mm long, subglobose drupe, 1-seeded, black. Occasional in some forest stands on coastal strip in low-lying areas near base of escarpment and in some home gardens. Branches used for fishing rods for small fish; flowers and leaves used in garlands and other body ornamentation; seeds used to make garlands; young leaves and meristem crushed with coconut oil as a cure for fever blisters; juice of fruit drunk as a cure for fits and convulsion. 2, 3(58635), 4(119N), 5(19, 56), 6, 7, 8(9584).

VITACEAE (Grape Family)

Cissus sp. "cissus"

Recent introduction. Trop. Asia? Rare. Thick-stemmed vine; leaves, cordate; flowers not seen. Planted ornamental. 6.

Vitis vinifera L. "grape"

Recent introduction. S.E. Europe to India. Rare. Tendril-bearing, woody vine; leaves, 5 to 10 cm across, subcordate in outline, usually palmately lobed, usually serrate, more or less glabrate above, white- or reddish-tomentose beneath; inflorescences, leaf-opposed panicles; flowers bisexual and male, 5-merous; calyx, subtruncate; corolla, 5-parted, petals coherent distally, the calyptra caducous before full anthesis; fruit, 1 to 2 cm in diameter, and ovoid to suglobose, 2- to 4-seeded berry, juicy, edible; seeds, rostrate at base, light brown. Single immature plant at Location. 5, 6.

BIBLIOGRAPHY

Alkire, W.H. 1974. Numbers of plant, insect and land bird species on nineteen remote islands in the southern hemisphere. *Journal of the Linnaean Society: Biology* 6:143-152.

Bellwood, P. 1978. *Man's conquest of the Pacific: The prehistory of southeast Asia and Oceania*. William Collins, Auckland.

Bryan, E.H. Jr. 1972. *Life in the Marshall Islands*. Pacific Science Information Center, Bernice P. Bishop Museum, Honolulu.

Carter, J.(ed.). 1981. *Pacific islands yearbook* (14th edition). Pacific Publications, Sydney.

____. 1984. *Pacific islands yearbook* (15th edition). Pacific Publications, Sydney.

Catala, R. L. A. 1957. Report on the Gilbert Islands: Some aspects of human ecology. *Atoll Research Bulletin* No. 59:1-187.

Christophersen, E. 1927. *Vegetation of Pacific equatorial islands*. Bulletin 44. Bernice P. Bishop Museum, Honolulu.

Coyne, T. (J. Badcock, and R. Taylor, eds.) 1984. *The effect of urbanization and western diet on the health of Pacific island populations*. Technical paper no. 186. South Pacific Commission, Noumea.

Dahl, A.L. 1980. *Regional ecosystems survey of the south Pacific area*. Technical paper no. 179. South Pacific Commission, Noumea.

Douglas, Norman and Ngaire Douglas. 1989. *Pacific islands yearbook* (16th edition). Angus and Robertson, North Ryde, Australia.

Fosberg, F.R. 1952. Vegetation of central Pacific atolls, a brief summary. *Atoll Research Bulletin* 23:1-25.

____. 1960. *The vegetation of Micronesia. Bulletin of the American Museum of Natural History* 119(1):1-75.

____. 1965. The island ecosystem. In Fosberg, F.R. (ed.), *Man's place in the island ecosystem: A symposium*. Bernice P. Bishop Museum Press, Honolulu. Pp. 1-6.

____. 1969. Plants of Satawal Island, Caroline Islands. *Atoll Research Bulletin* 132:1-13.

____. c.1972. *Phytogeography of Micronesian mangroves*. Smithsonian Institution, Washington, D.C.

____. 1988. Vegetation of Bikini Atoll. *Atoll Research Bulletin* 315:1-28.

Fosberg, F.R., and M. Evans. 1969. A collection of plants from Fais, Caroline Islands. *Atoll Research Bulletin* 133:1-15.

Fosberg, F.R., D. Otobed, M.-H. Sachet, R.L. Oliver, D.A. Powell, and J.E. Canfield, 1980. *Vascular plants of Palau with vernacular names*. Department of Botany, Smithsonian Institution, Washington D.C.

Fosberg, F.R., G. Paulay, T. Spencer, and R. Oliver. 1989. New collection and notes on the plants of Henderson, Pitcairn, Oeno, and Ducie Islands. *Atoll Research Bulletin* 329:1-18.

Fosberg, F.R., and M.-H. Sachet. 1987 Flora of the Gilberts, checklist. *Atoll Research Bulletin* No. 29:1-30.

Fosberg, F.R., M.-H. Sachet, and R. Oliver. 1979. A geographical list of the Micronesian dicotyledonae. *Micronesica* 15(1-2):41-295.

____. 1982. Geographical checklist of the Micronesian Pteridophyta and gymnosperms. *Micronesica* 18(1):23-82.

____. 1987. A geographical checklist of the Micronesian Monocotyledonae. *Micronesica* 20(1-2):19-130.

Fosberg, F.R., M.-H. Sachet, and D.R. Stoddart. 1983. Henderson Island (South eastern Polynesia): Summary of current knowledge. *Atoll Research Bulletin* 272:1-47.

Good, R. 1947. *The geography of flowering plants*. Longman, Green and Co., London.

Griffiths, T. 1923. Report of the Administration of Nauru during the year 1922. Government Printer, Melbourne.

Guerin, M. 1982. The flora of the atolls of French Polynesia. In Lambert, M. (ed.), *Regional technical meeting on atoll cultivation, Papeete, Tahiti, French Polynesia, 14-19 April 1980: Collected papers*. Technical paper no. 180. South Pacific Commission, Noumea. Pp. 77-89.

Haselwood, E.L. and G.G. Motter (eds.). 1976. *Handbook of Hawaiian weeds*. Lyon Arboretum Association, Honolulu.

Hay, R., F.R. McQuown, G. Beckett, and K. Beckett. 1974. *The dictionary of indoor plants in colour*. Peerage Books, London.

Henderson, C.P. and I.R. Hancock. 1989. *A guide to the useful plants of Solomon Islands*. Research Department, Ministry of Agriculture and Lands, Honiara.

Henty, E.E. and G.S. Pritchard. 1973. *Weeds of New Guinea and their control*. Botany Bulletin No. 7. Division of Botany, Department of Forests, Lae, Papua New Guinea.

Herklots, G.A.C. 1972. *Vegetables in South-east Asia. George Allen and Unwin, London.*

Kanehira, R. 1933. *Flora Micronesica*. Southseas Bureau Under the Japanese Mandate, Tokyo.

Luomala, K. 1953. *Ethnobotany of the Gilbert Islands*. Bulletin 213. Bernice P. Bishop Museum, Honolulu.

Macoboy, S. 1969. *What flower is that?* Summit Books, Sydney.

____. 1979. *What tree is that?* Ure Smith, Sydney.

Manner, H.I. 1987. Atoll flora and vegetation. *Alafua Agricultural Bulletin* 12 (3):67-80.

Manner, H.I., R.R. Thaman, and D.H. Hassall. 1984. Phosphate-mining induced vegetation changes on Nauru Island. *Ecology* 65(5):1454-1465.

____. 1985. Plant succession after phosphate mining on Nauru. *Australian Geographer* 16:185-195.

Massal, E. and J. Barrau. 1956. *Food plants of the south sea islands*. Technical paper no. 94. South Pacific Commission, Noumea.

Merrill, E.D. 1945. *Plant life of the Pacific world*. Macmillan, New York.

Morrison, R.J. 1987a. Chemistry and classification of Pacific low atoll soils. *Alafua Agricultural Bulletin* 12 (3):25-30.

____. 1987b. Comments on the soils of Nauru. Unpublished paper prepared for the Commission of Inquiry into Rehabilitation of the Worked-out Phosphate Lands in Nauru. Institute of Natural Resources, University of the South Pacific, Suva.

Mueller-Dombois, D. 1975. Some aspects of island ecosystem analysis. In Golley, P.B. and E. Medina (eds.), *Coastal ecological systems -trends in aquatic and terrestrial research*. Vol. 11. Ecological studies series, analysis and synthesis. Springer Verlag, New York. Pp. 353-366.

Neal, M.C. 1965. *In gardens of Hawaii*. Bernice P. Bishop Museum special publication 50. Bishop Museum Press, Honolulu.

Overy, R., I. Polunin, and D.W Wimblett. 1982. Some plants of Kiribati: An illustrated list. National Library and Archives, Tarawa.

Parham, B.E.V. 1971. The vegetation of the Tokelau Islands with special reference to the plants of Nukunonu Atoll. *New Zealand Journal of Botany* 9(4):576-609.

____. 1972. *Plants of Samoa*. Information series No. 85. Botany Division, Department of Scientific and Industrial Research, Wellington.

Parham, J.W. 1972. *Plants of the Fiji Islands* (revised edition). Government Printer, Suva.

Paulay, G., and T. Spencer. 1989. Vegetation of Henderson Island. *Atoll Research Bulletin* 328:1-13.

Purseglove, J.W. 1972. *Tropical crops: Monocotyledons (Volumes 1 and 2 combined)*. English Language Book Society and Longman, Harlow.

____. 1974. *Tropical crops: Dicotyledons (Volumes 1 and 2 combined)*. English Language Book Society and Longman, Harlow.

Rotar, P.P. 1968. *Grasses of Hawaii*. University of Hawaii Press, Honolulu.

St. John, H. 1973. *List and summary of the flowering plants in the Hawaiian Islands*. Memoir number 1. Pacific Botanical Garden, Lawai, Kauai.

St. John, H., and W.R. Philipson. 1962. An account of the flora of Henderson Island, South Pacific Ocean. *Transactions of the Royal Society of New Zealand: Botany* 1(14):175-194.

Small, C.A. 1972. *Atoll agriculture in the Gilbert and Ellice Islands*. Department of Agriculture, Tarawa.

Smith, A.C. 1979. *Flora Vitiensis nova: A new flora of Fiji (spermatophytes only)*. Vol. 1. Pacific Tropical Botanical Garden, Lawai, Kauai, Hawaii.

____. 1981. *Flora Vitiensis nova: A new flora of Fiji (spermatophytes only)*. Vol. 2. Pacific Tropical Botanical Garden, Lawai, Kauai, Hawaii.

____. 1985. *Flora Vitiensis nova: A new flora of Fiji (spermatophytes only)*. Vol. 3. Pacific Tropical Botanical Garden, Lawai, Kauai, Hawaii.

____. 1988. *Flora Vitiensis nova: A new flora of Fiji (spermatophytes only)*. Vol. 4. Pacific Tropical Botanical Garden, Lawai, Kauai, Hawaii.

____. 1991. *Flora Vitiensis nova: A new flora of Fiji (spermatophytes only)*. Vol. 5. Pacific Tropical Botanical Garden, Lawai, Kauai, Hawaii.

Speake, J.D., T.W. Cutress, and M.E. Ball. 1979. *The Prevalence of dental caries and the concentration of fluoride in enamel of children in Pacific Islands*. Technical paper 178. South Pacific Commission, Noumea.

Stemmermann, L. 1981. *A guide to Pacific wetland plants*. U. S. Army Corps of Engineers, Honolulu.

Stone, B.C. 1970. The flora of Guam. *Micronesica* 6 (complete):1-659.

Sykes, W.R. 1970. *Contributions to the flora of Niue*. Bulletin 200. New Zealand Department of Scientific and Industrial Research, Wellington.

Taylor, R.J. 1983. *Nauruan mortality, 1976-1981 and a review of previous mortality*. South Pacific Commission, Noumea.

Thaman, R.R. 1982. Deterioration of traditional food systems, increasing malnutrition and food dependency in the Pacific islands. *Journal of Food and Nutrition* 39(3):109-121.

____. 1983. Food for urbanizing Polynesian peoples. *Proceedings of the Nutrition Society of New Zealand* 8:26-37.

____. 1985. Pacific islands health and nutrition: Trends and areas for action. In *Development and Change: Issue Papers. (Pacific Islands Conference, Rarotonga, Cook Islands, August 1985)*. Pacific Islands Development Programme (PIDP), East-West Centre, Honolulu. Pp. III 1-27.

____. 1987a. Urban agroforestry: The Pacific Islands and beyond. *Unasylva* 39(155):2-13.

____. 1987b. Plants of Kiribati: A listing and analysis of vernacular names. *Atoll Research Bulletin* 296:1-42.

____. 1988a. Health and Nutrition in the Pacific Islands: Development or Underdevelopment. *GeoJournal* 16(2):211-227.

____. 1988b. By the people and for the people: Home gardening and national development in the Pacific Islands. In Hurst, J., Overton, J., Allen, B. and Byron, Y. (eds.), *Small scale agriculture*. Commonwealth Geographical Bureau, London and Department of Human Geography, Research School of Pacific Studies, Australian National University, Canberra. Pp. 167-182.

____. 1992. Vegetation of Nauru and the Gilbert Islands: Case studies of poverty, degradation, disturbance, and displacement. *Pacific Science* 46(2):128-158.

Thaman, R.R., H.I. Manner, and D.C. Hassall. 1985. Nauruan plant names. Environmental studies report no. 21. Institute of Natural Resources, The University of the South Pacific, Suva.

Turbot, J. 1954. Portulaca, a speciality in the diet of the Gilbertese in the Phoenix Islands. *Journal of the Polynesian Society* 63(1).

Tyrer, T.G. 1963. *Nauru and Ocean Islands story*. New Zealand Dairy Exporter, Wellington.

Viviani, N. 1970. *Nauru: Phosphate and political progress*. Australian National University Press, Canberra.

Wedgewood, C.H. 1936. Report on research work in Nauru Island. *Oceania* 7(1):1-62.

Wester, L. 1985. Checklist of the vascular plants of the northern Line Islands. *Atoll Research Bulletin* 287:1-38.

Whistler, A.W. 1980. *Coastal flowers of the tropical Pacific*. The Pacific Tropical Botanical Garden, Lawai, Kauai, Hawaii.

____. 1983. *Weed handbook of Western Polynesia*. German Agency for Technical Cooperation (GTZ), Eschborn.

____. 1991. Polynesian plant introductions. In Cox, P.A. and Banack, S.A. (eds.), *Islands, plants and Polynesians: An introduction to Polynesian ethnobotany*. Dioscorides Press, Portland, Oregon. Pp. 41-66.

____. 1992. *Flowers of the Pacific Island seashore: A guide to the littoral plants of Hawaii, Tahiti, Samoa, Tonga, Cook Islands, Fiji and Micronesia*. National Tropical Botanical Garden, Lawai, Kauai, Hawaii.

Wiens, H.J. 1962. *Atoll environment and ecology*. Yale University Press, New Haven.

Wilder, G.P. 1934. *The flora of Makatea.* Bulletin 120. Bernice P. Bishop Museum, Honolulu.

Woodroffe, C. 1991. Vegetation of Tuvalu. *South Pacific Journal of Science* 11:82-128.

Wright, M., S. Minter, and B. Carter. 1984. *The complete handbook of garden plants.* Michael Joseph/Rainbow, London.

Yuncker, T.G. 1959. *Plants of Tonga.* Bulletin 220. Bernice P. Bishop Museum, Honolulu.

Zimmet, P.Z., P. Taft, A. Guinea, W. Guthrie, and K. Thoma. 1977. The high prevalence of Diabetes Mellitus on a central Pacific island. *Diabetologia* 13:111-115.

Zimmet, P.Z., M. Arblaster, and K. Thoma. 1978. The effect of westernisation on native populations. Studies on a Micronesian community with a high diabetes prevalence. *Australian and New Zealand Medical Journal* 8(2):141-146.

Appendix I. Class, subclass, family and antiquity status of the vascular flora of Nauru.

Class/Subclass Family	Indi-genous	Abori-ginal	Recent	Total
PTERIDOPHYTA (Ferns and Fern Allies)				
Aspleniaceae	1	-	-	1
Davalliaceae	2	-	1	3
Ophioglossaceae	1	-	-	1
Polypodiaceae	2	-	-	2
Psilotaceae	1	-	-	1
Pteridaceae	1	-	2	3
Subtotal	8	-	3	11
GYMNOSPERMAE				
Araucariaceae	-	-	1	1
Cycadaceae	-	-	1	1
Subtotal	-	-	2	2
ANGIOSPERMAE (Flowering Plants)				
MONOCOTYLEDONS				
Araceae	-	-	26	26
Arecaceae	-	1	6	7
Bromeliaceae	-	-	4	4
Cannaceae	-	-	1	1
Commelinaceae	-	-	5	5
Cyperaceae	2	-	6	8
Dioscoreaceae	-	-	2	2
Iridaceae	-	-	3	3
Liliaceae	-	-	34	34
Marantaceae	-	-	6	6
Musaceae	-	-	3	3
Orchidaceae	-	-	6	6
Pandanaceae	1	-	1	2
Poaceae	3	-	23	26
Pontederiaceae	-	-	1	1

Strelitziaceae	-	-	4	4
Taccaceae	-	1	-	1
Zingiberaceae	-	-	6	6
Subtotal	6	2	137	145
DICOTYLEDONS				
Acanthaceae	-	-	21	21
Amaranthaceae	1	-	10	11
Anacardiaceae	-	1	2	3
Annonaceae	-	-	4	4
Apiaceae	-	-	2	2
Apocynaceae	2	-	9	11
Aquifoliaceae	-	-	1	1
Araliaceae	-	-	7	7
Aclepiadaceae	-	-	3	3
Asteraceae	-	-	14	14
Balsaminaceae	-	-	2	2
Basellaceae	-	-	1	1
Begoniaceae	-	-	3	3
Bignonicaceae	-	-	3	3
Bombacaceae	-	-	1	1
Boraginaceae	3	-	-	3
Brassicaceae	-	-	6	6
Cacataceae	-	-	5	5
Capparidaceae	2	-	2	4
Caricaceae	-	-	1	1
Casuarinaceae	-	-	1	1
Chenopodiaceae	-	-	3	3
Clusiaceae	1	-	-	1
Combretaceae	1	-	1	2
Convolvulaceae	3	-	5	8
Crassulaceae	-	-	2	2
Cucurbitaceae	-	-	9	9
Ericaceae	-	-	1	1
Euphorbiaceae	2	-	22	24
Fabaceae	6	-	35	41
Gentianaceae	1	-	1	1
Geraniaceae	-	-	1	1
Gesneriaceae	-	-	4	4
Goodeniaceae	1	-	-	1
Hernandiaceae	1	-	-	1
Lamiaceae	-	-	7	7

Lauraceae	1	-	1	2
Lecythidaceae	1	-	-	1
Lythraceae	-	-	1	1
Malpighiaceae	-	-	2	2
Malvaceae	4	-	12	16
Meliaceae	-	-	2	2
Moraceae	1	2	5	8
Moringaceae	-	-	1	1
Myrtaceae	-	-	4	4
Nymphaeaceae	-	-	1	1
Nyctaginaceae	1	-	3	4
Oleaceae	-	-	2	2
Onagraceae	-	-	1	1
Oxalidaceae	-	-	1	1
Passifloraceae	-	-	3	3
Piperaceae	-	-	2	2
Polygalaceae	-	-	1	1
Polygonaceae	-	-	2	2
Portulacaceae	-	-	2	2
Rhamnaceae	1	-	-	1
Rhizophoraceae	1	-	-	1
Rosaceae	-	-	2	2
Rubiaceae	4	-	12	16
Rutaceae	-	-	5	5
Sapindaceae	1	-	1	2
Sapotaceae	-	-	1	1
Saxifragaceae	-	-	1	1
Scrophulariaceae	-	-	1	1
Solanaceae	-	-	10	10
Sterculiaceae	-	-	1	1
Surianaceae	1	-	-	1
Tiliaceae	1	-	1	2
Urticaceae	1	-	4	5
Verbenaceae	3	-	6	9
Vitaceae	-	-	1	1
Subtotal	45	3	287	335
GRAND TOTAL	59	5	429	493

Appendix II. Nature and ecological and cultural (ethnobotanical) importance of coastal plant species of the tropical Pacific Ocean (Notes: 1) Under "Habitat", O = outpost strand zone, I = inner littoral zone, M = mangrove habitats, W = coastal wetland or marshes; N = also found naturalized or wild in non-coastal habitats, and C = cultivated or planted; 2) Under "Origin", I = indigenous, A = aboriginal introduction, R = recent post-European contact introduction, and ? = status unsure; 3) Under "Importance", "Eco" = ecological importance in coastal plant communities and "Cult" = cultural importance in terms of a species' range throughout the Pacific islands or its overwhelming importance in some localities, with +++ = very important in most island groups, with multiple usage in terms of cultural importance, ++ = of considerable importance in some island groups or some important uses locally, + = present in some island groups or of some use in restricted localities, and - = of minor ecological importance or no cultural uses reported from Melanesia, Polynesia, or Micronesia).

Latin Name	Habitat	Origin	Importance	
			Eco	Cult
FERNS				
Acrostichum aureum	I,W,M	I	++	+
Asplenium nidus	I,N	I	++	++
Davallia solida	I,M,N,C	I	+	+
Nephrolepis spp.	I,M,N,C	I	++	++
Polypodium scolopendria	I,N	I	+++	+++
Pteris spp.	I,N	I	+	+
Pyrrosia adnascens	I,N,M	I	+	+
Stenochlaena palustris	I,N,M,W	I	+	+
Tectaria spp.	I,N	I	+	+
Thelypteris spp.	W,I,N	I	++	+
HERBS				
Achyranthes spp.	I	A?	+	++
Boerhavia spp.	O,I	I	+	++
Crinum asiaticum	O,C	I?,A?,R	+	++
Dendrobium spp.	I,M,N,C	I	+	+
Hedyotis spp.	O,I	I	+	-
Heliotropium spp.	O,I	I	+	+
Hymenocallis littoralis	O,I,C	R	+	+
Laportea spp.	I,N	I	+	+

Lepidium bidentatum	O	I	+	+
Peperomia spp.	O,I,N	I	+	+
Portulaca australis	O,I	I?	+	++
Portulaca pilosa	O	I	+	+
Procris pedunculata	O,I,N	I	+	+
Sesuvium portalucastrum	O,W	I	+	+
Tacca leontopetaloides	O,I,N,C	A	+	++
Taeniophyllum fasicola	I,N	I	+	-
Triumfetta procumbens	O	I	+	++
GRASSES AND SEDGES				
Cyperus javanicus	O,I,W,N	I,A,R	++	++
Cyperus laevigatus	W	I,A?	+	++
Cyperus polystachyos	O,I,W	I	+	-
Digitaria setigera	O,I,N	I	++	-
Eleocharis spp.	W	I,A?	+	++
Fimbristylis cymosa	O,I	I	++	+
Ischaemum spp.	O	I?	+	+
Lepturus repens	O	I	++	-
Paspalum spp.	O,W	I,A?	+	+
Sporobolus spp.	O,I	I,A,R?	+	-
Stenotaphrum spp.	O	I,A?	+	+
Thuarea involuta	O	I	++	-
VINES AND LIANAS				
Abrus precatorius	I,M	I,A	+	+
Canavalia cathartica	I,N	I,R	+	+
Canavalia rosea	O,I,N,C	I,R	++	++
Canavalia sericea	O	I	+	+
Cassytha filiformis	O,I,N	I	++	++
Derris trifoliata	O,I,M	I	++	++
Entada phaseoloides	I,N	I	++	+++
Epipremnum pinnatum	I,N	I	+	++
Hoya australis	I,N	I,R	+	+
Ipomoea littoralis	O,I,N	I	++	+
Ipomoea macrantha	O,I,N	I	++	++
Ipomoea pes-caprae	O,W	I	+++	++
Mucuna gigantea	I,N	I	+	+
Vigna marina	O,I,C	I	+++	++

SHRUBS

Abutilon spp.	I,N,C	I	+ ++
Acanthus ebracteatus	M	I	+ +
Allophylus timoriensis	I,N	I	+ +
Bikkia tetrandra	O	I	+ +
Caesalpinia bonduc	I,N,M	I	+ +
Canthium spp.	I,N	I	+ ++
Capparis spp.	O,I	I	+ +
Clerodendrum inerme	O,I,M,C	I	+++ ++
Colubrina asiatica	O,I,N	I	++ ++
Desmodium umbellatum	I,N	I	+ +
Dalbergia candenatensis	I,M	I	+ +
Dodonaea viscosa	I,N	I,A,R	++ ++
Euphorbia chamissonis	O	I	+ +
Gardenia taitensis	I,C	I,A,R	+ ++
Geniostoma spp.	I	I	+ +
Jossinia reinwardtiana	O,I	I	+ -
Nypa fruticans	M,W	I,R	++ ++
Pemphis acidula	O,I,C,M	I	++++++
Scaevola taccada	O,I,C,	I	++++++
Sida fallax	I,N,C	I,A?	+ ++
Sophora tomentosa	O,I	I	+ +
Suriana maritima	O	I	+ +
Timonius spp.	I	I	+ +
Tephrosia purpurea	I,N	I,A	+ ++
Wollastonia biflora	O,I,P	I	++ ++
Wikstroemia spp.	I,N,C	I,A	+ ++
Ximenia americana	O,I	I	+ +

TREES

Acacia simplex	O,I,M	I	++ ++
Aidia cochinchinensis	I,N	I	+ +
Avicennia maritima	M	I	++ ++
Barringtonia asiatica	O,I,C	I	+++ ++
Barringtonia racemosa	I,W	I	+ +
Bruguiera gymnorhiza	M	I,R	++++++
Calophyllum inophyllum	O,I,N,C	I	++++++
Casuarina equisetifolia	O,I,N,P	I,R	++++++
Cerbera manghas	I,N,M,C	I	+ ++
Ceriops tagal	M	I	+ +
Cocos nucifera	O,I,N,C	A,I?	++++++

Cordia subcordata	O,I,C	I,A	+++++
Cycas circinalis	I,N,C	I,A?,R	+ ++
Cynometra spp.	M,C	I	+ +
Diospyros spp.	I,N	I	+ +
Dolichandrone spathacea	M,I	I	+ +
Erythrina fusca	M,W,I	I	+ +
Erythrina variegata	O,I,N,C	I,A	+++++
Excoecaria agallocha	M,O,W	I	++ +
Ficus obliqua	I,N	I	++ ++
Ficus prolixa	I,N	I	++ +++
Ficus scabra	O,I,N	I,A?	+ +
Ficus storkii	I,N	I	+ +
Ficus tinctoria	I,N,C	I,A?	++ +++
Glochidion spp.	I,N,C	I	+ ++
Grewia crenata	I,N	I	+ ++
Guettarda speciosa	O,I	I	+++++
Gyrocarpus americanus	I,N	I	+ ++
Heritiera littoralis	O,I,M	I	+ +
Hernandia sonora	O,I,C	I,A?	++ ++
Hibiscus tiliaceus	O,I,M,N,P	I,A	++++++
Inocarpus fagifer	M,W,N,C	I,A?	+++++
Intsia bijuga	I,N,M	I	+ ++
Leucaena insularum	O	I	+ +
Lumnitzera littorea	M,I	I	++ ++
Mammea odorata	I,M	I	+ +
Manilkara spp.	I,N	I	+ +
Metroxylon spp.	W,N,C	I,A,R	++ ++
Morinda citrifolia	I,N,P	I,A?	+++++
Neisosperma oppositifolia	O,I	I	++ ++
Pandanus tectorius	O,I,N,W,P	I,A	++++++
Phaleria disperma	I,N,C	I	+ ++
Pipturus argenteus	I,N	I	++ ++
Pisonia grandis	O,I,C	I	++ ++
Pittosporum arborescens	I,N	I	+ +
Planchonella costata	I,N	I	+ +
Polyscias spp.	I,N	I	+ +
Pongamia pinnata	O,I,M,N	I	+ +
Premna serratifolia	I,N,C	I	+++++
Rhizophora spp.	M	I	++++++
Santalum spp.	I,N	I	+ ++
Serianthes spp.	I,N	I	+ +
Sonneratia alba	M	I	+ +
Soulamea amara	I?	I	+ +
Syzygium spp.	I,N	I	+ +

Terminalia catappa	O,I,N,C	I,A,R	++++++
Terminalia littoralis	O,I,C	I	+ +
Thespesia populnea	O,I	I	++ +++
Tournefortia argentea	O,I,C	I	+++++++
Vavaea amicorum	I,N	I	+ +
Vitex spp.	O,I,N,P	I	++ ++
Xylocarpus spp.	M,I	I	+ ++

Sources: An extensive review of the available literature and personal records and observations by the author; for full listing of sources, see Thaman, 1992.

ATOLL RESEARCH BULLETIN

NO. 393

FLORA OF THE PHOENIX ISLANDS, CENTRAL PACIFIC

BY

F. RAYMOND FOSBERG AND DAVID R. STODDART

ISSUED BY
NATIONAL MUSEUM OF NATURAL HISTORY
SMITHSONIAN INSTITUTION
WASHINGTON, D.C., U.S.A.
FEBRUARY 1994

FLORA OF THE PHOENIX ISLANDS, CENTRAL PACIFIC

BY F. RAYMOND FOSBERG[1] AND DAVID R. STODDART[2]

ABSTRACT

This paper lists the vascular flora of the three atolls (Canton, Gardner, Hull) and five small islands (Birnie, Enderbury, McKean, Phoenix, Sydney) of the Phoenix Group, located in the arid equatorial belt of the Central Pacific, based on extensive collections made in 1973 and 1975 and on previous records and collections. The flora includes 87 species in 36 families. Only 28 of the species (32%) are considered native. A further 60 species have been recorded in the literature, many of them deliberate introductions which have not persisted. These are mentioned but not described.

INTRODUCTION

The Phoenix Islands lie in the geographic center of the Pacific Ocean, at approximately 170°W longitude and 5°S latitude (Figure 1). They comprise eight islands and atolls (Figure 2). Canton, Gardner (Nikumaroro) and Hull (Orona) are atolls; McKean, Birnie, Sydney, Phoenix and Enderbury are smaller islands with residual enclosed lagoons. Locations and areas are as follows:

	Longitude	Latitude	Land area
Atolls:			
Canton	171°41'W	2°49'S	10.9 sq km
Gardner	174°31'30"W	4°40'30"S	6.7 sq km
Hull	172°11'W	4°31'S	4.3 sq km
Islands:			
Birnie	171°31'W	3°35'S	62 ha
Enderbury	171°5'15"S	3°7'45"S	745 ha
McKean	174°7'30"S	3°35'45"S	91 ha
Phoenix	170°42'45"W	3°43'15"S	94 ha
Sydney	171°14'45"W	4°27'15"S	1067 ha

---

[1] Department of Botany, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560, U.S.A.

[2] Department of Geography, University of California at Berkeley, Berkeley, California 94720, U.S.A.

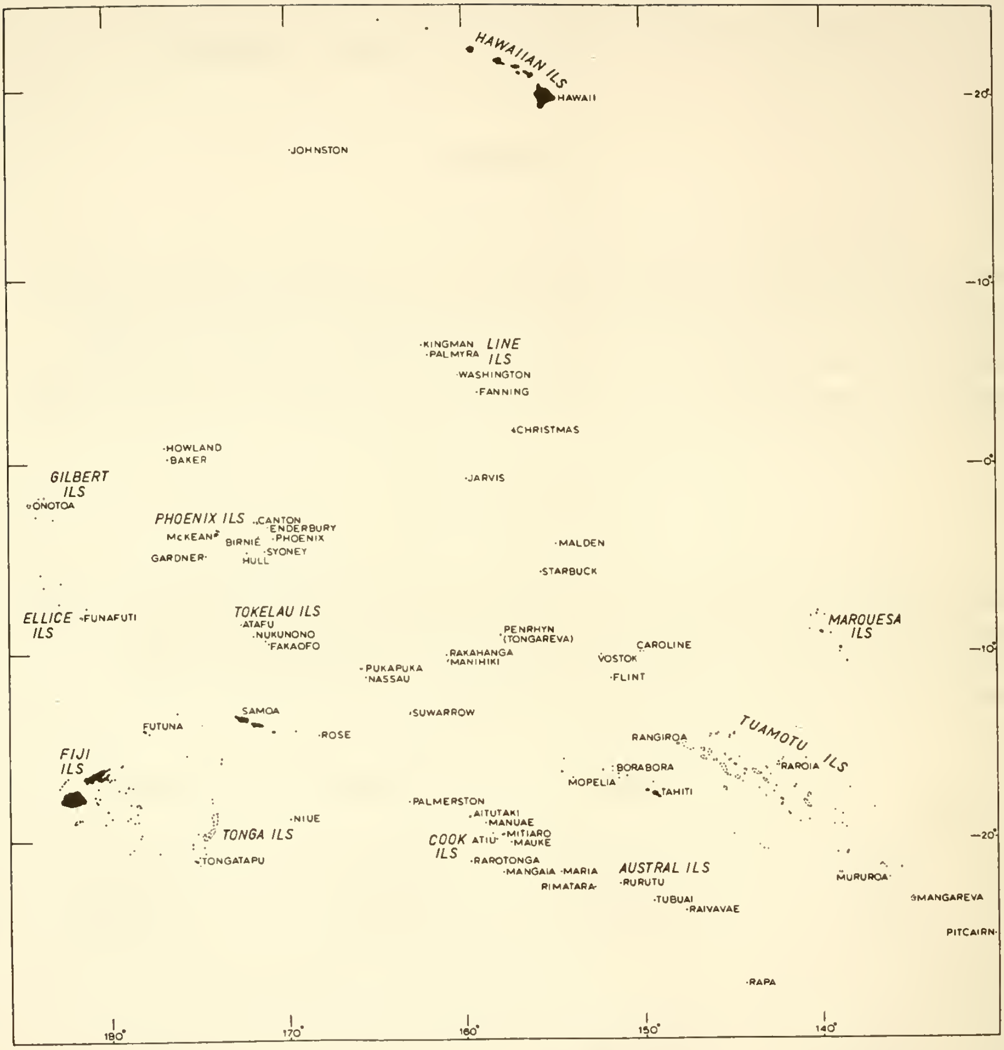


Figure 1. Location of the Phoenix Islands in the Central Pacific.

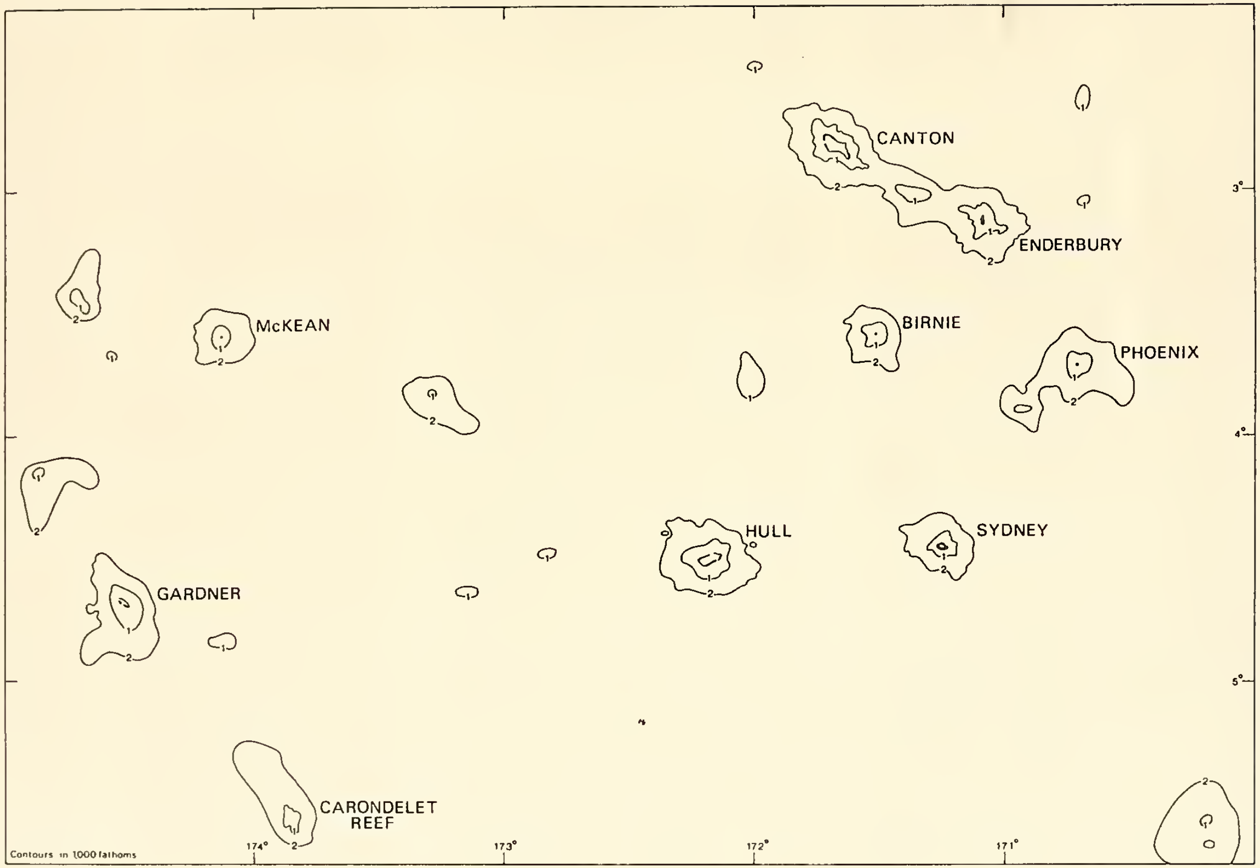


Figure 2. The Phoenix Islands.

Land areas are wholly formed of reef derived materials and mostly rise only a few meters above sea level. The highest measured elevations are 7.0 m on Enderbury, 6.3 m on Sydney, 6.0 on Birnie, 5.5 m on Gardner, 5.4 m on Canton, McKean and Phoenix, and 4.0 m on Hull. The group is located east of Kiribati (of which it forms a part) and Tuvalu, north of the Tokelau Islands, and south of the equatorial islands of Howland and Baker. The nearest high islands are those of Samoa and Fiji to the south and southwest.

All the Phoenix Islands are dry, with great fluctuations in annual rainfall and periods of severe drought. Canton in the north has a mean annual rainfall of 710 mm (1942-67, 1972-75), and the central tier of small islands (McKean, Birnie, Phoenix, Enderbury), though lacking instrumental records, are probably equally dry. The southern group of Hull, Sydney and Gardner are rather wetter and support scrub forest and coconut groves. Mean annual rainfall at Hull (1952-63) is 1171 mm, with a highest recorded annual total of 2599 mm and a lowest of 565 mm; Sydney has a mean (1948-49, 1952-61) of 985 mm (Highest 1846 mm, lowest 463 mm); and Gardner a mean (1951-61) of 1319 mm (highest 2722 mm, lowest 275 mm).

From May 29 to June 12, 1973 a party from the Smithsonian and the Royal Society was able through the courtesy of the U. S. Air Force SAMTEC Project, to visit and study the flora and vegetation of six of the eight islands in the group, and to make collections needed to document the vascular floras of these islands. The party was accommodated on Canton, and Birnie, Enderbury, Phoenix, Hull and Sydney were visited for periods of one to several days. The visit occurred toward the end of a major El Niño event: the total rainfall at Canton over the nine-month period July 1972 to March 1973 was 2629 mm. The vegetation was perhaps at its best during this visit and excellent collections were made, including a number of species not previously recorded from certain of the islands. The best sets of the specimens collected have been deposited in the U. S. National Herbarium and in the herbaria of the B. P. Bishop Museum, Honolulu, and the Royal Botanic Gardens, Kew, England. Others have been sent to several other institutions with Pacific interests.

In 1975, from March 19 to April 2, the same party revisited the Phoenix Islands, again under USAF/SAMTEC auspices, and was able to fill gaps in the 1973 collections, and to observe changes in vegetation and in the abundance of some species. This was a normal arid year in the Phoenix Islands. Canton total rainfall for the nine months July 1974 to March 1975 was 255 mm (for the same period in 1973-74 it had been only 155 mm). The effects of dry conditions were studied, as well as the responses of some of the species to extreme drought. All eight of the islands in the archipelago were visited, including especially Gardner and McKean, which could not be reached in 1973. Excellent collections were gathered on these two islands.

The climatic conditions in the Phoenix Islands are marginal for human settlement, and the group is at present uninhabited. There is archaeological evidence of Polynesian settlement, but it was probably sporadic. The islands were visited by whalers and guano diggers during the nineteenth century, when small settlements were established on the wetter southern islands and efforts made to establish coconut plantations. Hull, Sydney and Gardner were the site of a Gilbertese colonization project beginning in 1938-40. Climatic conditions proved marginal for cultivation, however, and following a severe drought in 1960 the scheme was abandoned in 1962 and the colonists resettled in the Solomon Islands. Canton was occupied by British and American personnel in the late 1930s, pursuing the territorial claims made to the group by both countries, and when Canton began to be used by trans-Pacific Pan-American flights. In World War II it became a major air force base, and the U.S. Air Force was still in occupation of Canton (with small facilities on Enderbury, Hull and Sydney) at the time of our visits. Military use ended shortly afterwards.

The attempts at colonization and the recent occupation by military and aviation personnel are responsible for the introduction of a large number of the plant species recorded below. Experience has shown, however, that the majority of these exotic species will not persist long without the help of man. In 1950-51 Otto Degener, at the request of the U. S. Civil Aeronautics Administration, then in charge of Canton Island, introduced 129 species of plants to the atoll (Degener and Gillaspy 1955, pp. 35-39). Of these only 14 were observed to be persisting in 1973, and only two, *Coccoloba uvifera* and *Conocarpus erecta*, showed any tendency to spread out of the continually disturbed areas of present human occupation. Certain other exotic species persist at the sites of abandoned Gilbertese settlements, and a very few around old guano operations. Some weeds have been brought in accidentally and have persisted, including *Cenchrus echinatus*, *Eleusine indica*, *Portulaca oleracea*, *Euphorbia hirta*, *E. hypericifolia*, *Pluchea carolinensis*, *P. indica*, *Tridax procumbens*, and *Vernonia cinerea*.

Botanical investigations in and collections from the Phoenix Group have been few. The Wilkes Expedition visited Enderbury in 1840 and 1841 and possibly also Gardner. John Arundel sent a few specimens to Kew Herbarium in 1882. E. H. Bryan visited the group in 1924 and again in 1938. His collections are in the B. P. Bishop Museum, Honolulu. F. R. Fosberg and E. H. Walker collected a few plants by moonlight during a one hour refueling stop enroute to New Zealand in early February 1949, and F. R. Fosberg got another small collection during a slightly longer stop on his return trip in March of the same year. These collections are deposited in the U. S. National Herbarium, as are a few collected by Dr. Leonard Schultz in 1939. Otto Degener and W. H. Hatheway collected on Canton in 1950 and 1951, and Dr. and Mrs. Degener in 1958. S. H. Lamb made a few collections in 1938 which are in the Bishop Museum. Under the auspices of the Pacific Biological Survey Program of the Smithsonian Institution, in 1964, C. R. Long made extensive collections and observations on the vegetation on all the Phoenix Islands, and P. Marshall and P. W. Woodward a few more. These are divided between the U. S. National Herbarium, B. P. Bishop Museum and the University of Hawaii. A small collection was made by Dr. Katherine Luomala in 1949-1950, now housed in the Bishop Museum. Roger Clapp brought a small collection from Canton and Hull Atolls in 1971. On our 1973 expedition 196 numbers were gathered, mostly by Fosberg and Stoddart, a few by Fosberg and Clapp, and in 1975, 97 numbers were collected by Fosberg, with at least five sets of duplicates of most of them.

All specimens that we have seen, and those listed by Degener and in manuscripts by C. R. Long are cited below. If we have actually examined and verified them the herbaria where they are deposited are cited by Index Herbariorum abbreviations. Unfortunately, time has not been available to examine many of the rich collections in the Bishop Museum and the University of Hawaii.

Species considered exotic are indicated by an asterisk *.

A few doubtful species are noted in the discussion. Species mentioned as growing on Canton by Degener, but not found on this survey are mostly mentioned but not described. Of great utility during the present investigation were manuscript lists of species and notes on vegetation made by C. R. Long during the Pacific Biological Survey and furnished to us by Mr. Roger Clapp, who was also a most agreeable companion and an encyclopaedic source of information on the Phoenix group during the expeditions.

The late Dr. Marie-Hélène Sachet furnished many records from herbaria and literature that she had examined and contributed greatly to the organization of the information included in the paper.

A full account of the Phoenix Islands is near completion and includes a description of the vegetation of each island. This flora though published separately forms an integral part of that larger account. The flora is organized alphabetically by family, and the species named are indexed at the end of the paper.

ACANTHACEAE

******Pseuderanthemum carruthersii*** var. ***atropurpureum*** (Bull) Fosb.

Upright, branched purplish or purplish-green shrub, stems white speckled, leaves elliptic to elliptic oblong; flowers borne in terminal spikes, corollas salverform, slightly irregular, limb thickly speckled with dark magenta-crimson.

A single sterile shrub that is probably this plant persists in the old Gilbertese village on Hull. In sterile condition this is very hard to distinguish with certainty from *Graptophyllum pictum*. Planted, also, on Canton in U.S.A.F. area, 1975.

CANTON: Fosberg 55715 (US, BISH). HULL: Fosberg & Stoddart 54795 (US, HAW, K); Clapp P-71-42 (US).

AIZOACEAE

Sesuvium portulacastrum L.

Fleshy, prostrate, mat-forming herb, rooting at nodes; leaves opposite, very fleshy but somewhat flattened, linear-oblong to obovate, blunt, sessile or narrowed to a very short thick petiole; flowers axillary on short pedicels, 4-parted, with one whorl of perianth parts that are expanded and petaloid, white or colored within, somewhat appendiculate and slightly cucullate at apices; capsule closely invested by sepals; seeds compressed, orbicular, black.

Two Pacific varieties are easily distinguished; both have been reported from the Phoenix Islands.

Sesuvium portulacastrum** L. var. ***portulacastrum

This was reported from Canton near the dock by Degener in 1959 but was not seen in 1973 or 1975. It was also collected by Long on McKean. It is red-stemmed, with shiny green leaves and purplish flowers.

CANTON: Degener & Degemer 24651. McKEAN: Long 2035 (US), 2430 (US).

Sesuvium portulacastrum var. ***griseum*** Degener & Fosberg

Stems pale green, not at all reddish; leaves thick, dull grayish green, surface under a lens, when fresh, covered with distended turgid epidermal cells; flowers white to pale pink.

This variety is known only from the Central Pacific atolls, including the Phoenix group, while the other is pan-tropical. This plant forms dense mats along the shores of lagoons and other low areas where salinity is high and drainage poor.

CANTON: Fosberg & Walker 30207 (US, BISH), Fosberg 30203 (BISH), 30204 (BISH), 30205 (BISH); Degener & Hatheway 21305, 21313, Degener 21451 (BISH, type); Bryan 24 (BISH). BIRNIE: Fosberg & Stoddart 54725 (US, HAW, K); Long 2635 (US). ENDERBURY: Fosberg & Stoddart 4756 (US, HAW, K); Lamb in 1938 (BISH); Marshall 2 ; Long 2097 (US), 2112, 2653 (US). PHOENIX: Fosberg & Stoddart 54763 (US, HAW, K); Bryan 19 (BISH); Long 2083 (US), 2088 (US), 2625 (US). HULL: Fosberg & Stoddart 54822 (US, HAW, K). SYDNEY: Stoddart 54865 (US, HAW, K); 55713 (US, BISH,K). GARDNER: Long 2452 (US); Fosberg 55767 (US). McKEAN: Fosberg 55792 (US, BISH, K).

Refs.: Degener and Fosberg (1952), pp. 45-47; Degener and Gillaspy (1955), p. 21; Degener & Degener (1959), p. 9; Maude (1952), p. 70; Pickering (1876), pp. 240, 241, 243.

**Tetragonia tetragonioides* (Pallas) O. Ktze. New Zealand Spinach. Mentioned by Hatheway (1955, p. 5) as planted on Canton in 1951 but not seen in 1973 or 1975.

AMARANTHACEAE

******Alternanthera bettzickiana*** (Regel) Nicholson

Low, bushy intricately branched herb with reddish stems and reddish or variegated small ovate to elliptic leaves and small tight axillary clusters of white chaffy flowers.

Planted sparingly on Canton among buildings as an ornamental foliage border plant. A recent import.

CANTON: Fosberg 55722 (US, BISH, K).

******Amaranthus dubius*** Mart. ex Thell. Pigweed

Reported in 1941 by Van Zwaluwenburg as introduced to Canton from Oahu, and by Degener as growing sparingly in 1951, but as not seen in 1958. We did not find it in 1973 or 1975, but it may well persist around dwellings and installations.

CANTON: Degener & Hatheway 21295.

Refs.: Van Zwaluwenburg (1941, 1943); Degener & Gillaspy (1955), p. 21; Degener & Degener (1959), p. 9.

******Amaranthus viridis*** L. Pigweed; Chinese spinach

Small herb with alternate ovate-triangular leaves, greenish spikes of small flowers, with tiny green deeply rugose fruits, shiny black seeds.

Very rare, established in terminal area on Canton Island.

CANTON: Fosberg 55726 (US).

ANACARDIACEAE

**Schinus terebinthifolius* Raddi, reported by Degener as present in 1958 on Canton, was not seen in 1973 or 1975.

APOCYNACEAE

Catharanthus roseus (L.) G. Don — Madagascar periwinkle

Erect herb, sparingly branched below; leaves opposite, oblong obtuse, sessile; flowers on very short pedicels or in very condensed cymes in upper axils; sepals 5, small; corolla salverform, tube somewhat swollen below summit, limb very patent, white to deep rose or white with a red eye, anthers sessile near top of tube surrounding stigma which terminates a filiform style; fruits paired linear terete follicles.

A native of Madagascar now at home in all tropical countries, planted but easily naturalizing itself. Occasional in residence area of U.S.A.F. establishment on Canton.

CANTON: Fosberg & Stoddart 54903 (US).

**Nerium oleander* L. was mentioned but not collected by Luomala, 1951, pp. 166, 173.

**Ochrosia* sp. [probably *O. elliptica* Labill.] was seen cultivated on Canton in 1950, but has apparently not been recorded since, nor was it seen in 1973 or 1975 by us.

**Plumeria rubra* L., the Frangipani or Plumeria, grown everywhere in the tropics, has been tried a number of times in Canton without much success (Luomala 21 (BISH), Degener 21298 (BISH)). One small, poor-looking plant (Fosberg & Stoddart 54910 (US)) was seen in 1973 and one or two more in 1975 growing in the U.S.A.F. residence area. When well-grown the species is a small tree wlth very thick branchlets, abundant latex, and spirally arranged elliptic acuminate leaves, white and veiny beneath; very fragrant tubular funnelform white, yellow, pink or red flowers with recurved obovate obtuse coralla lobes.

Refs.: Degener & Gillaspy (1955), p. 27; Degener & Degener (1959), p. 12; Luomala (1951), pp. 167, 173.

A small **Plumeria obtusa* L. was also seen in 1975.

ARACEAE

**Anthurium* and **Philodendron* mentioned as house-plants in Canton by Degener in 1955, not seen in 1973.

**Cyrtosperma chamissonis* (Schott) Merr., the "Babai" or Giant Taro as reported (as *Alocasia indica* p. 156 and *C. chamissonis* p. 153) by Laxton (1951), pp. 153 and 156, from Gardner. It has in all likelihood not persisted after the Gilbertese left the atoll.

Alocasia macrorrhiza (L.) Schott was seen in a pot at the U.S.A.F. installation on Canton, 1975.

**Dieffenbachia seguine* (Jacq.) Schott (*Dieffenbachia picta* Schott) Dumb Cane

This was seen in 1975 around a house in the U.S.A.F. residence area on Canton. It will probably not persist here without shelter and irrigation.

**Syngonium angustatum* Schott cv. "*Albolineatum*," planted close to buildings in U.S. Air Force settlement on Canton in 1973, one sterile individual climbing on a residence (Fosberg & Stoddart 54909). This may survive as long as it is watered regularly.

ARALIACEAE

**Polyscias guilfoylei* (Bull) Bailey, the Hedge Panax of Hawaii and other tropical countries was found in Canton in 1953 by Katherine Luomala (7). It was still growing in 1958 according to Degener, collected by Clapp (P-71-15 (US)), and was seen but not collected by Fosberg and Stoddart in 1973 beside a building in the old British Settlement. It is a tall bush with a strong odor when broken, alternate pinnately compound leaves, with few large elliptic leaflets usually irregularly white-margined, the margins toothed. It seldom flowers and is always propagated by cuttings. A sterile bush of the similar **P. fruticosa* (L.) Harms was found beside a building in the U.S. Air force residence area, Fosberg & Stoddart 54908 (US); Clapp P-71-16 (US). These are not regarded as part of the established flora.

Refs.: Degener & Gillaspy (1955), pp. 26-27; Luomala (1951), pp. 168, 173.

ARECACEAE (PALMAE)

****Cocos nucifera*** L. Coconut

Tree, often very tall, with a columnar trunk ringed by leaf scars, surmounted by a rosette of gigantic pinnately compound leaves; inflorescences axillary, paniculate, at first enclosed in a woody sword-shaped spathe or surrounding bract which is caducous as the panicle expands; staminate flowers distal on panicle branches, pistillate toward bases, perianth of ivory-colored scale-like segments; fruit a large oval 3-sided fibrous drupe, one of 3 locules developed and with a single gigantic seed, this with a thin brown testa, a layer of white endosperm, jelly-like when young, oily when mature, surrounding a large cavity, when young filled with a very palatable water which later largely disappears.

A most useful tree, planted on all the islands except Birnie and Phoenix (and McKean?). Those earlier reported on Enderbury are now gone, but seedlings were planted around U.S.A.F. installation and one naturally started from a drift nut on the beach. Very abundant on Hull and Sydney and Gardner, forming planted forests, especially around abandoned Gilbertese village sites. Able to tolerate considerable salinity and some drought, but disappearing on small islands and islets during extreme dry periods. 600 were said to have been planted on Birnie by Maude in 1952 but have vanished if indeed they ever grew.

SYDNEY: Bryan 42.

Refs.: Degener & Gillaspy (1955), p. 10; Degener & Degener (1959), p. 7; Laxton (1951), pp. 138 et seq.; Groves (1951), p. 5.

* *Phoenix dactylifera* L., the Date Palm, was planted on Canton by Degener in 1950; two small palms survived in 1958 (Degener & Degener (1959), p. 8); none were seen in 1973 or 1975.

ASCLEPIADACEAE

Calotropis gigantea (L.) Ait. Crown Flower

Strong erect shrub with abundant milky sap; leaves orbicular to broadly oblong, opposite, cordate at base, round at apex, arachnoid tomentose beneath; flowers in pedunculate umbels in upper axils, light dull purple or (in forma *wilderi* Deg.) white, calyx 5-parted, corona a handsomely scultured structure surrounding the anther tube which closely surrounds the large fleshy stigma; fruit a large follicle, borne in pairs.

Introduced on Canton in 1940 or earlier (Van Zwaluwenburg 1942) and by Degener in 1950-51. Both white and purple color forms were growing on Canton in 1958, according to Degener, and at least one large bush of forma *wilderi* was seen in the U.S.A.F. residence area in 1973 and again in 1975. The purple-flowered form had apparently not survived.

CANTON: Degener & Hatheway 21294 (BISH); Clegern 4 (BISH).

Refs.: Van Zwaluwenburg (1942), p. 50; Degener & Gillaspy (1955), p. 27; Degener & Degener (1959), p. 112; Luomala (1951), pp. 166, 173.

ASTERACEAE (COMPOSITAE)

**Conyza canadensis* (L.) Cronq. (Degener & Hatheway 24961), **Gaillardia picta* Sweet, and **Tagetes* sp. were reported on Canton by Degener as present in 1958, and **Emilia sonchifolia* (L.) DC., by Van Zwaluwenburg in 1941 but none of them were seen in 1973. **Borrichia arborescens* (L.) DC. had persisted from 1951 to 1958 (Degener & Degener 24615 (POM)), but was not seen in 1973 or 1975.

***Pluchea carolinensis** (Jacq.) G. Don (*P. odorata* (L.) Cass.)

Resinous aromatic shrub to 2 m tall, with grayish oblong-lanceolate leaves, corymbiform flat-topped terminal clusters of dull purplish heads, fruit with a crown of capillary pappus enabling it to be carried readily by wind.

Locally abundant on Canton near the docks and air strip on very-much-disturbed ground. Considered by Degener to have been of recent introduction in 1951; found by Fosberg & Walker in 1949.

CANTON: MacDaniels in 1950 (BISH); Fosberg & Stoddart 54888 (US, HAW, K); Fosberg & Walker 30210 (US); Degener & Hatheway 21295 (BISH, US, NY, A); Luomala 27 (BISH).

Refs.: Degener & Gillaspy (1955), p. 31; Degener & Hatheway (1952), p. 34; Degener & Degener (1959), p. 17; Luomala (1951), p. 174.

***Pluchea indica** (L.) Less.

Erect shrub to 1 m tall; leaves green, somewhat dentate, erect, with a resinous odor, terminal rounded corymbose clusters of purplish pink narrow heads; fruits with a crown of short pappus bristles.

Very local on Canton, on very disturbed ground near the docks, in 1950-51 introduced from Hawaii, where it is abundant.

CANTON: Fosberg & Stoddart 24889 (US, HAW, K).

Ref.: Degener & Degener (1959), p. 17.

Pluchea* x *fosbergii Coop. & Gal.

Rather depressed, much branched grayish shrub; leaves oblong, distally toothed; heads dusty dull purplish in rather large, open, flattopped clusters; fruits lacking fertile seeds.

A spontaneous, sterile hybrid between the two preceding species, that seems to be so successful here that locally it is more abundant than either of its parents. It is interesting in that its rather depressed habit and lanky branching are characters not found in either parent.

CANTON: Fosberg & Stoddart 54890 (US, HAW, K); Fosberg 55719 (US, BISH, K); Degener 24637 (BISH).

Tridax procumbens L.

Decumbent leafy herb with erect flowering scapes; leaves angular or somewhat lobed, dull dark green; heads with whitish rays, yellowish disk; receptacle with prominent chaffy bracts; fruits with scale-like pappus.

Apparently not present in 1958 but present in 1971 according to photographs by Roger Clapp, now very abundant in disturbed areas around the U.S.A.F. establishment on Canton. Found in 1975 on Hull at abandoned U.S.A.F. site. All plants seen were removed.

CANTON: Fosberg & Stoddart 54887 (US, HAW, K). HULL: Fosberg 55742 (US, BISH, K).

***Vernonia cinerea** (L.) Less. Little Iron-weed

Erect, simple to sparsely branched herb with a basal rosette of obovate leaves and leaves on stem decreasing in size upward, with terminal open clusters of small narrow purple heads with white bristly pappus.

Abundant in weedy disturbed areas on Hull and Sydney around old Gilbertese village sites, not known elsewhere in the group.

HULL: Fosberg & Stoddart 54798 (US, HAW, K); Long 2006 (US), 2012 (US), 2044; Clapp P-71-43 (US). SYDNEY: Fosberg & Stoddart 54851 (US, HAW, K); Long 2546 (US), 2585, 2562 (US), 2563 (US); Bryan 41 (BISH).

***Zinnia elegans** Jacq. Zinnia

An erect herb with opposite leaves and conspicuous heads with bright colored spreading spatulate ligules.

This was, in 1975, seen growing in a sheltered garden at the U.S.A.F. base on Canton.

BORAGINACEAE

***Cordia sebestena** L. Geiger Tree

Small tree; leaves alternate, ovate, subcordate to cordate at base, obtuse at apex, very rough above, somewhat stiff, petiolate; flowers in terminal rather compact cymes, calyx cylindric, striate, toothed, corolla funnelform-salverform, brilliant scarlet, about 2 cm across; stamens included, style twice branched; fruit a large soft fleshy white drupe.

Originally from sea-beaches in the Caribbean, this beautiful tree is widely planted in the tropics. Introduced on Canton before 1949, it persists in the old British Settlement site and here and there in the U.S.A.F. establishment.

CANTON: Fosberg 30874 (US); Degener 21374; Luomala 16 ; Fosberg 55721 (US, BISH, K); Clapp P-71-24 (US), P-71-20 (US).

Refs.: Degener & Gillaspy (1955), p. 28; Degener & Degener (1959), p. 13; Luomala (1951), pp. 167, 174.

Cordia subcordata Lam.

Small tree with low sweeping branches; leaves alternate, broadly ovate to broadly elliptic, tending to be acuminate, base obtuse, upper surface of blade slightly scabrous to almost smooth, petiolate, petioles often yellow; flowers in loose few-flowered cymes, calyx cylindric, not ribbed, 4-5 toothed at apex, teeth hirsute within; corolla funnelform, limb flaring, intense reddish orange, somewhat crispate, stamens in throat, anthers oblong; style bifid, the branches again bifid just below stigmas; fruit a green drupe with thin flesh and a narrow neck, formed by the calyx remaining around the corky rugose stone.

A tree native to most tropical Pacific islands, especially coral islands, found on all the islands studied except Birnie and Phoenix; rare on Gardner; forming a small forest on Sydney's lagoon shore.

CANTON: Bryan 21 (GH), 1332 (A); Degener 21374; Luomala 1, 11; Degener & Hatheway 21287 (A); Fosberg 55724 (US); Clapp P-71-9 (US); Browne in 1939 (BISH, A). ENDERBURY: Fosberg & Stoddart 54751 (US, HAW, K); Bryan 1336; Lamb s. n.; Marshall 10; Long 2091 (US), 2093 (US), 2100, 2662 (US). HULL: Fosberg & Stoddart 54812 (US, HAW, K). SYDNEY: Fosberg & Stoddart 54867 (US, HAW, K); Long 2577 (US), 2590 (US). GARDNER: Fosberg 55765 (US, BISH, K), 55784 (US, BISH, K). "Gardner's and Birney's Islands", U.S. Expl. Exped. (US).

Refs.: Bryan (1942), pp. 50, 60, 71; Degener & Gillaspy (1955), pp. 28-29; Hatheway (1955), pp. 3-9; Luomala (1951), pp. 167, 174; Laxton (1951), p. 143; Maude (1952), p. 70; Pickering (1876), pp. 240, 242, 243; Degener & Degener (1959), pp. 13-14.

*****Heliotropium procumbens*** Mill. (*H. ovalifolium* var. *depressum* (Cham.) Merr.)

Low herb, stems branching, prostrate to ascending; leaves narrowly oblong or spatulate to obovate, appressed hairy; flowers in terminal scorpioid cymes, tiny, white, fruit depressed globose, somewhat 4-lobed, eventually falling into 4 parts.

Recently introduced on Canton probably from Guam or Wake, found only in area of U.S.A.F. establishment, at least as early as 1971 from a photo by Roger Clapp, but now common there; introduced from there to the enclosure around the U.S.A.F. installation on Hull, still present in 1975.

CANTON: Fosberg & Stoddart 54897 (US, HAW, K); Fosberg & Clapp 54898 (US, HAW). HULL: Fosberg & Stoddart 54842 (US, HAW); Fosberg 55741 (US, BISH); Clegern 119 (BISH) .

Tournefortia argentea L. f. (*Messerschmidia argentea* (L. f.) Johnst.) Tree Heliotrope

Rounded shrub or small tree, young growth and leaves sericeous-strigose, giving leaves a grayish frosty green appearance; leaves alternate, elliptic to obovate, obtuse, thinly fleshy, narrowed to short, thick petioles; flowers in dense, 1-2 times branched scorpioid cymes, these terminal but very soon becoming axillary by growth of branches at base of peduncle; flowers white, very fragrant, corolla 5-lobed; fruiting clusters pendent, fruit a drupe with 4 stones, the flesh of which dries to a firm highly aerogenous pithy material causing the pea-size fruits to float.

A widespread Indo-Pacific strand plant, one of the first colonists of sand and gravel bars, not reproducing in shade, but abundant in beach ridge scrub and in other peripheral vegetation. Known from Canton, Enderbury, Hull, Sydney, also on Gardner.

CANTON: Fosberg 30884 (US); Luomala 13 (BISH); Bryan 22 (BISH); Murphy in 1949 (BISH). ENDERBURY: Fosberg & Stoddart 54752 (US, HAW, K); Lamb in 1938 (BISH); Marshall 1; Long 2095 (US), 2681. HULL: Fosberg & Stoddart 54816 (US, HAW, K); Schultz in 1939 (US); Clegern 94 (BISH). SYDNEY: Fosberg & Stoddart 54843 (US, HAW, K). GARDNER: reported by Laxton; Fosberg 55744 (US, BISH, K).

Refs.: Bryan (1942), pp. 46, 50, 60; Degener & Gillaspy (1955), p. 29; Hatheway (1955), pp. 4-5, 7-9; Luomala (1951), pp. 164, 165, 174; Degener & Hatheway (1952), p. 34; Laxton (1951), p. 143; Maude (1952), p. 70; Pickering (1876), pp. 240, 242, 243.

CANNACEAE

A hybrid **Canna* was growing in a sheltered spot in the U.S.A.F. installation in 1975.

CARICACEAE

Carica papaya L. Papaya or Pawpaw

A gigantic tree-like herb, with a stem 8-20 cm thick, a crown of great palmately incised orbicular leaves on long petioles, milky sap; large cream-white pistillate flowers sessile on the stem, smaller staminate and hermaphrodite flowers in open elongate panicles; large melon-like orange edible fruit with a large central cavity containing many globose rough black seeds, each in a juicy globose envelope.

The papaya was planted and growing at various times on Canton (Luomala 15), but did not prosper (Degener & Gillaspy (1955), p. 26; Degener & Degener (1959), p. 12; Luomala (1951), p. 173). A single plant was seen in the U.S.A.F. establishment in 1973. Long collected it on Hull in 1964, 2025 (US) and also on Gardner 2474 (US). Clapp also collected it on Hull, P-71-41 (US).

CARYOPHYLLACEAE

**Spergularia marina* (L.) Griseb., introduced on Canton by Degener in 1958, probably never became established. It was not seen in 1973 or 1975.

CASUARINACEAE

****Casuarina equisetifolia*** L. Ironwood

Erect tree with very heavy hard wood, dark green, jointed, cylindric photosynthetic branchlets or "needles, each segment bearing a whorl of tiny scale-like or tooth-like, vestigial leaves; male and female flowers borne in separate catkins, reduced to stamens and pistils enclosed in small bracts, the pistils rose-purple; the pistillate inflorescence accrescent, the bracts enlarging, becoming woody, the whole inflorescence superficially resembling a diminutive pine cone, the actual fruit small, winged.

Growing sparingly around the U.S.A.F. residence area and at the abandoned British settlement.

CANTON: Degener & Hatheway 21303.

Refs.: Degener & Gillaspy (1955), p. 20; Degener & Degener (1959), p. 8.

****Casuarina glauca*** Sieb.

Similar to the above, but more a large shrub than a tree, producing root sprouts, the needles coarse, stiffer, glaucous green, less prominently striate.

Persisting in a healthy condition around the old British Settlement on Canton.

CANTON: Degener 21372; Fosberg 30876 (US); Clapp P-71-11 (US); Fosberg & Stoddart 54777 (US, HAW, K).

Refs.: Degener & Gillaspy (1955), p. 20; Degener & Degener (1959), p. 8.

COMBRETACEAE

Conocarpus erectus **L.** Button-wood or Button Mangrove

Small tree or bushy shrub, leaves alternate, rather small, elliptic, either bright green or silvery-sericeous; flowers small, with inferior ovaries; crowded in catkin-like oval heads which are borne in terminal panicles; fruits flat and somewhat winged, borne packed together in ellipsoidal or oval heads.

Both the green and silvery forms of this species are well-established on Canton, resulting from Degener's introductions in 1950-51. This, and *Coccoloba uvifera*, are the only ones of Degener's introductions that have tended to spread at all beyond the areas of intensive human activity, past or present. They are both very sparingly established part way east on both north and south sides of the atoll.

CANTON: Fosberg & Stoddart 54885 (US, HAW, K) (green form), 54886 (US, HAW, K) (silvery form); Clapp P-71-35 (US) (silvery form); P-71-34 (US) (green form), P-71-33 (US) (silvery form), P-71-29 (US) (green form).

Refs.: Degener & Gillaspy (1955), p. 26; Degener & Degener (1959), p. 12.

Terminalia catappa **L.** Tropical almond

Tree with conspicuously horizontal whorls of branches, dark brown velvety pubescence on young tips, and a characteristic style of branching with a branchlet from below the terminal growing point of a horizontal branch assuming dominance, dipping downward and arching up level with the turned up apical rosette of the original branch, then the process repeating itself; leaves spirally crowded into rosettes at the branchlet-tips, large, obovate, stiff, glossy, turning bright red before falling off; flowers in axillary slender spikes, cream-white, ovary inferior, perianth campanulate, of one series, 5-lobed, caducous from the top of the ovary, stamens 10, with subulate filaments, conspicuously exserted, pistil 1, conspicuously exserted, hooked at summit, soon caducous; fruit about 4 cm long, 2.5 cm wide, a somewhat compressed ovoid drupe with two keels, the flesh drying rather corky, the seed like an almond, only one or two fruits usually maturing on a spike.

This widespread tropical cultivated and spontaneous strand and lowland tree was growing about the old Pan American Hotel in 1949, but was not seen in 1973, or 1975, although the following species was flourishing.

CANTON: Fosberg 30875 (US); Luomala 2; Clapp P-71-30 (US).

Refs.: Degener & Gillaspy (1955), p. 26; Degener & Degener (1959), p. 12; Luomala (1951), pp. 167, 173.

**Terminalia muelleri* Benth. (*T. melanocarpa* sensu Luomala and Degener & Gillaspy, non F. v. M.).

Well-shaped tree with a spreading crown, leaves somewhat similar, darker green than in *T. catappa*, glaucous beneath, similar branching, similar inflorescence and flowers; fruiting spikes maturing a number of fruits, these ovoid, somewhat compressed, about 2 cm long, with dark blue epidermis and dark red juicy flesh, rather sour and astringent.

Several trees are in very healthy condition, bearing flowers and fruits in the old British Settlement.

CANTON: Fosberg & Stoddart 54783 (US, HAW, K), 54784 (US, HAW, K); Luomala 22; Fosberg 30879 (US); Clapp P-71-22 (US), P-71-13 (US).

Ref.: Degener & Gillaspy (1955), p. 26; Luomala (1951), pp. 167, 173.

Terminalia samoensis Rech.

Shrub or small tree, young growth with yellowish close pubescence; leaves alternate, obovate, short-petioled, thinly coriaceous; flowers on axillary spikes, white, small, fruits fleshy, dark red when ripe, ovoid, somewhat compressed, 1-1.5 cm long, 1 cm wide.

Known in the Phoenix Islands only from Gardner. The record from Canton (Luomala (1951), p. 173), based on Fosberg 30879, was a misidentification of *T. muelleri*.

GARDNER: Long & Woodward 2475 (US); Long 2494 (US); Fosberg 55762 (US, BISH, K), 55768 (US, BISH, K).

COMMELINACEAE

**Rhoeo spathacea* (Sw.) Stearn and **Setcreasia purpurea* Boom, mentioned by Degener & Degener (1959, p. 8) as doing well in gardens on Canton in 1958, were not seen in 1973; however, *Rhoeo* was still present in 1971, as it was photographed then by Roger Clapp.

CONVOLVULACEAE

**Ipomoea batatas* (L.) Poir., Sweet Potato, was observed by Degener in 1958 as planted and growing, but chlorotic, "in the housing area" (Degener and Degener (1959), p. 13), but had disappeared by 1973.

Ipomoea macrantha R. & S. (*I. tuba* (Schlecht.) Don; *Calonyction* sp.; *Ipomoea turpethum* sensu Pickering, non *Operculina turpethum* (L.) Manso; *Ipomoea grandiflora* Lamarck). Moon flower

An extensive and climbing twiner; leaves alternate, large, orbicular cordate, shortly pointed, petiolate, flowers in few-flowered axillary cymes, with 5 overlapping orbicular concave sepals; coralloa long tubular-salviform, to 10-12 cm long, limb spreading, delicate, white, contorted in bud, opening in the evening, collapsing the following day when sun gets hot; stamens 5, included; style filiform, stigma capitate, included; calyx strongly accrescent, fleshy, closely investing the capsule, when mature becoming reflexed, the capsule thin, dehiscent, with four black hairy large seeds with one angle.

Indigenous on most coral atolls, pan-tropical, elsewhere climbing trees, in the Phoenix Islands as often spreading over large patches of herbaceous and shrubby vegetation or on bare coral rubble, dying back to a thick root-crown in very dry periods, sending out new creeping, twining stems when water is available. The thickened fruiting calyces are known elsewhere to serve as a source of water for rats, and may well do the same in the Phoenix Islands. Found on Canton, Enderbury, Hull, Sydney and Gardner. Mentioned from these islands as *I. grandiflora* Lam. by Hemsley and in notes with a specimen, Arundel 7 (K), collected October 1882.

CANTON: Degener & Hatheway 21309, 21310; Degener 24359 (BISH), 24360 (BISH); Luomala 42 (BISH), 43 (BISH); Bryan 25 (BISH); Clegern 41 (BISH); Fosberg 55725 (US, BISH, K). ENDERBURY: Fosberg & Stoddart 54735 (US, HAW, K); Bryan 13, 31 (BISH), 1333 (BISH); Lamb in 1938 (BISH); Marshall 11; Long 2099 (BISH, US), 2655 (US), 2678 (BISH, US); Clegern 138 (BISH). HULL: Fosberg & Stoddart 24793 (US, HAW, K); Long 2071 (BISH, US); Clegern 85 (BISH). SYDNEY: Fosberg & Stoddart 54858 (US, HAW, K); Long 2538 (BISH, US), 2584 (BISH, US). GARDNER: Woodward & Long 2523 (US); Long 2503 (BISH, US); Fosberg 55774 (US, BISH, K).

Refs.: Degener & Gillaspy (1955), p. 27; Degener & Degener (1959), p. 13; Luomala (1951), pp. 164, 171, 173; Degener & Hatheway (1952), p. 34; Pickering (1876), pp. 240, 242, 243; Hemsley (1885), p. 116.

Ipomoea pes-caprae ssp. ***brasiliensis*** (L.) van Ooststr. (*Convolvulus maritimus* sensu Pickering non Gouan, nec. Lam., nec Pall., prob. Desr.). Beach Morning-glory

Extensive creeper, rooting at nodes; leaves alternate, ovate-cordate, deeply bilobed at apex, petiolate, subcoriaceous; flowers in few-flowered ascending axillary cymes; sepals 5, orbicular, closely imbricate and concave; corolla deeply campanulate, with short tube and long throat, limb flaring, rich rose purple, darker in center, open at night, collapsing about midday; stamens 5, included; style 1, filiform, included, stigma capitate, white; fruit a hard dehiscent capsule; seeds 4, dark brown, hairy.

A pan-tropical beach species, occasionally inland, found in the past very sparingly on Canton by Hatheway in 1951; a single plant was seen by us at an old fortified spot on a high beach ridge on the north side and some in front of the U.S.A.F. residence area on the lagoon beach. On Hull it was found on an open sand flat back of the beach and in an opening in the coconut plantation in the old Gilbertese village, and seedlings on a dry channel beach with many other drift seeds, on the north side.

CANTON: Fosberg & Stoddart 54880 (US, HAW, K); Degener in 1951; Bryan 1326 (BISH), 27 (BISH). HULL: Fosberg & Stoddart 54800 (US, HAW, K), 54806 (US); Clegern 67 (BISH).

Refs.: Pickering (1876), p. 243; Hatheway (1955), p. 7; Degener & Gillaspy (1955), pp. 27-28; Luomala (1951), pp. 166, 173.

***Ipomoea quamoclit** L.

Slender twiner with pinnately dissected leaves, and small bright red trumpet-shaped flowers with strongly exserted stamens and pistil.

Planted in shelter of buildings and seeding itself in the immediate vicinity, on Canton in the U.S.A.F. residential area. Not likely to persist.

CANTON: Fosberg & Stoddart 55802 (US).

**Merremia tuberosa* (L.) Rendle. A vigorous extensive twining vine with palmately divided leaves, clusters of bright yellow morning-glory-like flowers; the fruiting calyxes become enlarged and hardened surrounding the globose capsule, forming a "wood rose."

Seen planted on Canton, climbing on a trellis, but not yet flowering in March 1975.

CRASSULACEAE

**Kalanchoe pinnata* (Lam.) Pers. (*Bryophyllum pinnatum* (Lam.) Kurz), was said to be present on Canton in 1958 (Degener & Degener (1959), p. 10) but was not seen in 1973 or 1975.

CRUCIFERAE

**Lepidium bidentatum* var. *o-waihiense* (C. & S.) Fosb. (*L. o-waihiense* C. & S.) was introduced to Canton by Degener in 1950-51. It was said to be abundant in 1958 (Degener & Degener 24636), but was not seen at all in 1973 or 1975.

CUCURBITACEAE

**Cucurbita pepo* L., the pumpkin, was collected by Bryan on Sydney in 1938 (Bryan 44 (BISH)). It was not seen there in 1973, nor in 1975.

Three other cucurbits were reported on Canton by Degener (Degener & Gillaspy (1955), p. 30; Degener & Degener (1959), p. 16), but do not seem to have persisted. They were **Citrullus lanatus* var. *caffer* (Schrad.) Mansf. (*C. vulgaris* Schrad.), the watermelon, collected by Luomala (20) (seen again by Fosberg in the U.S.A.F. residential area in 1975); **Cucumis dipsaceus* Ehrenb., the Teasle-gourd, introduced by Degener in 1951 and abundantly naturalized in 1958; and **Cucumis melo* L., the Muskmelon, growing spontaneously in 1950, in a garden in 1958. None of them were seen in 1973. *Cucumis melo* was collected on Hull by Long (2003 (US)) in 1964, but we did not see it in 1973. **Cucumis sativa* L., the cucumber, was collected on Canton by Luomala 28 (BISH) in 1950, but was not seen by us in 1973 nor in 1975.

CYPERACEAE

Cyperus javanicus Houtt.

Loosely tufted rough-leafed sedge with grayish-green color, ascending to erect stout peduncles, umbelloid inflorescences with very long bracts, spikelets falling intact.

Introduced on Canton by Degener in 1950-51, persisting in 1958, but not seen in 1973 or 1975. Common on Sydney, in coconut plantation, not on wet ground.

CANTON: Degener & Degener 24650. SYDNEY: Fosberg & Clapp 54850 (US, HAW, K); Long 2557 (US).

Refs.: Degener & Gillaspy (1955), p. 34; Degener & Degener (1959), p. 7.

**Cyperus polystachyos* Rottb. was reported from Canton (Degener & Degener 24655) by Degener in 1959, but not seen in 1973 or 1975.

Cyperus rotundus L. Nut-grass

Plant spreading by underground rhizomes and persisting by small nut-like tubers, narrow bright green leaves arching close to ground, peduncle erect with clusters of linear brown spikelets.

Introduced on Canton at least as early as 1941, seen in 1951 and 1959 by Degener and colleagues, and again by us near the terminal in 1973 and in 1975. It had increased its area considerably between 1973 and 1975. Seen only sterile.

CANTON: Degener 21413 (US); Fosberg 55717 (US); Clapp P-71-32 (US).

Refs.: Van Zwaluwenburg (1941), p. 19; Degener & Gillaspy (1955), p. 19; Degener & Degener (1959), p. 7.

Fimbristylis cymosa R. Br. (*F. diphylla* sensu Degener 1955 and *F. dichotoma* sensu Degener 1959, non (L.) Vahl; *F. pycnocephala* Hbd.)

Dense clumps of short branches and stiff narrowly linear blunt leaves, fibrous roots with a pleasantly peppery odor, erect peduncles with dense to open clusters of ovoid to fusiform spikelets, dark brown or black achenes.

Common on Canton, perhaps introduced, very abundant on Sydney, local near desiccating pond on Hull, very recently introduced in U.S.A.F. Station enclosure on Enderbury and about the U.S.A.F. station on Hull. Varying enormously in stature, also varying in inflorescence from dense and button-like (var. *pycnocephala* (Hbd.) Kük. ex F. Br.) to open and spreading, spikelets ovoid to lanceolate.

CANTON: Degener & Hatheway 21290, 21288, 21289 (UC, NSW); Fosberg & Stoddart 54882 (US, HAW, K), 54901 (US, HAW, K), 54902 (US, HAW, K); Clapp P-71-28 (US), P-71-3 (US). ENDERBURY: Fosberg & Stoddart .54743 (US, HAW), 54744 (US, HAW). HULL: Fosberg & Stoddart 54826 (US, HAW, K), 54837 (US, HAW, K); Long 2048, 2059 (US), 2021 (US). GARDNER: Long 2459 (US); Fosberg 55746 (US, BISH, K). SYDNEY: Fosberg & Stoddart 54848 (US, HAW, K), 54849 (US, HAW, K); Bryan s.n.; Long 2543 (US), 2548 (US), Woodward & Long 2575 (US).

Refs.: Degener & Gillaspy(1953), p. 19; Degener & Degener (1959), p. 7.

Scirpus subulatus Vahl. Bulrush

This was not found in 1973 or 1975, and is not clear where a habitat for such a marsh plant could exist on Canton. However, a specimen was supposedly collected in 1964.

CANTON: Holway in 1964 (BISH)

EUPHORBIACEAE

**Acalypha wilkesiana* M.-A.; a colored-leafed ornamental, was seen cultivated on Canton in 1950-51 by Degener, but had disappeared by 1958 and was not seen by us in 1973, or 1975.

Euphorbia L.

A protean genus of a great many species, found almost everywhere except in the Polar and Sub-Polar regions, differing widely in habit and other vegetative characters, but united in the reduction of the inflorescences to cup-like fused involucres or cyathia, which may resemble flowers because of petaloid appendages on glands on their rims. This genus is divided into several or many by some authors, and there is something to be said for this course. However, there seems no logical place to stop dividing the aggregate and, on the whole, it seems more convenient to maintain the genus in the broad Linnaean sense.

****Euphorbia cyathophora*** Murr. (*Poinsettia cyathophora* (Murr.) Kl. & Garcke; *E. heterophylla* var. *cyathophora* (Murr.) Griseb.). Wild or Fiddle-leafed Poinsettia

Erect branched herb with abundant milky sap; alternate leaves, oblong in general outline but deeply several-lobed on the sides; clusters of cyathia terminal, surrounded by a whorl of leaves similar to those below but usually with a red blotch on the upper surface at the base. Fruit a 3-celled capsule; seeds rather cubical, blackish, very rough.

Introduced on Canton, Hull, Gardner, and Sydney, found in weedy places, noted on Canton by Degener as in the British Settlement, but on this survey seen only around the buildings of the U.S.A.F. establishment, more abundant in 1975. One plant, only, seen on Hull in 1973, locally abundant in edges of coconut plantation on Sydney and around the native village site on Gardner.

CANTON: Fosberg 30885 (US); Degener & Hatheway in 1951; Foale 5 (K); Clegern 46 (BISH); Luomala 24 (BISH). HULL: Fosberg & Stoddart 54797 (US, HAW, K); Bryan 49 (BISH); Long 2018 (BISH, US). SYDNEY: Fosberg & Stoddart 54873

(US, HAW, K); Long 2536 (BISH, US). GARDNER: Long & Woodward 2466 (US); Fosberg 55753 (US, BISH, K).

Refs.: Degener & Gillaspy (1955), p. 24; Degener & Degener (1959), p. 10; Luomala (1951), pp. 168, 169, 173; Degener & Hatheway (1952), p. 34.

*****Euphorbia hypericifolia*** L. (*Chamaesyce hypericifolia* sensu Degener, *Euphorbia glomerifera* (Millsp.) Wheeler

Slender erect or ascending herb, arching at tips, rarely reaching 0.5-1 m tall and then rather woody at base or a slender shrub, sap milky; leaves oblong, opposite, minutely toothed; cyathia in small clusters in upper leaf axils, gland-appendages white; seeds gray.

A widespread tropical weed, in the Phoenix group known only from Canton, where it is common around U.S.A.F. installations and from Enderbury. We have no information as to exactly where on Enderbury the Clegern specimen was found in 1973.

CANTON: Fosberg & Walker 30216 (US); Degener & Hatheway 21300 (BISH); Fosberg & Stoddart 54780 (US); Fosberg 55718 (US, BISH, K): Clapp P-71-23 (US); Clegern 55 (BISH). ENDERBURY: Clegern 173 (BISH).

Refs.: Degener & Gillaspy (1955), p. 23; Degener & Hatheway (1952), p. 34; Degener & Degener (1959), p. 10; Luomala (19 51), p. 166.

*****Euphorbia hirta*** L. (*Chamaesyce hirta* (L.) Millsp.) Hairy Spurge

Small generally pubescent herb, erect to ascending, arching at tips; leaves opposite, pointed, ovate, serrate, up to 2 cm long, reddish or brownish-green; cyathia in dense axillary clusters, gland appendages whitish.

One of the most common tropical weeds, having followed man almost everywhere in the tropics and subtropics except where it is extremely dry. It is facultatively annual or perennial. In the Phoenix group known from Canton, Enderbury, Hull and Sydney. On Enderbury it has been established locally for a long time and was probably introduced by the guano-diggers. One tiny plant of it was found by us in the enclosure of the U.S.A.F. station, far from any other places where it is found. This probably represents a second accidental introduction from Canton. On Hull it was found around both the U.S.A.F. station, and the abandoned Gilbertese village, on Sydney around the abandoned Gilbertese village, more abundant in 1975 than in 1973 and had become extremely abundant there and throughout the surrounding coconut plantation.

CANTON: Fosberg 30873; Degener & Hatheway 21298; Fosberg & Stoddart 54786 (US, HAW, K); Luomala 17; Clapp P-7-1-4 (US), P-71-6 (US), P-71-21 (US). ENDERBURY: Bryan 30 (P); Fosberg & Stoddart 54745 (US), 54757 (US, HAW, K). HULL: Fosberg & Stoddart 54786 (US, HAW, K); Long 2028 (US). SYDNEY: Fosberg & Stoddart 54852 (US, HAW, K); Long 2545 (US), 2571.

Refs.: Degener & Gillaspy (1955), p. 23; Degener & Degener (1959), p. 10; Degener & Hatheway (1952), p. 34.

***_Euphorbia prostrata_** Ait. (*Chamaesyce prostrata* (Ait.) Small). Prostrate Spurge

Very prostrate very slender plant forming tiny purplish green mats, sap milky; leaves orbicular or nearly so, very small, opposite; cyathia on axillary pedicels or in several-flowered clusters; capsules 3-angled, the angles hairy.

Common on bare ground around U.S.A.F. installations and old British settlements on Canton and Hull, and in abandoned Gilbertese villages on Hull and Sydney, not seen on Sydney in 1975. Luomala's (1951, p. 169) description of a change in habit from prostrate to erect suggests that either the plants were infected by a rust, causing the erect habit, or that the erect plants were really *E. hypericifolia* misidentified as *E. prostrata*.

CANTON: Degener & Hatheway 21299 (BISH); Fosberg & Stoddart 54779 (US, HAW, K); Luomala 29 (BISH); Clapp P-71-5 (US); Clegern 43 (BISH); Fosberg 30880 (US); Fosberg 55715 (US, BISH). HULL: Clegern 130 (BISH); Jenkin in 1865 (K); Fosberg & Stoddart 54788 (US, HAW, K); Bryan 48 (BISH, K). SYDNEY: Fosberg & Stoddart 54860 (US, HAW, K).

Refs.: Degener & Gillaspy (1955), p. 23; Degener & Degener (1959), p. 10; Luomala (1951), pp. 169, 173.

**Euphorbia pulcherrima* Willd. (*Poinsettia pulcherrima* (Willd.) R. Grah.) Poinsettia

This common ornamental was reported by Degener & Hatheway (1952), p. 35, as present on Canton in 1951, but was not seen in 1973.

***_Pedilanthus tithymaloides_** (L.) Poit. Shoe-flower

Fleshy erect shrub or stiff herb with zig-zag branches; leaves alternate, ovate, acute, distichous; cyathia red, slipper-shaped, pointed.

Widely planted tropical ornamental, one bush seen in U.S.A.F. establishment.

CANTON: Fosberg & Stoddart 54912 (US, HAW, K). GARDNER: Long 2506 (US).

***_Phyllanthus amarus_** Schum. & Thonn. (*P. niruri* sensu Degener, non L.).

Erect pale green herb with horizontal branches with tiny pinnately arranged leaves which hang together and "go to sleep" at night; flowers tiny, greenish, in axils of leaves, male and female in same axil; capsules small, depressed globose; seeds are like sections of a depressed sphere, strongly striate.

A common pantropic weed, said by Degener to have been introduced to Canton probably in soil from Fiji, also abundant around the abandoned Gilbertese village on Hull.

CANTON: Fosberg & Stoddart 54715 (US); Clapp P-71-25 (US); Degener & Degener 24646 (BISH). HULL: Fosberg & Stoddart 54803 (US, HAW, K); Long 2005 (US); Clegern 79 (BISH). GARDNER: Woodward & Long 2471a (US).

Refs.: Degener & Gillaspy (1955), p. 23; Degener & Degener (1959), p. 10.

GOODENIACEAE

Scaevola taccada (Gaertn.) Roxb. (*S. frutescens* sensu Degener, non (Mill.) Krause; *S. sericea* Vahl)

Tall shrub, rounded and mound-like when growing in open stands or isolated, to 3-4 m tall; leaves obovate, entire, narrowed to a sessile base, rounded at apex, bright green, exstipulate, with few to abundant white axillary hairs; cymes axillary, dichotomous, flowers white, gamopetalous, tube split to base dorsally, lobes 5, patent, arranged in a semicircle like a small fan, margins very thin; fruit a drupe with white flesh, a ribbed corky stone that floats very well.

Common generally on Canton, Hull and Sydney; one individual bush on Enderbury at the top of the east beach; occurs as almost impenetrable thickets on Sydney. Forms with glabrous and pubescent leaves were seen in mixed populations, in different proportions. Var. *fauriei* Deg. & Deg. was introduced from Oahu by Degener in 1950-51, but was not seen in 1973 or 1975.

CANTON: Fosberg 30872 (US); Bryan 1339 (BISH, NY); Degener 24644 (NY); Degener & Hatheway 21301 (G, BISH), 21302 (G, BISH, NY, A); Fosberg & Stoddart 54877 (US, HAW, K); Luomala 12 (BISH); Long 2409 (US). ENDERBURY: Clegern 134 (BISH); Fosberg & Stoddart 54737 (US, HAW, K). HULL: Fosberg & Stoddart 54810 (US, HAW, K), 54841 (US, HAW, K), 54824 (US, HAW, K); Bryan in 1924 (BISH); Long 2002; Clegern 92 (BISH). SYDNEY: Fosberg & Stoddart 54845 (US, HAW, K), 54846 (US, HAW, K); Bryan 43 (BISH, A); Long 2586 (US), 2559 (US), 2560 (US). GARDNER: Long 2453 (US, BISH), 2488 (US), 2495 (US); Fosberg 55745 (US, BISH, K), 55778 (US, BISH, K).

Refs.: Bryan (1942), pp. 46, 60; Degener & Gillaspy (1955), pp. 30-31; Hatheway (1955), pp. 2-9; Luomala (1951), pp. 164, 165, 174; Degener & Hatheway (1952), p. 34; Maude (1952), p. 70; Laxton (1951), p. 143; Pickering (1876), pp. 240, 241; Degener & Degener (1959), pp. 16-17.

GUTTIFERAE (CLUSIACEAE)

Calophyllum inophyllum L. Portia Tree or Kamani

Large tree with milky sap; leaves opposite, leathery, large, oblong to elliptic, rounded at ends, petiolate; flowers in axillary panicles, white to slightly pinkish, sepals small, petals 4, orbicular, stamens many, pistil 1; fruit a pendent globose drupe 2.5-3 cm in diameter, corky within, seed much smaller.

Introduced on Canton before 1950, and still growing well in 1958 (Degener & Degener (1959), p. 11), but not located in 1973 nor 1975. Several fairly large trees on Hull in the old Gilbertese village site; probably planted here, although presumably native or at least of spontaneous introduction in some other islands of the South Pacific.

CANTON: Luomala 18; Clapp P-71-36 (US). HULL: Fosberg & Stoddart 54794 (US, HAW, K); Long 2033 (US).

Refs.: Degener & Gillaspy (1955), p. 25; Degener & Degener (1959), p. 11; Luomala (1951), pp. 168, 173.

LAURACEAE

Cassytha filiformis L. Love-vine

Leafless green to orange tangled string-like twining stems, sending haustoria or penetrating organs into the tissues of other plants (or itself) when it touches them; flowers very small, white, in short spikes; fruits globose drupes, greenish white turning purple when very ripe, with a hard globose stone.

Native on most tropical beaches and on most Pacific Islands including two of the Phoenix group, Canton and Enderbury; parasitic on many plant species including, in the Phoenix group, at least *Scaevola*, *Portulaca*, *Boerhavia*, *Suriana*, *Sida*, and *Triumfetta*. On Enderbury droppings, presumably of curlews, were found to be packed with *Cassytha* stones, suggesting one of the means by which the plant may be dispersed from island to island.

CANTON: Bryan 26 (BISH), 1338 (BISH) in 1938; Degener & Hatheway 21282; Luomala 31 (BISH). ENDERBURY: Marshall 4; Long 2106 (US), 2682 (US).

Refs: Degener & Gillaspy (1955), p. 22; Degener & Degener (1939), p. 9.

LECYTHIDACEAE

Barringtonia asiatica (L.) Kurz

Tree reaching a large size, with large alternate obovate leathery entire leaves, large flowers with many long showy pink and white stamens, the filaments coherent at base, and pendent large square fruits each containing a single large poisonous seed.

This species has not been known from the Phoenix Islands, but in 1975 a 1 m seedling was seen in the shelter of a building in the U.S.A.F. area on Canton Island. In all probability a drifted fruit was picked up on the beach and planted.

LEGUMINOSAE (MIMOSACEAE)

**Desmanthus virgatus* (L.) Willd. was introduced to Canton in 1950-51 by Degener. A few plants survived in 1958 (Degener & Degener 1959, p. 10) but were not seen in 1973 or 1975.

**Intsia bijuga* (Colch.) O. Ktze Degener & Degener 24687 (US). Drift seed only.

****Leucaena leucocephala*** (L.) deWit (*L. glauca* sensu auct. plur., non (L.) Benth.)

Shrub with alternate twice pinnately compound leaves with many small oblong-lanceolate leaflets; flowers in globose heads on axillary peduncles, white, with many stamens; fruit a thin flat, linear-oblong dehiscent pod with transversely arranged flattened dark brown hard seeds.

This was introduced to Canton with soil from Oahu before 1941 and still persisted around the old British settlement in 1975.

CANTON: Fosberg 30881 (US); Degener & Hatheway 21296; Luomala 3; Clapp P-71-14 (US).

Refs.: Van Zwaluwenburg (1941), p. 19; Degener & Gillaspy (1955), p. 22; Degener & Degener (1959), p. 10; Degener & Hatheway (1952), p. 35; Luomala (1951), pp. 169, 172.

**Prosopis pallida* (H. H. K.) Willd. (*P. chilensis* sensu Degener, non (Mol.) Stuntz) was seen by Degener as a pot plant in 1958 but evidently has not persisted. Seedlings of **Delonix regia* (Boj.) Raf. were seen in a bath house on Canton in 1975.

LILIACEAE (sensu latissimo, including AGAVACEAE and AMARYLLIDACEAE)

A sterile *Aloe*, possibly **A. barbadensis* Mill. and a sterile **Yucca* appear in photos of Canton made by Roger Clapp in 1971 and were seen by us, around dwellings in the U.S.A.F. establishment there in 1973 and in 1975. They were not collected or identified.

Cordyline fruticosa (L.) Chev. (*C. terminalis* (L.) Kunth) Ti

Erect stick-like woody stem with a feather-duster-like rosette of large elliptic or oblong leaves. Various red-variegated horticultural forms as well as the normal green-leafed one are commonly planted as ornamentals. Several color forms seen planted about USAF buildings on Canton in 1975. A small plant of the green form of **Cordyline fruticosa* (L.) Chev. was seen in a bath-house on Canton in 1975.

Crinum asiaticum L. Crinum lily

Large rosettes of soft lanceolate leaves, often caespitose and reproducing by offsets, with axillary scapes overtopping leaves with subumbellate clusters of large white flowers, perianth tubular with linear-oblong recurved lobes, 6 long-exserted stamens with linear anthers, a single long pistil; fruit fleshy, with very large fleshy seeds.

A common ornamental, persisting around abandoned village sites on Hull and Sydney atolls; reported from Canton in 1955 and 1959 but not seen there in 1971; unless Clapp P-71-17 (US) is this species; persisting in the old village site on Gardner in 1975.

HULL: Long 1998. SYDNEY: Bryan 45; Fosberg & Stoddart 54874 (US). GARDNER: Fosberg 55769 (US, BISH).

LYTHRACEAE

Pemphis acidula Forst.

Erect stiff shrub with many intricate slender branches and a very hard wood; leaves opposite, small, 1-2 cm long, elliptic, thick, astringent to taste; flowers axillary, calyx united, campanulate, striate, with 12 teeth, petals 6, white, clawed, stamens 12, in 2 series, styles of different lengths on different plants; fruit a dark reddish brown capsule, closely invested by calyx to give the appearance of an inferior ovary; seeds many, small.

One of the most characteristic coral island plants, usually growing on coral rock, rarely, as on Canton, on loose coral sediments; apparently recorded earlier from Canton (Degener and Gillaspy (1955), p. 23) but the records discounted by Degener as misidentifications of *Suriana*, which sometimes looks similar but has yellow flowers.

The present Canton plant was a single bush growing along the road on the lagoon beach and is positively *Pemphis*. It is abundant on Hull Atoll. Not recorded previously nor found on this survey on Birnie, Enderbury, Phoenix or Sydney. Reported by Hemsley as collected on Hull by J.T. Arundel.

CANTON: Fosberg & Stoddart 54717 (US, HAW, K). HULL: Fosberg & Stoddart 54805 (US, HAW, K); Fosberg 55731 (US, BISH, K), 55738 (US, BISH, K); Bryan 54; Schultz 43; Long 2054, 2014 (US).

Ref.: Hemsley (1885), p. 116; Pickering (1876), p. 241.

MALVACEAE

**Gossypium brasiliense* Macf. and **G. tomentosum* Nutt. were introduced on Canton by Degener in 1950-51 (Degener & Degener (1959), p. 11) but have apparently not persisted, as they were not seen in 1973. **Hibiscus rosa-sinensis* L., reported as present on Canton in 1951 and 1958 by Degener, likewise was not found in 1973. A single plant of a pink garden hybrid *Hibiscus* (Fosberg & Stoddart 54802 (US, HAW, K); Clapp P-71-39 (US)) was found flowering abundantly but not fruiting in the old Gilbertese village on Hull. It is not likely to spread. Another hybrid, red flowered (Fosberg & Stoddart 54904 (US)), grows near a house in the U.S.A.F. area, Canton.

****Hibiscus tiliaceus*** L. (*Pariti tiliaceum* (L.) Britt.) Hau (Hawaii)

A fair-sized tree, often low and with weak, tangled branches, and tough inner bark; leaves orbicular, cordate, slightly pointed, to 10-15 cm across, dark green above, white beneath, long petiolate, with large oblong stipules that enclose the terminal buds; flowers in few-flowered open terminal racemes, base of each flower subtended by a whorl of linear involucral bracts; calyx short, toothed, corolla large, showy, campanulate, petals imbricate rolled, united at base, yellow with maroon base, turning reddish and falling toward evening; stamens many, filaments united into a fleshy column, their tips, with the anthers, free; ovary densely hairy, style filiform, 5-branched, stigmas hairy, capitate; fruit a 5-valved loculicidal hairy capsule; seeds dark brown, small.

A few trees in the U.S.A.F. establishment on Canton, but not seen in the old British settlement where Degener reported it. It was "recently introduced" according to Van Zwaluwenburg in 1943. Several large, but slightly chlorotic plants grow in the old Gilbertese village on Hull.

CANTON: Fosberg & Stoddart 54900 (US, HAW, K); Fosberg 30888 (US); Degener & Hatheway 21284; Luomala 45; Clapp P-71-37 (US) (leaves green beneath, possibly var. *sterilis* F. Br.), P-71-27 (US). HULL: Fosberg & Stoddart 54799 (US).

Refs.: Van Zwaluwenburg (1943); Degener & Gillaspy (1955), p. 24; Degener & Degener (1959), p. 11; Luomala (1951), pp. 167, 173.

**Sida acuta* Burm f. (*Sida carpinifolia* L. f.) introduced on Canton prior to 1951 in soil imported from Fiji, but not reported since 1951, and not seen in 1973 or 1975.

Ref.: Degener & Gillaspy (1955), p. 25.

Sida fallax Walp. Ilima (Hawaii)

Shrub varying in habit from prostrate and mat-forming to erect and 2.5 m tall; leaves alternate, dull green to gray-green, tomentulose, orbicular, cordate, margin crenulate, petioles slender; flowers on axillary pedicels, sepals united, with 5 acute lobes, corolla orange, rarely (in the Phoenix Is.) reddish in center, 1.5-2 cm across, petals united at base, closing in the evening and falling, stamens united into a column, style with 5 branches; fruit splitting into 5 segments or carpids, these shortbeaked, the beak splitting into a pore for the ultimate escape of the seed, sides of carpids reticulate rugose. Some specimens (Long 2670, 2540) have very small leaves.

Generally distributed, one of the most abundant plants on all the Phoenix Islands, where it dominates the vegetation in many areas, except on Birnie where there was in 1973 only a very small colony of less than a dozen plants. This had apparently disappeared by 1975. It was mentioned from Canton, Enderbury, Hull and Gardner in notes with a specimen, Arundel 11 (K) collected Oct. 1882.

CANTON: Fosberg & Walker 30201 (US); Lister in 1889 (K); Degener & Hatheway 21329, 21330, 21331, 21332 (NSW); Degener & Degener 24661 (NY); Fosberg & Stoddart 54761 (US, HAW, K), 54914 (US, HAW, K), 54915 (US, HAW, K); Long 2408 (US); Schultz 22 (US); Luomala 34. BIRNIE: Fosberg & Clapp 54720 (US, HAW, K), (not found in 1975). ENDERBURY: Fosberg & Stoddart 54733 (US, HAW, K), 54736 (US, HAW, K); Marshall 9; Long 2098 (US), 2650 (US), 2670 (US); Lamb in 1938 (K). PHOENIX: Fosberg & Stoddart 54761 (US, HAW, K); Fosberg 55801 (US; BISH); Long 2077 (US), 2079, 2080, 2089 (US), 2614 (US), 2634 (US). HULL: Fosberg & Stoddart 54815 (US, HAW, K), 54835 (US, HAW, K); Long 2007, 2067 (US); Schultz 43 (US). SYDNEY: Fosberg & Stoddart 54847 (US, HAW, K); Long 2540 (US), 2589 (US). GARDNER: Fosberg 55750 (US, BISH, K); U.S. Expl. Exped. (NY). McKEAN: Recorded in Long's notes; Fosberg 55794 (US, BISH, K).

Refs.: Bryan (1942), pp. 50, 53, 54; Laxton (1951), p. 147; Degener & Hatheway (1952), p. 34; Maude (1952), p. 70; Degener & Gillaspy (1955), p. 25; Degener & Degener (1959), p. 11; Hatheway (1955), pp. 5-7; Luomala (1951), pp. 162, 163, 171, 173; Pickering (1876), pp. 240, 241, 243; Van Zwaluwenburg (1942), p. 49.

**Thespesia populnea* Sol. ex Correa, a pantropical strand tree but not native in the Phoenix Islands, was introduced to Canton before 1942 (Van Zwaluwenburg (1943), p. 3; Degener & Gillaspy (1955), p. 25) and was growing around the wharf and the Pan American Hotel in 1951 (Degener & Hatheway 21308 (NY) and still in 1958 (Degener &

Degener (1959), p. 11), also shown on a 1971 photograph by Roger Clapp, but was not seen in 1973 or 1975. Hemsley reported it as having been collected by J.T. Arundel on Enderbury before 1884.

Ref.: Hemsley (1885), p. 116; Luomala (1951), pp. 166, 170, 173; Degener & Degener (1959), p. 11.

MORACEAE

**Artocarpus altilis* (Park.) Fosb. (or *A. altilis* X *mariannensis*). The breadfruit was seen and collected in the Gilbertese village on Hull, presumably planted, by Long [1999 (US)], but was not seen in 1973. The species was seen as a pot plant on Canton in 1975.

**Ficus microcarpa* L.

The Chinese banyan usually starts as an epiphyte, becoming a strangler, surrounding the trunk of the host tree with roots, these anastomosing to form a very irregular trunk with the remains of the host tree within; leaves alternate, blade obovate to broadly elliptic, obtuse to acuminate, thick, veins rather obscure except basal pair; stipules acuminate; figs small, axillary, globose.

A plant, probably this, seen in photograph taken on Canton in 1971, not seen in 1973 or 1975. Clegern 170 (BISH), labeled as from Enderbury, could scarcely have come from there, and was probably from a pot plant, or from around buildings on Canton.

MUSACEAE

**Musa nana* and, presumably, **Musa sapientum* were reported by Degener & Gillaspy (1955), p. 20 and Degener & Degener (1959), p.8, as introduced and and cultivated on Canton, but in 1973 and 1975 they were not seen. A species of **Musa* was identified on a photograph of Canton taken by Roger Clapp in 1971 and Clapp P-71-38 (US), leaf only, is presumably the same; likewise a young plant on a photo taken on Canton by Robert Clegern in September 1973. In 1975 a small but healthy banana was seen in a sheltered spot around a house in the USAF residence area on Canton. Such plants will doubtless grow as long as they are sheltered from salt spray and kept well watered.

NYCTAGINACEAE

Boerhavia albiflora Fosb.

Similar to *B. tetrandra* below but stems green, leaves irregularly oval or ovate, peduncles from beside the leaf axils rather than in them, bearing umbellate branches, the flower clusters glomerate, perianth white, campanulate, 5-lobed, lobes emarginate, not recurved, stamens 1-3, mostly 2, style curved.

A widespread species found on all eight islands studied on this survey, growing abundantly in different habitats, in places in pure stands, forming large mats or a continuous ground-cover. The thickened tap roots reach 8 cm or more in diameter and produce long horizontal branch roots, especially in sandy places. Plants similar to this occur from Wake and the Northern Marshalls to the Phoenix Islands, with a variety on the Great Barrier Reef of Australia, where it was recently found on Heron Island. It has generally been referred to *B. diffusa* or *B. repens*, both of which seem to be different.

CANTON: Fosberg & Walker 30207; Degener & Hatheway 21305, (NY); Fosberg & Stoddart54892 (US, HAW, K); Clapp P-71-10 (US), P-71-2 (US); Browne in 1939 (BISH); Murphy in 1949 (BISH); Lamb in 1938 (BISH); Long 2404 (BISH); Holway in 1964 (BISH); MacDaniels in 1950 (BISH); Luomala 35 (BISH), 1OA (BISH); Clegern 30 (BISH); Bryan 1327 (BISH). BIRNIE: Fosberg & Stoddart 54724 (US, HAW, K); Long 2636. ENDERBURY: Fosberg & Stoddart 54747 (US, HAW, K), 54748 (US, HAW, K), 54759 (US); Bryan 32 (BISH); Lamb in 1938; (BISH); Marshall 13; Long 2094 (BISH), 2096 (BISH), 2102 (BISH), 2119, 2121 (BISH), 2651 (BISH), 2666 (BISH); Clegern 150 (BISH). PHOENIX: Fosberg & Stoddart 54762 (US, HAW, K), 54767 (US, HAW, K), 54768 (US, HAW), 54770 (US); Bryan 17 (BISH); Long 2077 (HAW) (slightly infected with *Albugo*, habit condensed, leaves small), 2081 (US, BISH), 2083 (US, BISH), 2087 (US, BISH), 2622 (US). HULL: Fosberg & Stoddart 54823 (US, HAW), 54832 (US, HAW, K); Bryan 52 (BISH, P); Long, 2010, 2061, 2062, 2064, 2065, 2066, 2068, 2069; Clegern 102 (BISH). SYDNEY: Fosberg & Stoddart 54854 (US), 54859 (US, HAW, K), 54864 (US, HAW, K); Long 2541 (US, BISH), 2580 (US), 2588 (US, BISH). GARDNER: Fosberg 55761 (US, BISH, K), 55772 (US, BISH, K). McKEAN: Long 2030 (US) (very large leafed form), 2046 (US), 2028 (BISH), 2041 (US, BISH), 2034 (US), 2037 (US, BISH), 2428 (US, BISH) (peduncles and their branches very heavy), 2439 (US, BISH), 2443 (US, BISH); Fosberg 55788 (US, BISH, K), 55795 (US, BISH, K).

Two collections, Long 2612 (US, BISH) and 2622 (BISH) from Phoenix, and two from Hull, Long 2068, 2010, have the appearance of this species, but have pink flowers according to the labels. They do not appear to be *B. tetrandra*, as neither the leaves nor the inflorescence resemble that species.

Gräffe (1864, p, 207), mentions a plant with thick heart shaped leaves, small white flowers and thick insipidly sweet root which is cooked and eaten by colonists. Plant described as probably cruciferous. McKEAN. This may be *Boerhavis albiflora*.

Ref.: Degener & Gillaspy (1955), p. 21; Hatheway (1955), pp. 4-6; Pickering(1876), pp. 240, 242, 243; Fosberg (1978), pp. 11-12.

Boerhavia tetrandra Forst. f.

Prostrate reddish stems radiating from a thickened vertical tap-root, elongate, leaves oval or broadly oblong, rounded at both ends, white beneath; inflorescences axillary, umbelloid, at least twice branched, flowers in open clusters, pink, perianth scarcely lobed, its margin tending to be turned back, stamens 3-4, mostly 4, pistil 1; fruits 5-ribbed, club-shaped, the ribs glandular viscid.

One patch, only, found on a bare cobbly flat on Hull; reported by Degener from Canton, but since he specifically says the flowers are white, he probably collected *B. albiflora*. Long, (m.s.), reports both pink and white flowered plants from Phoenix, but his pink-flowered specimens (2612, 2622) are not *B. tetrandra*. His 2120 (BISH), from Enderbury may be *B. tetrandra* but has acute leaves which are not right. It is not disposed of here. None but white-flowered plants were seen by us on any but Hull and Gardner Islands. A single small pink flowered plant was found in the village site on Gardner. Bryan (1942, pp. 54, 57, 238) indirectly reports *B. tetrandra* from Phoenix and Birnie, but says nothing that would permit one to think he distinguished 2 species. Hemsley reported this species as collected on Canton, Hull, and Enderbury by J. T. Arundel, but we have not seen the specimens.

HULL: Fosberg & Stoddart 54820 (US, HAW, K); Bryan 53 (BISH); Long 2065 (BISH). GARDNER: Fosberg ,55777 (US).

Ref.: Pickering (1876), p. 242? Hemsley (1885), p. 116.

****Bougainvillea glabra*** Choisy — Bougainvillea

A white form of this thorny vine was growing by one of the buildings in the U.S.A.F. establishment in 1973 (Fosberg & Stoddart 54911 (US, HAW, K)) but will not likely persist unless it is kept watered during dry periods. The same form was seen in another sheltered spot in 1975.

**Mirabilis jalapa* L., the garden four-o'clock, was planted in the Gilbertese village on Hull (Long 2032 (US), 2039 (US)), but was not found there in 1973 or 1975.

Pisonia grandis R. Br. (*Calpidia ovatifolia* sensu Pickering probably an error for *Calpidia ovalifolia* Bojer which is totally different.) — Buka

Large tree with pale smooth often enormous trunk, soft brittle pulpy wood; opposite large ovate to oblong, obtuse to somewhat acuminate light green leaves, deciduous during drought periods, dioecious umbelloid cymes of small greenish flowers, open panicles of clavate, 5 ribbed, spinose very glutinous fruits.

Common on Hull, collected once on Sydney by Bryan and by Long, but not seen by us in 1973 or 1975; locally abundant on Gardner (1975). This is one of the characteristic atoll trees, found from eastern Polynesia to the western Indian Ocean, its fruits admirably adapted to being carried around by sea birds, which use the tree as a nesting site. A specimen collected by the U.S. Expl. Exped. s.n. (US) has a label that seems to read "Enderbury's Island." This species has not been seen or collected on Enderbury in recent years. The Expedition called there in 1840 and 1841.

Canton: Degener & Hatheway 21285 (BRI), 21283 (BISH); Luomala 30 (BISH); Cranwell Smith in 1956 (BISH). HULL: Fosberg & Stoddart K); Clegern 99 (BISH). SYDNEY: Bryan 38 (BISH). Long 2015 (US). GARDNER: Long 2507 (US); Fosberg 55764 (US, BISH, K), 55779 (US, BISH, K), 55783 (US, BISH, K). ENDERBURY: [?] Clegern 154 (BISH), 153 (BISH).

Refs.: Bryan (1942), pp. 60, 64, 71; Laxton (1951), p. 136; Maude (1952), p. 70; Pickering (1876), pp. 240, 242.

PANDANACEAE

******Pandanus tectorius*** Park. (*sensu lato*) Screw Pine

Small tree with long linear prickly-margined leaves and subglobose to crylindric-oval heads of fruits.

In all likelihood not native to the Phoenix Group. Introduced from Hawaii to Canton in 1950 and said by Degener to have been well-established in gardens in 1958. Several healthy trees were seen at the abandoned settlement, on the lagoon shore in 1973. This is a small-fruited form. In the coconut plantations and around the abandoned village sites on Hull (planted according to Long), Sydney, and Gardner several of the large-fruited Micronesian forms (*P. pulposus* Mart.) are common. These are edible forms doubtless introduced and propagated vegetatively by the Gilbertese settlers. Quite a few seedlings of them were seen, but none large enough to give any indication of the types of fruits they would bear. Information from Marshallese informants suggests that seedlings of the large-fruited forms usually bear small inedible fruits, at least in the Marshall Islands, where the edible varieties are propagated vegetatively. On Sydney *Pandanus* trees were seen sparingly in the old village site, much more abundantly toward the lagoon from the village.

CANTON: Fosberg & Stoddart 54878 (US, HAW, BISH); Luomala 25. HULL: Long 2004 (US), 2041; Fosberg & Stoddart 54827 (US, BISH). SYDNEY: Long 2535 (US); Fosberg & Stoddart 54844 (US, HAW, BISH, K). GARDNER: reported by Pickering and Laxton; Fosberg 55771 (US, BISH, K).

Refs.: Laxton (1951), p. 144; Pickering (1876), p. 240; Degener & Gillaspy (1955), pp. 16-17; Degener & Degener (1959), p. 4; Degener & Hatheway (1952) p. 35; Luomala (1951), p. 171.

PASSIFLORACEAE

**Passiflora foetida* L. was observed growing in cultivation on Canton in 1950 and more seeds were sown (Degener & Gillaspy 1955, p. 26), establishing the plant locally, as observed by Degener (1959) in 1958. The species was not seen in 1973 nor in 1975.

POACEAE (GRAMINEAE)

**Cenchrus echinatus* L. Sand-burr

An annual or perennial grass with racemes of prickly bur-like fruits about the size of a small pea.

Abundant on Canton around present and former installations, introduced at least prior to 1949. Common on Sydney in the plantation, very local on Gardner, rare in Hull, seen by us there only at the U.S.A.F. installation, but found earlier by Long. Not known previously from Enderbury where in 1973 it was well established around the U.S.A.F. installation, doubtless brought accidentally from Canton. We recommended in 1973 to the Air Force authorities that it be eliminated from the stations on Hull and Enderbury. In 1975 a few plants persisted around the abandoned sites. All seen were pulled up.

CANTON: Fosberg & Walker 30202 (US, BISH), 30217 (US, BISH, K); Degener & Hatheway 21252; Luomala 9, 38. ENDERBURY: Fosberg & Stoddart 54732 (US, HAW, K). HULL: Long 2005 (US), 2052 (US), 2034 (US); Fosberg & Stoddart 54840 (US, HAW). SYDNEY: Long 2583 (US); Fosberg & Stoddart 54885 (US, HAW); Fosberg 55730 (US, BISH, K). GARDNER: Fosberg 55752 (US, BISH, K).

Refs.: Degener & Hatheway (1952), p. 34; Degener & Gillaspy (1955), p. 17; Laxton (1951), p. 143; Hatheway (1955), p. 1; Degener & Degener (1959), p. 4; Luomala (1951), pp. 169, 173.

**Chloris inflata* Link Finger Grass

Loosely tufted grass with purplish digitate inflorescences, these rather hairy.

Introduced to Canton in 1950, now abundantly naturalized around the U.S.A.F. installations and housing. Recently established and spreading about the U.S.A.F. enclosure on Hull.

CANTON: Degener & Hatheway 21251; Luomala 40. HULL: Fosberg & Stoddart 54787 (US, HAW, K).

Refs.: Degener & Gillaspy (1955), p. 17; Degener & Degener (1959), p. 5; Degener & Hatheway (1952), p. 34; Luomala (1951), p. 172.

***Cynodon dactylon** (L.) Pers. Bermuda Grass

Prostrate, tightly rooted, mat-forming fine grass with erect slender peduncles and digitate inflorescences.

Naturalized at least before 1941, on Canton; still persisting here and there about U.S.A.F. installations but only on Canton through our visit in 1973, but what was probably this was seen sterile at the abandoned U.S.A.F. site on Hull in 1975.

CANTON: Degener & Hatheway 21286.

Refs.: Van Zwaluwenburg (1941), p. 19; Degener & Hatheway (1952), p. 34; Degener & Gillaspy (1955), p. 17; Degener & Degener (1959), p. 5; Luomala (1951), p. 172.

***Digitaria ciliaris** (Retz.) Koel. (*D. sanguinalis* sensu Degener, non (L.) Scop., *D. timorense* sensu Degener, non (Kunth) Bal.) Crab Grass

A slender depressed grass with digitate inflorescences. Found on Canton by Degener, not seen there in 1973 or 1975, but found by us on Hull in the old village site. CANTON: Hatheway 518 (US); Degener & Hatheway 21315 (US); Degener & Degener 24645 (US), 24648 (US); Clegern 42 (BISH). HULL: Fosberg & Stoddart 54813 (US, HAW); Clegern 113 (BISH).

Refs.: Degener & Hatheway (1952), p. 34; Degener & Degener (1959), p. 5.

***Digitaria ciliaris** ssp. **chrysoblephara** (Fig. & De Not.) S.T. Blake

HULL: S.W. part of I. 16/8/65, Jenkin 4 (K) det. Veldkamp 1970.

***Digitaria henryi** Rendle Henry's Crab-grass

A prostrate slender slightly glaucous grass with digitate inflorescences on short pedicels, the racemes not spreading much.

Introduced on Canton by Degener in 1950, noted by him as established in 1958 (Degener & Degener 24647 (US)), not seen on Canton in 1973 or 1975. Possibly seen near old village in 1975.

Refs.: Degener & Gillaspy (1955), p. 34; Degener & Degener (1959), p. 5.

Digitaria pacifica Stapf (*D. stenotaphrodes* sensu central Pacific authors, non (Nees) Stapf)

A robust, broad-leafed usually tufted grass, sometimes forming spreading masses; inflorescences digitate, racemes very stiffly erect. A very distinctive grass, endemic to the Central Pacific atolls, with its closest relative in the Tuamotu and Society atolls of southeastern Polynesia. It is to be expected on all of the Phoenix group, but has not been found on Birnie, Phoenix, or Sydney. Like many *Digitaria* species, it behaves in a weedy fashion when opportunity affords, and the continued disturbance on Canton has enabled it to become much more abundant than it probably was before.

Some specimens of *D. pacifica* approach *D. stenotaphrodes* of Southeast Polynesia in habit and number of racemes, e. g. Bryan 46 (US). However the elliptic spikelets of this sheet suggest that it is merely a depauperate specimen of *D. pacifica.* It is on this type of material that recent records of *D. stenotaphrodes* from the Central Pacific are based.

CANTON: Fosberg 30886 (US, BISH); Degener & Hatheway 21316 (US), 21318 (US); Luomala 5, 39, 41; Degener & Degener 24589 (US), 24638; Fosberg & Stoddart 54899 (US, HAW, K); Clegern 49 (BISH); bet. wharf & airfield, M.A. Foale 3 (K). ENDERBURY: Fosberg & Stoddart 54729 (US, HAW); Long 2107 (US), 2680 (US, K); Marshall 6; Clegern 160 (BISH); A.C. Brown, s n. (US). HULL: Long 2063; Fosberg & Stoddart 54829 (US, HAW, K); W. Side, Bryan 46 (US, K). GARDNER: Long 2476 (US), 2292 (UA); Fosberg 55775 (US, BISH, K). McKEAN: Long 2045 (US), 2426 (US), 2031 (US); Fosberg 55990 (US, BISH, K).

Refs.: Degener & Gillaspy (1955), p. 17; Degener & Degener (1959), p. 5; Luomala (1951), pp. 163, 172; Degener & Hatheway (1952), p. 33.

*****Digitaria setigera*** Roth ex R. & S. (*D. pruriens* Fisch. ex Trin., *D. microbachne* sensu auct. non Presl). Crab Grass

Slender weak-stemmed diffusely spreading grass, flowering and fruiting culms ascending, racemes digitate or almost so, 4-7, appressed- erect in fruit, second glume usually less than half the length of spikelet.

A widespread Indo-Pacific species, here recorded for the first time from the Phoenix Islands, only known from Gardner, where it may possibly have been introduced by the Gilbertese. It is, however, a native plant in Polynesia.

GARDNER: Fosberg 55782 (US, HAW, K); Long 2504 (US).

__Eleusine indica__ (L.) Gaertn. Goose-grass

A tough wiry grass with ascending stems and 2-4 digitately arranged spike-like flowering panicles and tiny rough grains.

Occasional in paths, roadsides, and around buildings on Canton and in old village site on Hull, not seen on Gardner in 1975.

CANTON: Degener & Hatheway 21254; Fosberg & Walker 30211 (US, BISH, K). HULL: Fosberg & Stoddart 54814 (US, HAW, K); Long 2003 (US, K). GARDNER: Long & Woodward 2468 (US).

Refs.: Luomala (1951), p. 172; Degener & Hatheway (1952), p. 34; Degener & Gillaspy (1955), p. 18.

__Eragrostis amabilis__ (L.) W. & A. (*E. tenella* (L.) Beauv.) Love-grass

A fine, spreading soft grass, annual or in wet years possibly perennial, stems tufted, decumbent; inflorescences very finely much-branched, spikelets very small, compressed.

A pantropic weed of pioneer situations and waste ground, abundant on Canton, well established on Hull, especially abundant near the U.S.A.F. station; one tuft only seen on Sydney in 1973 in the coconut plantation. This seems to be the first record from Sydney; rare on Gardner in 1975 in coconut-*Morinda* forest, also a first record there.

CANTON: Degener & Hatheway 21297 (US); Clegern 62 (BISH). HULL: Bryan 47 (US); Long 2024 (US), Fosberg & Stoddart 54836 (US, HAW, K). SYDNEY: Fosberg & Stoddart 54856 (US, HAW, K). GARDNER: Fosberg 55751 (US, BISH, K).

Refs.: Degener & Hatheway (1952), p. 34; Degener & Gillaspy (1955), p. 18; Degener & Degener (1959), p. 5.

__Eragrostis pectinacea__ (Michx.) Nees

This was collected near the wharf on Canton in 1951 (Degener & Hatheway 21312 (US, BISH)) and reported by Degener and Hatheway (1952), p. 34 and Degener & Gillaspy (1955), p. 18, but was not relocated in 1973 or 1975. The specimen in US has been examined by Leroy Harvey in 1980 and confirmed as *E. pectinacea*, rather than *E. pilosa* (L.) Beauv. which is very similar but with narrower spikelets. There is some question as to whether these are actually distinct species, but for our purposes we will accept Harvey's determination.

Eragrostis whitneyi Fosb.

Tiny tufted, many-stemmed annual grass, rarely producing bulbils in the inflorescence, which is of few very elongate usually curved spikelets. Another of the few coral atoll endemics, confined to the dry Central Pacific Atolls, except for a variety in the Leeward Hawaiian Atolls. Grows on sand, especially on low-lying fine compact sand, with *Sesuvium*, for example near the Enderbury Lagoon and in drying lagoonlets on the southwest corner of Hull. Related to the Hawaiian *E. paupera* and to the Australian *E. dielsii* and its allies. Rare on Sydney, as it was not found on either of our visits, 1973 and 1975. A habitat for it exists on Gardner, to the east of the passage into the lagoon, not visited and seen only from the air on leaving.

CANTON: Bryan 1343 (BISH); Degener & Degener 24614, 24586 (US, BISH); Degener & Hatheway 21319 (US, BISH); Fosberg & Walker 30206 (US); Hatheway 517 (US); Van Zwaluwenburg in 1940 (BISH). ENDERBURY: Fosberg & Stoddart 54734 (US, HAW, K); Long 2090, 2108 (US, HAW, BISH), 2111 (US, HAW, BISH), 2656, 2661 (US, BISH), 2668 (US, BISH), 2677 (US, BISH), 2683 (US, BISH); Woodward 1, 2, 3, 4 (US), 7; Fosberg 55710 (US, BISH, K); Browne in 1939 (BISH); Clegern 140 (BISH). HULL: Fosberg 55732 (US, BISH). SYDNEY: Long 2591 (US, HAW, BISH).

Refs.: Pickering (1876), pp. 240, 242?; Fosberg (1939), pp. 39-41; Degener & Hatheway (1952), pp. 33-34; Degener & Gillaspy (1955), p. 18; Degener & Degener (1959), pp. 5, 6; Luomala (1951), pp. 171-172.

Lepturus R. Br.

The populations of this genus in the Phoenix Islands are most complex. It is one of the dominant herbs in many open areas and is common in woods and groves that are not too dense. In addition to the rather distinctive *L. pilgerianus*, forms that fit four of the described varieties of *L. repens* (Fosberg, 1955) have been found in the Phoenix Group. This may very well reflect the central Pacific location of the group as well as the fact that the islands harbor such concentrations of sea-birds. Seeds of this genus are admirably adapted both for floating and for "hitch-hiking" attached to bird feathers. The main areas of distribution of the four varieties concerned are arranged radially in several directions from the Phoenix islands. Such variability is a perfect example of the complexity that may be found in common strand species.

Lepturus pilgerianus Hansen & Potztal (*Lepturus repens* var. *palmyrensis* F. Br.)

A coarse erect bunch-grass, rather stiff, basal branches, if produced, ascending to erect, not prostrate and rooting at nodes, inflorescence a terete jointed spike with the flowers and fruits borne in lateral depressions, covered by elliptic acute glumes; rachis disarticulating at maturity.

After seeing this grass in the field, we now agree that it is separable from *L. repens*, though scarcely on the basis of its being annual, as claimed by the authors of the species. All *Lepturus* species behave as annuals in extremely dry conditions, but can grow and produce new shoots indefinitely if the moisture supply holds out. *L. pilgerianus* is closer to *L. gasparricensis*, of Wake and Pokak atolls, than to *L. repens*, from which latter it differs in its erect or ascending basal branches and broader, elliptic glumes with scabrous margins at tips, usually not exceeding the joints. It is, actually, somewhat intermediate between the two, as occasionally an adventitious root or two will appear on the lowest nodes of the branches. Possibly these and the occasional prostrate branches of *L. pilgerianus* may result from hybridity with *L. repens*, with which it is occasionally found. Fosberg 55793, from McKean, is somewhat loose and depressed and has glumes very slightly acuminate. Rare cases of such hybridity are known between *L. repens* and *L. gasparricensis*. There is some question whether or not *L. gasparricensis* might better be treated as a variety of *L. pilgerianus* but further study may settle this.

Possibly *L. repens* var. *maldenensis* F. Br. from Malden, belongs here, but the spikes are more slender and the glumes only about half as long. Some of the Phoenix Is. specimens approach this but we see no break in the series. *L. pilgerianus* is not endemic to Canton, but is found also on Phoenix, Hull, Sydney. On Phoenix it forms extensive dense stands. It is common in Enderbury and parts of Hull, but rare on Sydney. It is by no means rare on Canton as stated by Degener & Gillaspy, but abundant in places. It has not been found on Gardner.

In 1975, after a severe drought, the tall dense stands seen on Phoenix Islands in 1973 were lying flat, dry and appearing dead except that under the influence of some recent moisture a few green sprouts and branches were appearing from some clumps. In a slightly lower spot these were more numerous. These may be taken as an indication that the species is not an obligate annual.

CANTON: Degener & Hatheway 21291 (MO, US, isotype); Fosberg & Stoddart 54718 (US, HAW, K), 54719 (US, HAW), 54881 (US, HAW, K). ENDERBURY: Fosberg & Stoddart 54740 (US, HAW, K), 54731 (US), 54741 (US, HAW, K); Long 2104 (US), 2109 (US), 2115 (US), 2118 (US), 2654 (US). PHOENIX: Fosberg & Stoddart 54765 (US, HAW, K), 55800 (US, BISH, K), 54766 (US, HAW, K); Long 2078 (US), 2079 (US), 2079b (US), 2086 (US), 2099 (US), 2615 (US), 2623 (US). HULL: Fosberg & Stoddart 54830 (US, HAW, K); Long 2017 (US), 2050 (US) (spikes very slender), 2057 (US). SYDNEY: Fosberg & Stoddart54861 (US, HAW, K); Long 2544 (US). McKEAN: Long 2027 (US), 2031 (US), 2032 (US), 2042 (US), 2047 (US), 2432 (US); Fosberg 55791 (US, BISH, K), 55796 (US, BISH, K), 55793 (US, BISH).

Refs.: Hansen & Potztal (1954), p. 268; Fosberg (1955), pp. 292-293; Degener & Gillaspy (1955), p. 18; Degener & Degener (1959), p. 6; Fosberg (1968), pp. 496-498; Pickering (1876), p. 243.

Lepturus repens var. ***cinereus*** (Burcham) Fosb. (*Lepturus cinereus* Burcham).

Lax, trailing slender plant, spikes 1 mm or less thick, glumes about 4 mm long, acute.

Uncommon but rather widely distributed in the western Pacific, found on Sydney and Gardner, not previously known from the Phoenix Islands.

SYDNEY: Fosberg 55714 (US, BISH, K). GARDNER: Fosberg 55785 (US, K).

Lepturus repens (Forst. f.) R. Br. var. ***repens***

Slender tufts, frequently bearing slender prostrate stolons rooting at nodes, slender jointed spikes, the glumes lanceolate, acute, not subulate or awned.

This form of the species, that originally described by Forster, is the common form in Southeastern Polynesia and only occurs sparingly in other parts of the Pacific. It was only found in 1973 near the old guano pit in the north third of Enderbury Island, also on Gardner in 1975.

ENDERBURY: Fosberg & Stoddart 54755 (US, HAW, K); Browne in 1939 (BISH). GARDNER: Fosberg 55748 (US, BISH, K), 55776 (US, BISH, K).

Lepturus repens var. ***septentrionalis*** Fosb.

More slender than var. *subulatus*, forming small hemispherical tufts, leaves a few cm long, spikes very slender, distinctly less than 1 mm thick.

This form is most abundant in the Northern Marshalls and Wake Island, but reaches Gardner Island. Common very locally on coral gravel near the west end and on the north side of Canton Island and on Gardner.

CANTON: Fosberg 55723 (US, BISH, K), 55736 (US, K). GARDNER: Long 2508 (BISH).

Lepturus repens var. ***repens*** appr. var. ***subulatus***

Canton: Lister in 1891.

Lepturus repens var. ***subulatus*** Fosb.

Slender tufted grass usually producing runners or stolons from the bases of the tufts, which root and give rise to secondary tufts at the nodes; inflorescence a slender teret jointed spike with the flowers and fruits sunken in lateral depressions in the rachis, glumes strongly subulate awned, rachis disarticulating into cylindrical floating sections at maturity.

Less common than *L. pilgerianus* except on Sydney, not found on Birnie or Phoenix. In the Phoenix islands usually forming large soft bunches, sometimes lacking stolons but easily distinguished from *L. pilgerianus* by the subulate glumes.

CANTON: Fosberg & Walker 30212 (US, BISH, K); Degener & Hatheway 21311 (US); Schultz 23 (US) (sterile); Fosberg 55706 (US, BISH, K). ENDERBURY: Fosberg & Stoddart 54730 (US, HAW, K), 54738 (US, HAW, K), 54755 (US, HAW, K); Fosberg 55708 (US), 55707 (US); Long 2092 (US), 2649 (US). HULL: Fosberg & Stoddart 54808 (US, HAW, K); 54821 (US, HAW, K), 54834 (US, HAW, K); Long 2013 (US), 2056 (US). SYDNEY: Fosberg & Stoddart 54869 (US, HAW, K). GARDNER: Long 2472 (US), 2489 (US); Fosberg 55749 (US, BISH, K), 55780 (US).

Refs.: Pickering (1876), p. 240?; Fosberg (1955), p. 290; Degener & Gillaspy (1955), p. 18; Hatheway (1955), pp. 4-6; Degener & Degener (1959), p. 6.

***Panicum distachyon** L. (*Brachiaria distachya* (L.) Stapf)

Prostrate mat-like grass, rooting at nodes, inflorescence a branched raceme of clavate spiklets.

Established on Canton around the Air terminal and here and there in the U.S.A.F. housing area. Collected and reported by Degener in 1958.

CANTON: Fosberg & Stoddart 54884 (US, HAW, K); Degener & Degener 24649 (US, BISH), 24656 (US, BISH).

Ref.: Degener & Degener, (1959), p. 6.

***Panicum miliaceum** L.

This was not seen in 1973, though reported by Degener & Gillaspy (1955, p. 18) as locally present on Canton in 1950 (Degener & Hatheway 21314 (US).

***Pennisetum ciliare** (L.) Link

Rather low, much-branched annual (?), with long spike-like, often purplish panicles, the spikelet, surrounded by an involucre of bristles, giving the panicle a foxtail-like appearance.

Introduced on Canton by Degener in 1950-51 (as *P. setosum* L. Rich.), this grass had become locally abundant in 1958. It still persisted as occasional tufts in 1973 and 1975.

CANTON: Fosberg & Stoddart 54771 (US, HAW, K), 54905 (US, HAW, K).

Ref.: Degener and Degener (1959), pp. 6-7.

**Setaria verticillata* (L.) Beauv., reported from Canton in 1955 (Degener & Hatheway 21253) and 1959, was not seen in 1973. Degener & Gillaspy (1955), pp.18-19; Hatheway (1955), p. 4; Degener & Degener (1959), p. 7.

* *Tricholaena rosea* Nees, introduced on Canton by Degener in 1950-51 and reported by him in 1959 as widely naturalized in 1958, was not seen in 1973 or 1975.

POLYGONACEAE

***Coccoloba uvifera* L. (*Coccolobis uvifera* L.)** Sea-grape

Coarse shrub or small tree with orbicular entire very leathery leaves on extremely short petioles, with short, sheathing stipules; terminal racemes of small white flowers with 6 similar perianth segments, 6 stamens and a single pistil; fruiting perianth much enlarged, becoming fleshy, closely investing the nut-like fruit so as to form an orbicular dark reddish black drupe, these borne in pendent spike-like racemes.

Common around U.S.A.F. installations on Canton, a few isolated plants near road as much as 7-8 miles from station: not seen by us on Hull in 1973 or 1975, one tiny plant in abandoned Gilbertese village on Gardner.

CANTON: Fosberg 30878 (US). HULL: Long 1998 (US). GARDNER: Fosberg 55770 (US).

Refs.: Van Zwaluwenburg (1943), p. 3; Degener & Gillaspy (1955), pp. 20-21; Degener & Degener (1959), pp. 8-9.

PORTULACACEAE

***Portulaca cyanosperma* Egler**

Prostrate, fleshy; leaves alternate, lanceolate or lance-linear, thickened, with abundant stipular hair; flowers in few-flowered terminal heads subtended by involucral leaves; sepals 2, petals obovate, purple; seeds iridescent, bluish.

Introduced on Canton by Degener in 1950-51, reported by him as established in 1958, still persisting sparingly in 1973. Native in the Hawaiian Islands. A specimen said to be from Enderbury, collected by Clegern in 1973, originally determined as *P. samoensis* v. Poelln., seems rather to be *P. cyanosperma*. There may be a confusion of labels, as there is no other record of its being introduced on Enderbury. On reexamination, the specimen seems unusually hairy, and may be *Portulaca australis* (*P. samoensis*), which could be native on Enderbury.

CANTON: Fosberg & Stoddart 54913 (US, HAW, K). ENDERBURY: 1973, Clegern 166 (BISH).

Ref: Degener & Degener (1959), p. 9.

The similar but much larger-flowered **Portulaca grandiflora* Hook. was seen in a sheltered garden on Canton in 1975.

Portulaca lutea Sol. ex Forst. f. Giant Purslane

(Here taken in the broadest sense, including large-flowered, thickstemmed mostly upright plants, probably comprising more than one species).

Tap root rather thick, stems several to many from base, thick, green or often grayish with a corky epidermis, branched, usually ascending; leaves opposite, usually appearing to be more or less distichous, obovate, rounded at apex, cuneate at base, fleshy, with a few stipular hairs; flowers in few-flowered terminal heads subtended by several involucral leaves; sepals 2, coherent, the resulting calyptra compressed and sharply keeled, caducous; petals 4-7, obovate 7-15 mm long, emarginate, yellow; stamens many, 15-45, style 1, its stigmatic branches 3-6, spreading, curved, hairy, ovary semi-inferior, one-celled, with many ovules on basal placentae; fruit a pyxis or circumscissile capsule, bearing many seeds on a cluster of stalks from the base of the capsule; seeds glossy, black.

Probably the most abundant plant on all the 8 islands studied, varying in flower size and other characters from island to island; flowers opening about 10 a.m., closing about 5 p.m. or later, the petals and stamens turning jelly-like as they shrivel. Degener has pointed out (1955) that on Canton the stamens and ovaries are eaten by hermit crabs. We found it impossible on Birnie and Sydney to find any fruits and seeds, though large numbers of plants were examined.

CANTON: Fosberg & Walker 30208; Degener & Hatheway 21285 (BM, BRI); Fosberg & Stoddart 54775 (US, HAW, K), 54893 (US, HAW, K); Fosberg 55735 (US, BISH, K); Clapp P-71-7 (US); Lamb in 1938 (BISH). BIRNIE: Fosberg & Stoddart 54721 (US, HAW, K); Long 2647 (US). ENDERBURY: Fosberg & Stoddart 4726 (US, HAW, K), 54727 (US, HAW, K), 54728 (US, HAW, K); Lamb in 1938 (BISH); Marshall 3, 8 ; Long 2613, 2667 (US), 2686 (US). PHOENIX: Fosberg & Stoddart 54764 (US, HAW, K), 54767 (US, HAW, K), 55798 (US, BISH, K), 55799 (US, BISH, K); Bryan 18; Long 2624 (US), 2082 (US). HULL: Fosberg & Stoddart 54828 (US, HAW), 54833 (US, HAW, K); Long 2046, 2043 (US) (very slender). SYDNEY: Fosberg & Stoddart 54870 (US, HAW, K), 54866 (US, HAW, K), 54875 (US, HAW); Long 2547 (US); Fosberg 55712 (US, BISH, K). GARDNER: reported by Catala (1952, p. 159) as a staple in the diet of the Gilbertese settlers (as *P. oleracea*). Long 2455 (US), 2499 (US); Fosberg 55759 (US), 55757 (US, BISH, K). McKEAN: Long 2038 (US), 2029 (US), 2026 (US); Fosberg 55787 (US, BISH, K), 55797 (US, BISH, K).

**Portulaca oleracea* L. Common Purslane

Fleshy plant with slender tap root and radiating prostrate branched red stems; leaves small, opposite, obovate, apex rounded to subtruncate, with few stipular hairs; flowers in several-flowered terminal heads subtended by several involucral leaves, sepals 2, petals 3-5 mm long, emarginate, yellow, stamens 10-12, style with 3-4 branches, capsule about 3 mm across, circumscissile about at middle, seeds black, stellulate-tuberculate. Flowers open about 10 a.m. and close about noon.

Naturalized on Canton and presumably from there introduced around the U.S.A.F. stations on Enderbury and Hull. Probably introduced by the Gilbertese on Sydney, Hull and Gardner. It flourishes on bare coral sand and gravel and forms hybrid swarms with P. lutea when they grow together as on Canton (Fosberg & Stoddart 54772, 54773, 54774, 54906 (all US, HAW, K), Fosberg 55738, 55739 (both at US, BISH, K)), possibly also on Hull (Long 2043) and Sydney, and almost certainly on Gardner (Fosberg 55758 (US, BISH, K), 55760 (US)). The hybrids vary in color of stems, stature and flower size. The swarms have not been analyzed in detail, hence remain in rather doubtful status.

The Canton Island plants, at least, seem to correspond fairly well to var. *granulato-stellulata* v. Poelln., with tuberculate seeds, but as yet we have rather vague ideas as to the definition and limits of the varieties within *P. oleracea* L. Adequate study would necessitate several days observation on the ground, noting flower opening and closing times, number of stamens, stature, stem color, stem thickness, and seed characters.

CANTON: Fosberg 30881 (US), 30209 (US); Degener & Hatheway 21283; Fosberg & Stoddart 54817 (US, HAW, K), 54883 (US, HAW, K), 54907 (US, HAW, K); Fosberg 55737 (US, BISH, K). ENDERBURY: Fosberg & Stoddart 54746 (US, HAW, K). HULL: Fosberg & Stoddart 54817 (US, HAW, K). SYDNEY: Fosberg & Stoddart 54871 (US, HAW, K), 55711 (US, BISH, K). GARDNER: Long 2501 (US); Fosberg 55754 (US, BISH, K), 55760 (US).

Ref: Degener & Gillaspy (1955), p. 22.

POTAMOGETONACEAE

Ruppia maritima var. ***pacifica*** St. John & Fosb.

A slender, submerged, rooted-aquatic with filiform leaves, slender stems and umbelloid clusters of asymmetric small fruits on long stipes. Found in Enderbury lagoon, not previously known from the Phoenix group. Tolerates brackish to highly saline water. Not found though looked for, in 1975, when the lagoon water was so low that most of the lagoon bottom was dry.

ENDERBURY: in lagoon, Fosberg & Stoddart 54749 (US, K, HAW).

RUBIACEAE

**Casasia clusiifolia* (Jacq.) Urb., an attractive shrub introduced from the Bahamas by Degener in 1950-51 (Degener & Degener 1959, p. 15), and apparently doing well in 1958, was not seen in 1973 or 1975.

Guettarda speciosa L.

A handsome tree with dark bark and a dense crown, branchlets rather thick; leaves opposite, 10-15 or more cm long, broadly oval to broadly oblong, obtuse at apex, cordate at base, on short petioles, with large flat obovate caducous stipules; flowers very fragrant at night, in axillary secund symmetrical cymes, calyx small, cup-shaped, corolla large, white, salverform, lobes 5-8, with membranous crispate margins, these infolded in bud, opening in evening, falling the next day when exposed to hot sun or, on overcast days, after noon, anthers attached below sinuses, included; style filiform, of two types, either subequal with corolla tube and with a broadly cylindric stigma with a drop of very sticky material on top, or 1/2-2/3 as long as corolla tube and with a more narrowly cylindric stigma; fruit a depressed-globose white drupe with coarse fibers in the flesh and a large corky stone with a number of cells each with a single seed.

Common in forests on Hull, Gardner and Sydney, appearing more or less chlorotic, yellowish green, on the latter island. The stones float very readily and it is likely that the absence of the species from an island means that it cannot survive there, at least for a long time. Found once, by Luomala, on Canton. Reported by Hemsley as collected on Hull by J.T. Arundel.

CANTON: Luomala 19; Clapp P-71-31 (US). HULL: Fosberg & Stoddart 54807 (US, HAW, K), 54809 (US, HAW, K); Fosberg 5733 (US, BISH, K), 55729 (US, BISH, K); Long 2000 (US), 2001 (US), 2070 (US), 2023 (US). SYDNEY: Fosberg & Stoddart 54868 (US, HAW, K); Long 2587 (US, BISH); Bryan 35 (BISH). GARDNER: Fosberg 55743 (US, BISH, K), 55754 (US, BISH, K), 55766 (US, BISH).

Ref.: Bryan (1942), p. 60; Luomala (1951), pp. 167, 174; Pickering (1876), pp. 240, 241; Fosberg (1937), p. 262; Hemsley (1885), p. 116.

Morinda citrifolia L. — Noni (Hawaii)

Shrub or small tree, smooth, branchlets rather thick; leaves large, glossy, broadly elliptic to ovate, petiolate, base obtuse, apex acutish, veins with pits or domatia in axils beneath; stipules fairly large, caducous; flowers in axillary pedunculate heads, only 1-3 in bloom at a time, as more flowers open the head tends to elongate, ovaries fused into a syncarp, calyx lobes very small, corollas salverform, 4-5 lobed, lobes linear-oblong; syncarp enlarging with maturity into a rather irregular large whitish potato-like compound drupe which develops a very disagreeable rancid odor when past maturity.

Native in the Pacific, but how far east is not known with any certainty. It was in all likelihood spread far beyond its original range by the aboriginal peoples, who had many uses for it. Locally abundant in coconut groves on Hull, one of the commonest trees or shrubs on Sydney and Gardner, forming the dominant understory in some of the coconut plantations. Found also on Canton.

CANTON: Degener 21412; Bryan 23 (BISH), 1341 (BISH), 1342 (BISH); Clapp P-71-1 (US). HULL: Fosberg & Stoddart 54838 (US, HAW, K); Long 2055 (US). SYDNEY: Fosberg & Stoddart 54853 (US, HAW, K); Long 2539 (US), 2570; Bryan 36 (BISH). GARDNER: Long 2458 (US); Fosberg 55747 (US, BISH, K), 55786 (US, BISH, K).

Refs.: Bryan (1942), p. 60; Degener & Gillaspy (1955), p. 30; Degener & Degener (1959), p. 15; Luomala (1951), pp. 166, 170 , 174; Laxton (1951), p. 143; Maude (1952), p. 70; Groves (1951), p. 19.

SOLANACEAE

**Capsicum frutescens* L., reported by Degener (1959, p. 14) as growing in a garden on Canton in 1958, was not seen in 1973. However, by 1975 several varieties were again in cultivation in very sheltered gardens. Several varieties of **Solanum lycopersicum* L. (*Lycopersicum esculentum* Mill.), also reported by Degener (Degener & Hatheway 21307), and not found in 1973 were seen on our visit in 1975, doubtless recently planted. These were variety *commune* Bailey, the large-fruited common garden tomato, and var. *galeni* (Mill.) Duckwill, the small-fruited cherry tomato, introduced on Canton in 1950-51, by Degener. **Solanum melongena* var. *esculenta* Nees was reported by Degener & Degener 1959, p. 15, as growing in a garden on Canton in 1958, not seen by us in 1973, but was flourishing around a house in the U.S.A.F. residence area in 1975. **Petunia hybrida* Nilm, reported by Degener, had also disappeared, as might have been anticipated, but was again seen in a pot in 1975. **Nicotiana glauca* R. Grah. might more likely have survived, but was not seen anywhere. It was collected in 1951 (Degener & Hatheway 21305).

***_Physalis angulata_ L.** Ground Cherry or Husk Tomato

A spreading, much-branched herb with thin ovate, usually more or less toothed or scalloped petiolate leaves, small solitary axillary rotate whitish or pale cream-yellow flowers with brownish or greenish centers, and a small fleshy tomato-like berry enveloped in a much enlarged papery loose fruiting calyx.

Very rare in weedy disturbed places on Canton and Hull, on the latter in the abandoned Gilbertese village. The record from Enderbury may have been a temporarily established weed, as it was not seen by us in 1973 or 1975. It was found in September 1973 by Clegern.

CANTON: Degener & Hatheway 21411 (BISH); Fosberg & Stoddart 54894 (US, HAW, K); Fosberg 55803 (US, BISH); Degener & Degener 24654 (BISH). ENDERBURY: Clegern 168 (BISH). HULL: Fosberg & Stoddart 54701 (US, HAW, K) (this collection possibly *P. lanceifolia* Nees).

Refs.: Degener & Gillaspy (1955), p. 30; Degener & Degener (1959), p. 15; Degener & Hatheway (1952), p. 34.

SURIANACEAE

Suriana maritima L.

Densely leafy green shrub up to 3 m tall; leaves alternate, crowded, linear-oblong, bright green, in loose rosettes on small branchlets, spreading in sunlight, closing, appressed to each other in rainy weather and at night; flowers axillary, 5-parted, petals yellow; stamens 5; pistils 5, fruits 5, arranged in a circle, each subglobose, about 1.5 mm across.

Common, especially near and on lagoon shores but also inland and on seaward beach-crests, present on Canton and Hull, only, among the islands studied.

CANTON: Degener & Hatheway 21305; Bryan 1328 (BISH), 1340 (BISH); Luomala 14 (BISH). HULL: Fosberg & Stoddart 54818 (US, HAW, K).

Refs.: Pickering (1876), p. 241; Bryan (1942), p. 46; Degener & Gillaspy (1955), p. 23; Hatheway(1955), pp. 6, 9; Luomala (1951), pp. 165, 173; Degener & Hatheway (1952), p. 34.

TAMARICACEAE

****Tamarix aphylla*** Karst. Tamarisk, Athel

Much-branched tree of a pale grayish green color; leafless, the fine branchlets terete, fleshy and containing the photosynthetic tissue; flowers in complex terminal panicles, small, pink, with oblong petals; fruit a small capsule.

An Old-World tree of Mediterranean and other dry or semi-dry regions, introduced to Canton prior to 1949, it is still growing well about the site of the old British Settlement. It does not seem to be expanding its range any, in spite of its wind-blown seeds.

CANTON: Fosberg 39877 (US); Degener & Hatheway 21306; Fosberg & Stoddart 54781 (US, HAW, K); Luomala 23 (BISH); Clapp P-71-12 (US).

Refs.: Degener & Gillaspy (1955), p. 26; Degener & Degener (1959), p. 11; Luomala (1951), pp. 168, 173.

TILIACEAE

Triumfetta procumbens Forst. f.

Prostrate trailing elongate branched herb, stems and leaves pubescent; leaves alternate, thick, varying from ovate or orbicular to deeply 3-5 lobed, lobes rounded; flowers axillary, with 5 sepals, 5 thin yellow oblong petals, many stamens with capillary separate filaments, and a single pistil; fruit a large dry bur with weak, non-pungent spinous processes.

A native plant on most Pacific coral atolls, present on beaches and in the interior of all the Phoenix Islands studied except Birnie. Not found in recent years on Phoenix. Mentioned from Canton and Enderbury in notes with a specimen, Arundel 6 (K) collected October 1882.

CANTON: Lister s.n. (CGE); Schultz 19 (US); Fosberg & Walker 30215 (US); Degener & Hatheway 21281 (US, G), 21282 (G); Luomala 32 (US). ENDERBURY: Fosberg & Stoddart 54742 (US, HAW); Bryan 1334; Lamb s.n.; Marshall 8; Long 2103 (US), 2105 (US), 2113 (US), 2116 (US), 2652 (US), 2684, 2685. PHOENIX: Bryan in 1924? HULL: Fosberg & Stoddart 54791 (US, HAW, K); Long 2011, 2047 (US), 2051 (US), 2060, 2022 (US). SYDNEY: Fosberg & Stoddart 54872 (US, HAW, K); Long 2569. GARDNER: Long 2487 (US); U. S. Expl. Exp. s. n. (P); Fosberg 55773 (US, BISH, K).

Refs.: Degener & Gillaspy (1955), p. 24; Hatheway (1955), pp. 1, 7; Luomala (1951), pp. 171, 173; Pickering (1876), pp. 240, 241, 243; Van Zwaluwenburg (1942), p. 49.

URTICACEAE

Laportea ruderalis (Forst. f.) Chew (*Fleurya ruderalis* (Forst. f.) Gaud. ex Wedd.)

Succulent stemmed erect branched herb; leaves alternate, petiolate, ovate, strongly dentate, acuminate, with three strong nerves; flowers usually monoecious, borne in axillary cymes, individual flowers very small and inconspicuous; fruit a minute flattened pointed achene, with thickened margin, whitish.

Widespread on coral islands throughout the tropical Pacific, especially on coral gravel and sand. It is only found on three of the Phoenix Group, Enderbury, Gardner, and Hull. On the latter it is very abundant. It was mentioned as from these three islands in notes on a specimen, Arundel 8 (K), collected Oct. 1882.

ENDERBURY: Fosberg & Stoddart 54758 (US, HAW, K); Bryan 29 (BISH); Long 2117 (US). HULL: Fosberg & Stoddart 54789 (US, HAW, K). GARDNER: Long 2502 (US); Fosberg 55756 (US, BISH, K). "Fanning: Suwarrow: Enderbury: Hull: Gardner Islds.", Arundel s.n. (GH).

Ref.: Pickering (1876), pp. 240, 242.

**Pilea microphylla* L. — Artillery-plant

This was seen planted in a sheltered spot on Canton in 1975.

VERBENACEAE

Clerodendrum inerme (L.) Gaertn.

Arching to sprawling glabrous shrub; leaves opposite, elliptic, blunt to acute; flowers in few-flowered axillary cymes; calyx gamosepalous, corolla white, salverform, somewhat zygomorphic, stamens and style long-exserted, maroon; fruit an obovoid to sub-globose drupe with thin black flesh, deeply 4-grooved and eventually drying and separating into 4 woody nutlets, about 1-1.5 cm high, 1 cm wide.

Probably not native in the Central Pacific east of the Marshall and Gilbert islands, extending west to the western Indian Ocean, growing as an ornamental in Canton around old British Settlement and planted in U.S.A.F. area, also in abandoned Gilbertese villages on Hull and Sydney. The Clegern specimen determined as var. *oceanicum* Gray.

CANTON: Fosberg & Stoddart 54776 (US, HAW, K); Fosberg 55720 (US, BISH, K); Clapp P-71-9 (US). HULL: Long 2008 (US); Clegern 111 (BISH). SYDNEY: Long 2592 (US, BISH).

Lantana camara var. ***aculeata*** (L.) Mold.

Prickly, branched, aromatic shrub; leaves ovate, acute, crenate, bullate-rugose, petiolate; flowers in axillary, pedunculate, corymbose heads, corollas orange turning red toward outside of head, bilabiate, lower lip large on peripheral flowers; fruit a small globose lead-colored drupe, borne in heads.

Introduced as an ornamental, the *Lantana* has persisted in surprisingly healthy condition but has not spread as it does in wetter, less saline climates. It was found on

Canton and Hull, on the former in the old British Settlement and in the U.S.A.F. residential area, on Hull in the abandoned Gilbertese settlement.

CANTON: Fosberg & Stoddart 54777 (US, HAW, K); Clapp P-71-8 (US). HULL: Fosberg & Stoddart 54804 (US).

***Premna serratifolia** L.

Aromatic shrub with ovate or oblong leaves and flat-topped paniculate cymes of small greenish flowers.

Seen only on Canton, planted around the dispensary. Although it is a common widespread atoll plant, this seems to be the only record of it from the Phoenix Islands. It was obviously brought in, but is not a plant often seen in cultivation.

A tree which may be *Premna serratifolia* L.appears on photos taken on Canton in 1971 by Roger Clapp, but the photos are not good enough for certain identification.

CANTON: Fosberg 55737 (US, BISH).

***Stachytarpheta indica** (L.) Vahl

Spreading to ascending herb, stems appearing to branch dichotomously with a spike of flowers or fruits in each forking, leaves opposite, ovate, with obtuse apex, margins with obtusish teeth; flowers in slender spikes, sunken into grooves in the slender rachises, corolla bluish, zygomorphic, fruits lying in grooves in rachises; resembling but more slender than the following species.

Seen only in the dock area, in 1973, not noted previously.

CANTON: Fosberg & Stoddart 54896 (US, type of *Stachytarpheta jamaicensis* var. *parviflora* Mold.; HAW, K).

This collection has been made the basis of *Stachytarpheta jamaicensis* f. *parviflora* Moldenke. It is obviously closely related to that species but requires further study before it can be finally disposed of. Meanwhile we will leave it under the name by which we know it as a widespread weed. It has much more slender spikes and smaller flowers than *S. jamaicensis*.

***Stachytarpheta jamaicensis** (L.) Vahl

Spreading slightly woody herb, the stems appearing repeatedly dichotomous with a spike of fruits or flowers in each forking; leaves opposite, ovate, with base decurrent into a petiole, apex obtuse, margin serrate with low obtuse teeth; flowers in terminal spikes with the calyx and ovary sunken in a groove in the thick rachis, the corolla light purplish blue, curving out from the rachis, strongly zygomorphic and 2-lipped with lower lip longer; fruit lance-ellipsoid, sunken in the rachis.

Introduced on Canton by Degener in 1951, locally common in weedy places around the U.S.A.F. installation in 1973.

CANTON: Fosberg & Stoddart 54895 (US, HAW, K).

Ref.: Degener & Degener (1959), p. 14.

Vitex trifolia L.

A shrub with leaves of 3 leaflets, white beneath, clusters of small bluish-purple 2-lipped flowers, and pea-like brownish green fruits. A small bush of this was seen in 1975, planted by a house in the USAF residence area on Canton. It is native in the Western Pacific, but probably will not survive without protection during dry periods on Canton.

ZYGOPHYLLACEAE

Tribulus cistoides L.

Stems herbaceous, hairy, prostrate to ascending, radiating from a root crown, sparsely or not branched; leaves opposite, pinnately compound, leaflets small, 1 cm long or less; flowers on axillary pedicels, 5-parted, petals yellow, 1-2 cm long, obovate, stamens 5, pistil one, ovary stiffly hairy, style short, stigma slightly lobed; fruit of 5 parts, united into a button-like thick disk with 10 spines, separating at maturity into 5 segments, each with 2 strong divergent spines.

Growing in open areas on Canton, Enderbury, Hull, Sydney, and McKean, often found where seabirds nest. It is very common on Canton, despite the fact that it was not seen by Degener and Gillaspy (1955, p. 23). It densely covers conspicuous areas on the lagoon coast of Sydney, and several patches including a large strip from beach top to lagoon on McKean.

CANTON: Fosberg & Stoddart 54716 (US, HAW, K). ENDERBURY: Fosberg & Stoddart 54750 (US, HAW, K); Fosberg 55709 (US, BISH, K). HULL: Fosberg & Stoddart 54790 (US, HAW, K). SYDNEY: Bryan s. n., 37; Woodward 2564 (US); Long 2537 (US); Long & Woodward 2574 (US); Fosberg & Stoddart 54857 (US, HAW, K); Arundel 52 (K). GARDNER: Long 2496 (US); Fosberg 55781 (US, BISH, K). McKEAN: Long 2044 (US), 2033 (US), 2441 (US); Fosberg 55789 (US, BISH, K).

Refs.: Van Zwaluwenburg (1941), p. 17; Degener & Gillaspy (1955), pp. 22-23; Luomala (1951), pp. 166, 173.

REFERENCES CITED

Bryan, E. H. 1942. *American Polynesia and the Hawaiian Chain.* Honolulu. 1-253.

Catala, R.L.A. 1952. *Rapport sur les îles Gilbert.* Noumea. 277 pp.

Degener, O. & Degener, I. 1959. Canton Island, South Pacific (Resurvey of 1958). *Atoll Res. Bull.* 64: 1-24.

Degener, O. & Gillaspy, E. 1955. Canton Island, South Pacific. *Atoll Res. Bull.* 41: 1-51.

Degener, O. & Hatheway, W. 1952a. Die Flora des Canton Atolls in stillen Ozean. *Revista Sudam. Bot.* 10(2): 33-37.

Fosberg, F. R. 1937. Some Rubiaceae of southeastern Polynesia. *Occ. Pap. Bishop Mus.* 13: 245-293.

Fosberg, F. R. 1939. Notes on Polynesian grasses. *Occ. Pap. Bishop Mus.* 15: 37-48.

Fosberg, F. R. 1955. Pacific forms of *Lepturus* R. Br. (Gramineae). *Occ. Pap. Bish. Mus.* 21: 285-294.

Fosberg, F. R. 1968. Systematic notes on Micronesian plants. 3. *Phytologia* 5: 469-502.

Fosberg, F. R. 1978. Studies in the genus *Boerhavia* L. (Nyctaginaceae), 1-5. *Smithsonian Contr. Bot.* 39: 1-20.

Gräffe, E. 1864. Eine Reise nach der Mac-Keans-Insel. *Vierteljahrsschrift der Naturforschenden Gesellschaft in Zurich*, 9: 205-217.

Groves, K. E. [1951]. *Report of an expedition to Polynesia*...[Loma Linda, Calif.], 24 pp.

Hansen, I. & Potztal, E. 1954. Beiträge zur Anatomie und Systematik der Leptureae. *Bot. Jahrb.* 76: 250-270.

Hatheway, W. H. 1955. The natural vegetation of Canton Island, an equatorial Pacific atoll. *Atoll Res. Bull.* 43: 1-9.

Hemsley, W.B. 1885. List of plants from various Pacific Islands, in *Challenger Repts., Bot.* I(IV): 116.

Laxton, P. B. 1951 [1952]. Nikumaroro. *Jour. Polyn. Soc.* 60: 134-160.

Luomala, K. 1951. Plants of Canton Island, Phoenix Islands. *Occ. Pap. Bishop Mus.* 20: 157-174.

Maude, H. 1952. The colonization of the Phoenix islands. *Jour. Polyn. Soc.* 61: 62-89.

Pickering, C. 1876. *Geographical distribution of animals and plants.* Philadelphia. 524 pp. (see pp. 221-248).

Van Zwaluwenburg, R. H. 1941. Canton Island. *Hawaiian Pl. Rec.* 45: 15-24.

Van Zwaluwenburg, R. H. 1942. Notes on the temporary establishment of insect and plant species on Canton Island. *Hawaiian Pl. Rec.* 46: 49-52.

Index of Specific Names

ATOLL RESEARCH BULLETIN

NO. 394

THE HOA OF HULL ATOLL AND THE PROBLEM OF HOA

BY

DAVID R. STODDART AND F. RAYMOND FOSBERG

ISSUED BY
NATIONAL MUSEUM OF NATURAL HISTORY
SMITHSONIAN INSTITUTION
WASHINGTON, D.C., U.S.A.
FEBRUARY 1994

THE HOA OF HULL ATOLL AND THE PROBLEM OF HOA

BY

DAVID R. STODDART[1] AND F. RAYMOND FOSBERG[2]

ABSTRACT

This paper describes the channels known as hoa which are characteristic of atoll land rims and of some islands on barrier reefs, where they often dissect previously more continuous reef-top sediment accumulations and conglomerate platforms. They are especially common in the central Pacific, and are particularly well developed in some atolls of the Tuamotu Archipelago and on some of the Society Islands. Published hypotheses accounting for the origin and development of hoa of different kinds are outlined. Contemporary hoa on the north side of Hull Atoll in the Phoenix Islands are described and surveyed, as are older, probably Holocene hoa, here termed 'paleohoa', on the same atoll. Regional and local distributions of hoa and paleohoa and differences in hoa morphology are used to assess theories of hoa formation. Both hoa and paleohoa are attributed to hurricane activity, and the presence of paleohoa may thus give an indication of the distribution of hurricanes in the Holocene.

---

[1]Department of Geography, University of California at Berkeley, Berkeley, California 94720, U.S.A.

[2]Department of Botany, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560, U.S.A.

INTRODUCTION

The Polynesian term hoa was first introduced into the reef literature by Danielsson (1954) and later incorporated into a comprehensive listing of Polynesian topographic terms by Vallaux (1955, 1991). Danielsson (1954, p. 94) defined hoa as a 'shallow channel beginning on the lagoon side [of an atoll rim], separating completely or partially two motu [reef islands].' He added the terms tairua for a 'closed hoa' and poehoga for the 'inner part of a closed hoa.' As defined by Danielsson hoa are one of the most striking and conspicuous geomorphic features of most central Pacific atolls, and as such had been mentioned by many previous investigators. Thus Agassiz (1903, p. 41-43) described and figured many 'cuts', as he termed them, on the north side of Rangiroa Atoll, Tuamotu Archipelago, as well as on other atolls in that group. But it was Newell's (1956) account of Raroia Atoll, also in the Tuamotu, and especially his spectacular aerial photographs, which brought the phenomenon to general attention. Though in recent years hoa have attracted increasing interest, especially in French Polynesia, they remain enigmatic features. It is the purpose of this paper to draw attention to problems of existing interpretations by reference to the hoa of Hull Atoll, Phoenix Islands, in eastern Kiribati, central Pacific.

CHARACTERISTICS OF HOA

The first detailed descriptions of hoa were made by Agassiz during the *Albatross* expedition through the Tuamotu Archipelago in 1899. In a preliminary paper he describes 'the narrow cuts which divide this part [of the northern rim of Rangiroa, between Tiputa and Avarua] into a number of smaller islands. These secondary passes leave exposed the underlying ledge, full of fossil corals. In some cases there is left a clear channel extending across from the lagoon to the northern [seaward] side through which water flows at high or half tide. In other cases the cuts are silted up with coral sand blown in from the lagoon side. In others the cut is shut off by a high sand-bank, or a bank composed of broken fragments of corals, leaving access to the water from the northern shore only; and finally the cuts are also shut off on the northern side by sand and broken coral banks, the extension of the north-shore beach leaving a depression which at first is filled with salt-water and gradually silted up both from the lagoon side and the sea side, and forms the typical north-shore land of the lagoon' (Agassiz 1900, p. 38). More detailed accounts of hoa on Rangiroa and many other atolls are given in his main report (Agassiz 1903).

At Raroia Newell (1956, p. 330) described 'approximately 260 shallow channels across the [atoll] rim which are drained or are awash during low water at the seaward ends and are filled by 2 to 2.5 meters of water near the lagoon ends'; he did not however use the term hoa for these channels. 'In addition to the shallow channels or spillways between islets, there are some 160 deep, angular clefts or notches (incomplete channels) in the lagoon shore similar to the channels except that they do not extend across the island to the seaward side'; these are the tairua of Danielsson, though this term, unlike hoa, has not entered the reef literature.

Newell saw the incomplete channels as a stage in the formation of hoa: they 'clearly are being lengthened headward as storm waters cross the islets towards the lagoon, and they represent various steps in the formation of shallow channels. It is concluded that the shallow channels are all of very recent origin and were formed chiefly by mechanical (hydraulic) erosion of the uplifted rim' (Newell 1956, p. 330).

Stoddart (1969, p. 8) described very similar features at Rangiroa Atoll, also in the Tuamotus: 'The islands are separated by shallow, narrow channels known as hoa. These are clearly erosional, and represent breaks in formerly more extensive islands. In the walls of islands transected by hoa, conglomerate rock is exposed underlying the island clastics and rising above the level of the reef flat. This conglomerate forms a ledge in the walls, and also floors the hoa itself. Channels cut in the conglomerate by water passing from sea to lagoon are extending seaward by headward erosion, often terminating in small waterfalls with plunge pools. . . . The lagoonward mouths of hoa are often almost closed by spits and bars of fresh small coral shingle. On Mahereretiatae a relict hoa was seen in the process of being recolonised by vegetation, after being sealed at both ends by beach ridges.' Stoddart gave schematic diagrams of the features he described.

Likewise at Borabora, Society Islands, Guilcher et al. (1969, p. 8) found examples of different kinds of shallow passages or hoa on the eastern barrier reef. Some of them are permanently open; others are closed during periods of moderate surf by spits built by lagoon waves at their inner ends and become tairua; still others are active only during exceptional storms, hurricanes or tsunamis. Aprons of sand are prograding into Borabora lagoon through the hoa and are beginning to fill it. Hoa, tairua and prograding sand aprons in lagoons are common elsewhere in the Society Islands and in other atolls of the Tuamotus. Further details are given by Guilcher et al. (1969, p. 28, 46-47), and comparisons made between hoa and tairua on Borabora and on Tahaa, Maupiti and Rangiroa.

Newell, Stoddart and Guilcher all viewed hoa as relatively unproblematic features (see also Guilcher, 1988, p. 148-152); none however surveyed them instrumentally.

CHEVALIER'S TYPOLOGY OF HOA

Chevalier et al (1968, p. 48-49) described hoa in some detail at Mururoa Atoll, Tuamotus, in similar terms. Chevalier in this paper, in his general survey of French Polynesian reefs (Chevalier, 1973), and especially in a paper devoted solely to hoa (Chevalier, 1972), proposed a general classification of hoa:

Type I: open on the lagoon side, closed on the ocean side, permitting throughput of water only during storms. This he found to be the most common type.

Type II: 'Functional hoa', comprising

(a) those open to the sea at high tide;

(b) those open to the sea at low tide during strong wave action;

(c) those fully open to the sea, notably where the algal ridge is unusually low; he quoted examples from Pukarua and Marutea Sud, Tuamotus.

Type III: hoa where the lagoon end is blocked by sediment deposits and the hoa is open only at the seaward end. This form is common on atolls with high sedimentation rates such as Reao. On Mururoa some hoa become enclosed pools open only during storms.

Type IV: hoa of Type I but completely closed by lagoon sediments. Examples are given from Marutea Sud and Fangataufa where as a result the channel becomes hypersaline.

Type V: dry hoa, comprising

(a) hoa of Type IV but completely blocked by sediment, dried out and vegetated. Chevalier (1972, p. 481) described this type as 'hoa colmaté', figuring an example from Reao.

(b) hoa emersed by a fall in sea-level leaving the floor at 20-40 cm above lagoon high water, examples being cited from Mururoa, Tureia and Maturei-Vavao.

Type VI: hoa open only to the sea, with the lagoon exit closed by conglomerate, as at Reao and Pukapuka (Tuamotus). These were interpreted as similar to Type III hoa but with the lagoon barrier lithifed.

Types III-VI Chevalier grouped as 'non-functional hoa', the others as 'functional'. At Mururoa he described 79 out of a total of 288 hoa, or 27 per cent, as functional (Chevalier et al. 1968, p. 51).

Chevalier's typology systematised and extended previous observations on hoa morphology. But he also drew attention to problems in their distribution, both between and within atolls. Thus he noted the paucity of functional hoa on Reao and Pukapuka and their frequency on Marutea. On Mururoa he found functional hoa concentrated on the southwest to southeast sectors of the atoll rim, with 34 per cent in the southwest compared with 2.4 per cent in the east. Chevalier constructed a rose diagram of the frequency distribution of hoa on the rim in comparison with wind direction and velocity (Chevalier et al. 1968, p. 12, 16): the graphs showed an inverse correlation between wind strength and hoa distribution. It was noted, however, that whereas the dominant winds are easterly the strongest swells are from the south and southwest.

Chevalier noted the probability of a Holocene fall in sea-level of ca. 1.5 m over the last 3000-4000 years. He also proposed that hoa had their origin in transverse fissures on the reef rim formed before the fall in sea-level. Finally, he suggested that lithification processes in reef-top sediments were more effective on the seaward side, and that this was the reason that hoa began eroding in the less consolidated sediments of the lagoon side, cutting back along the lines of fissures. He did not discuss the spacing or apparent clustering of such fissures, nor did he mention the rôle of catastrophic events such as hurricanes or tsunamis in hoa genesis.

Chevalier concluded his analysis by suggesting an evolutionary sequence in hoa development, given in outline in Chevalier et al. (1968, p. 53) and in more complex form in Chevalier (1972, p. 487) (Figure 1). Chevalier's work focussed attention on the

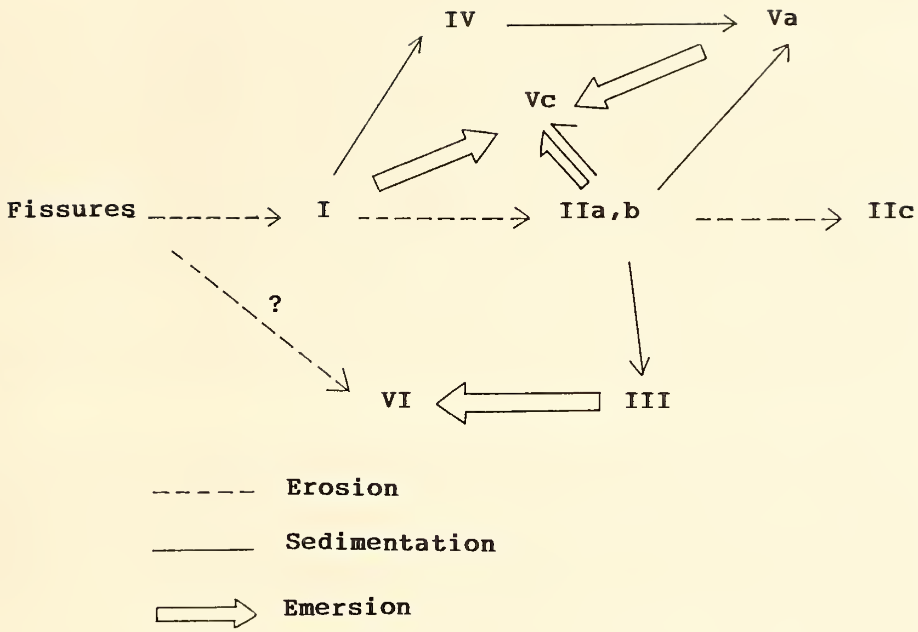


Figure 1. Evolutionary sequence in the development of hoa proposed by Chevalier (1972, p. 487).

diversity of hoa, but it also made clear that many problems remained in explaining their morphology, local and regional distribution, and history.

LATER WORK IN FRENCH POLYNESIA

Subsequent work in French Polynesia has provided additional information on hoa, especially in the context of Holocene sea-level history.

The 150 hoa of Rangiroa Atoll are classified by Ricard et al. (1985) into permanently functioning hoa; partly obstructed hoa, including those 'partly isolated from the ocean by coral boulders but open to lagoon influences' and those 'largely open to oceanic influences, but more or less isolated from the lagoon by a sandy strip'; and entirely obstructed hoa. At Takapoto Atoll Salvat and Ricard (1985) use the terms 'opened hoa' and 'unworking hoa'. At Borabora (Pirazzoli et al. 1985) there are both functional and non-functional hoa. The latter are subdivided into filled-in hoa, invaded by storm debris; emerged hoa, resulting from relative sea-level change; and 'obturated hoa', closed on the seaward side by coral conglomerate and sometimes on the lagoon side by spits of sediment.

In spite of terminological differences these classifications can all be clearly related to Chevalier's typology of hoa.

The Tuamotu atolls show great variability in frequency of hoa. Taiaro and Anaa have rather few (Salvat et al. 1977, Pirazzoli et al. 1988), and with one exception those at Taiaro are non-functional. Conversely hoa are frequent at Temoe and Reao (Pirazzoli 1987, Pirazzoli et al. 1987). In both cases they are highly concentrated on the west and southwest sides of the atolls, with few or none on the north and east sides. On the other hand at Tikehau the hoa are open in the east but closed in the northwest (Harmelin-Vivien et al. 1985).

Various factors have been suggested to account for the features and origins of the Tuamotu and Society Islands hoa. In particular Pirazzoli and Montaggioni (1988) have summarised a great deal of evidence from corals, conglomerate platforms, beachrock and intertidal notches that mean sea-level stood 0.8-1.0 m above its present level in the period 5000-1250 B.P., and that it did not fall below 0.7 m above present between 4500 and 1250 B.P. Emerged reef flat material in the floors of hoa has been described from Taiaro (+0.6 m, with dates of 1140±80 and 1110±80: Salvat et al. 1977) and Reao (+0.5 m, 4250±100: Pirazzoli et al. 1987). Pirazzoli (1987) has also described 'obturated hoa' blocked on the seaward side by continuous conglomerate platform with a date of 3170±60 B.P., attributed to a Holocene high sea-level stand, at Temoe. Other relevant dates are quoted by Pirazzoli and Montaggioni (1988) for Rangiroa, Takapoto, Pukarua, Mururoa, Borabora, Raiatea-Tahaa, and other localities with hoa.

Although Chevalier did not consider high-magnitude events such as hurricanes as causative agents in the formation of hoa, they have been specifically considered (together with other high-energy events such as tsunamis) by Bourrouilh-Le Jan and Talandier (1985) in the explanation of megablocks on the reef flat and the alternation of motu and hoa at Rangiroa. The megablocks they consider to be fragments of reef flat previously delineated by fractures and dislodged and transported during such events. Hoa they suggest are activated in sectors of reef rim not subject to previous fracturing. They discuss particularly the major hurricanes of January 1903, March 1905 and February 1906, and the six El Niño-related storms between December 1982 and April 1983. Both sets of storms affected Rangiroa and the northwestern Tuamotu atolls (Tikehau, Mataiva). The 1983 storms were particularly badly felt at Mataiva, where some defunct hoa were reactivated. These they call storm hoa ('hoa d'ouragan') (Bourrouilh-Le Jan and Talandier 1985, p. 316). While they give no detailed analysis of the hoa on any particular atoll, they suggest that their distribution and frequency results from the interaction of hurricane waves, their magnitude and angle of incidence, and reef topography and orientation.

Other workers have suggested that sediment transportation during hurricanes has been responsible for the transformation of functional into non-functional hoa. Thus at Taiaro, where the hoa are non-functional, Salvat et al. (1977) draw attention to the formation of storm embankments more than 2 meters high between 1878 and 1906, and Pirazzoli et al. (1987) suggest that the non-functional hoa on the northern rim of Reao were closed by the hurricane of 1903.

Chevalier's suggestion about the importance of diagenesis of reef-top sediments in controlling motu accretion and hoa erosion has been discussed in general terms by Bourrouilh-Le Jan et al. (1985), with specific reference to Rangiroa, Tikehau and Mataiva Atolls.

Lenhardt (1991) has studied the hydrodynamics of hoa at Tikehau, but in the context of their function as normal flow conduits rather than in terms of their formation during extreme events.

QUESTIONS ABOUT HOA

This review readily generates a number of questions about hoa, some of which are not often addressed in the literature. These include the following:

• why are hoa apparently regionally concentrated, especially in the central Pacific? [this is part of the larger question: why do some atolls have a considerable part of their reef rim occupied by land and others do not?].

• why are hoa locally concentrated in particular parts of atolls?

• why do the reef sectors on which hoa are most numerous vary between atolls?

• why do some atolls (for example Diego Garcia, Canton, Gardner) apparently have no hoa?

• why do some atolls (such as Raroia, Temoe, Reao, Rangiroa) have abundant hoa?

• why do some atolls have areas with abundant hoa and others apparently devoid of hoa?

• why on the same atoll can one find both active hoa (both functional and non-functional) and fossil hoa (paleohoa), often in close juxtaposition?

Answers to these and similar questions must include consideration of:

• erosive processes resulting from wave activity generated by trade winds, swell of more distant origins, and episodic storms.

• current sedimentary processes on both seaward and lagoon shores of motu.

• possible fall in sea-level from a Holocene high stand over the past few thousand years (a regional effect).

• possible tectonic deformation consequent on lithospheric flexure.

• the restricted spatial extent of even the most extreme catastrophic storm events.

These issues form the background to our consideration of the hoa of Hull (Orona) Atoll, Phoenix Islands, Central Pacific.

HULL HOA

Hull (or Orona) Atoll, in 172°11'W, 4°31'S, is the central atoll of the southern tier of the Phoenix Islands in the Central Equatorial Pacific. It was discovered by the U.S. Exploring Expedition in August 1840 (Wilkes, 1845, III, p. 369-370). Between 1938 and 1963 it was occupied by settlers from the Gilbert Islands, but has since been uninhabited except for a small U.S. military presence in the early 1970s. The atoll is located 185 km south of Canton Atoll and 98 km due west of Sydney Island; Gardner Atoll lies 245 km further west (Figure 2). It is 10.8 km long, 4.2-5 km wide, and has a total area of 40.5 sq km (Figure 3); of this islands occupy 6.7 sq km, peripheral reef and channels 7.8 sq km, and lagoon 26.0 sq km. There is no pass into the lagoon, and no bathymetric survey has been made of it; it is said to have depths of 15-18 m (Bryan, 1942, p. 63). The seaward reef flats are 80-200 m wide, being narrowest on the east and west sides and widest on the north and south.

The atoll has a mean annual rainfall (1952-1963) of 1171 mm (maximum 2599.2 mm, minimum 245.6 mm). Spring tidal range is approximately 80 cm.

The land rim varies in width from less than 50 m at the eastern point, where it consists of gravel ridges, to a maximum of 650 m on the west side; the average is 250-300 m. The total shoreline periphery on the seaward side, including hoa, is approximately 26.5 km. Of this 5 km (19 per cent) on the northwest side comprises islands with hoa. The definition of the hoa is somewhat problematic but there are some 20 intersecting the conglomerate platform as well as lesser channels between islands on the platform. In addition there are four hoa in the otherwise continuous southern rim, and none on the northeast and southwest sides. There is, however, a sector of ca 1500 m near the south point of former hoa (paleohoa), to be described.

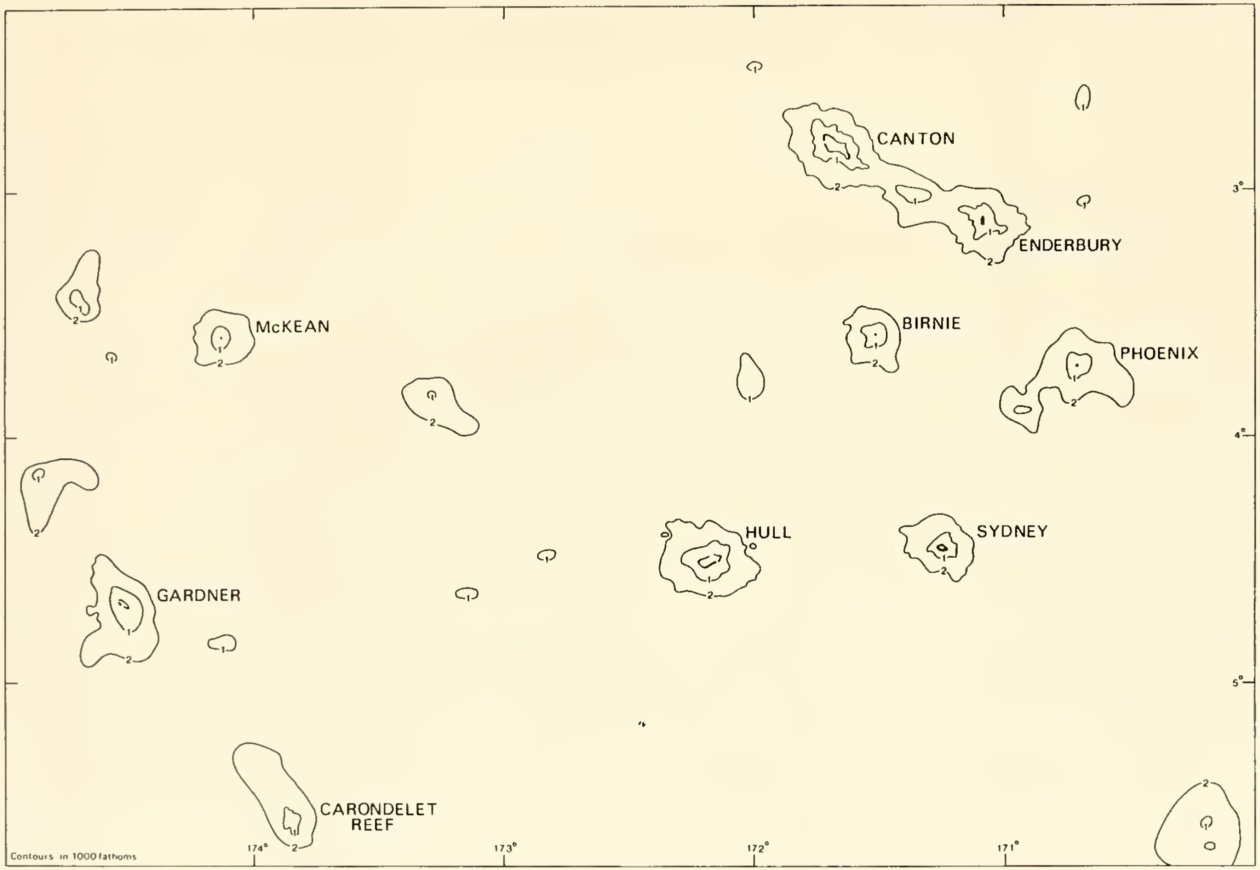


Figure 2. The Phoenix Islands, central Pacific.

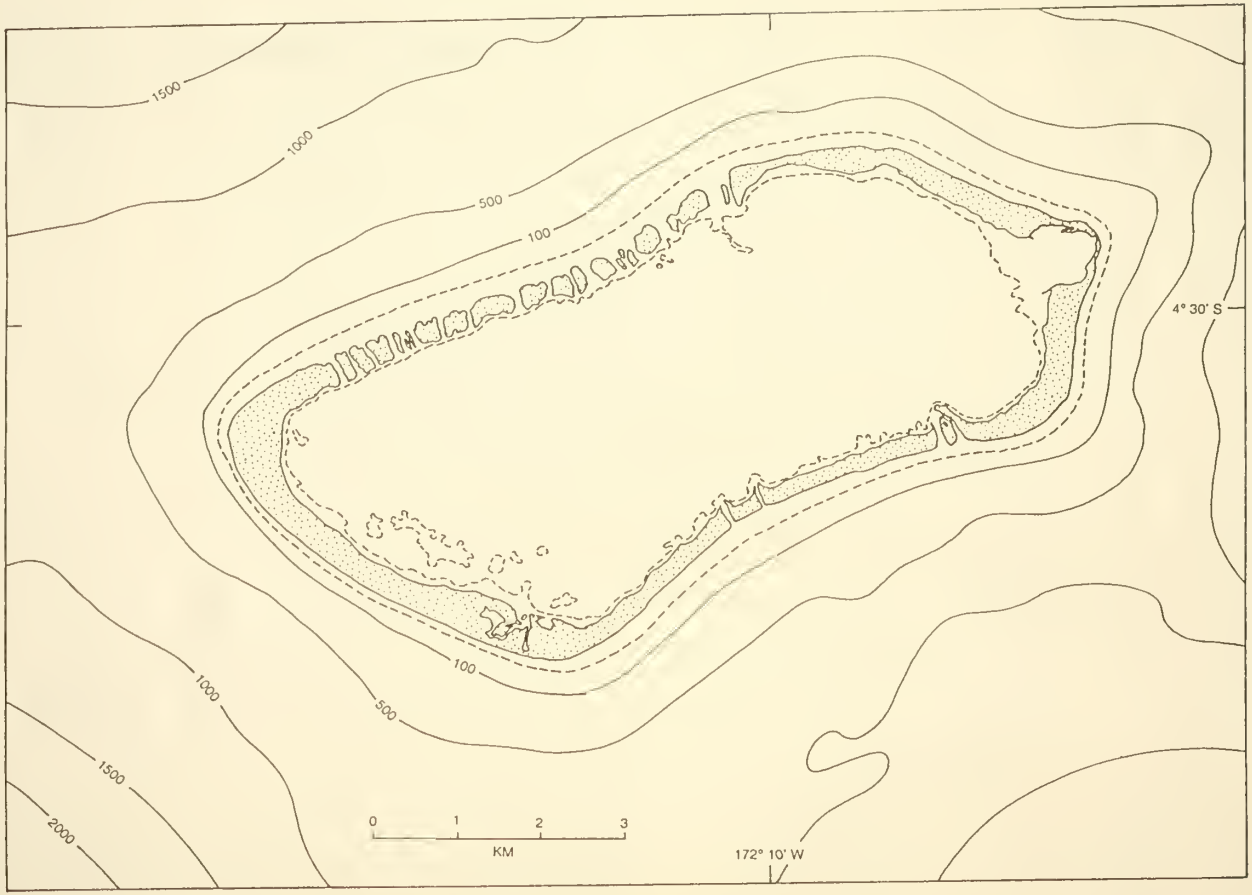


Figure 3. Hull Atoll. Bathymetric contours in meters.

Normal Rim

Profile 4 (Figure 4) was surveyed at the easternmost point of the atoll, near the former settlement, using a Kern automatic level. The land rim at this point is ca 600 m wide, and the profile extends inland for 280 m from the seaward shore. Extensive cemented conglomerate forms steep bastions rising to 3.4 m at the seaward beach, which is backed by a broad sand and rubble seaward ridge rising to over 3.0 m.

Aerial observation shows that much of the continuous land rim consists of parallel, presumably storm-deposited, shingle and rubble ridges (Figure 6). Lagoon beaches are low and sandy.

Hoa

The hoa on the north side of Hull are channels intersecting the broad conglomerate platform underlying the reef-rim motu. They are normally widest toward the lagoon end and narrow and sometimes bifurcate seawards (Figures 7, 10, 13 and 14). They rarely penetrate through the seaward reef rim, but terminate in a pronounced cliff of conglomerate over which water pours at high tide and during storms. The conglomerate platform usually outcrops along both sides of each hoa (Figures 11 and 12). The lagoon mouths are often partially closed by sandspits (Figures 7 and 8), and the lagoon ends of larger hoa are marked by lobate deltas and aprons of sand transported through the hoa and building out into the lagoon (Figures 9 and 10). The sectors of conglomerate platform defined by the hoa carry individual vegetated islands or motu; frequently there is more than one such vegetated island to a sector of conglomerate platform (Figures 7, 8, 9 and 10). The channels between the vegetated islands may be carpeted with sediment and thinly vegetated, and are less frequently occupied by water than the hoa.

The hoa and motu vary considerably in size. Most of the hoa are not more than 50-100 meters in maximum width, and most of the motu vary from less than 100 up to about 600 meters in maximum east-west dimension. Profile 1 in Figure 5 gives a section through one of the northern hoa. The seaward reef-flat surface rises to 1.1 m, with ponded living microatolls on the outer reef flat at 0.15 m. Sand dunes on the seaward side of the motu reach over 3 m. The conglomerate surface on which the motu stands declines from 1.1 to 0.4 m in a distance of 370 m from the seaward edge of the conglomerate to the lagoon.

Paleohoa

The term 'paleohoa' is here used to describe features now no longer active but which clearly originated in the same way as modern hoa in the southwest sector of the atoll rim (Figure 15). Profile 2 (Figure 5) crosses the island rim near the southwest point, where the seaward perched beach ridge reaches a height of 4.0 m. The floor of the paleohoa, which is completely dry, stands at approximately 1.5 m for its entire extent; it is scattered with undercut storm boulders, especially on its seaward side, and these must date from the time when the channels were active (Figures 17 and 18). The seaward end of the former

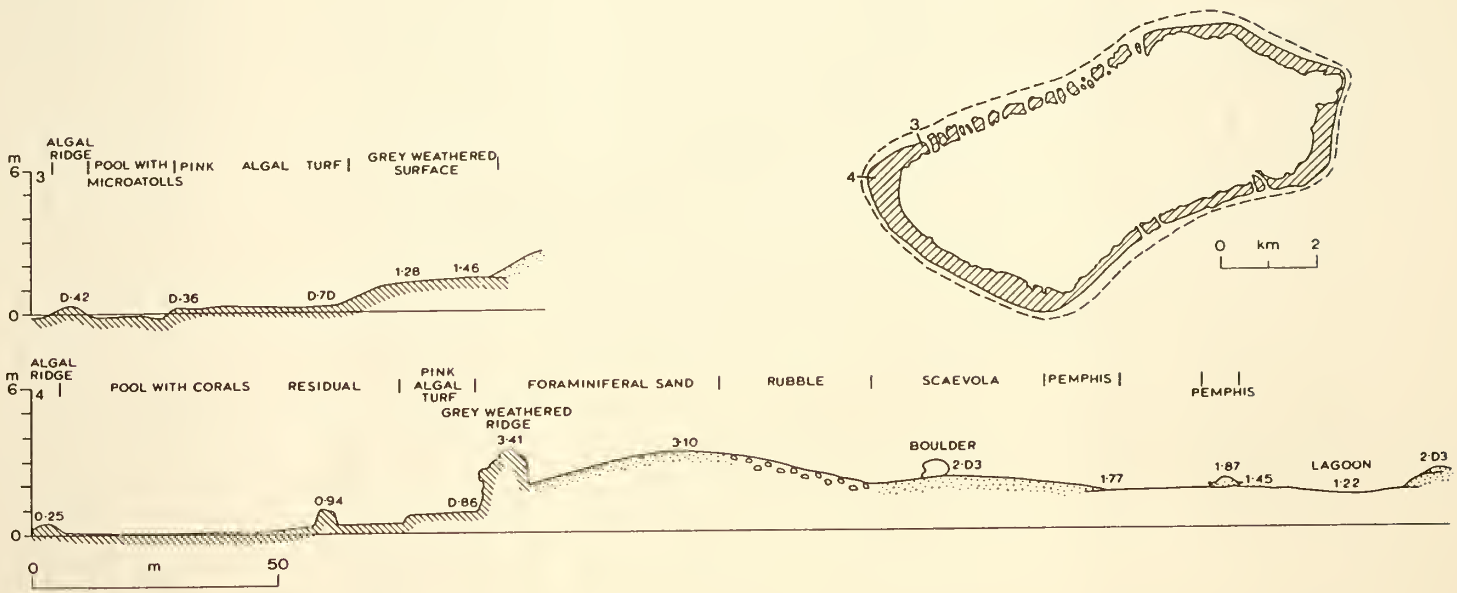


Figure 4. Topographic profiles 3 and 4 surveyed at the northwest corner of Hull Atoll. Datum is approximately mean low water (MLW).

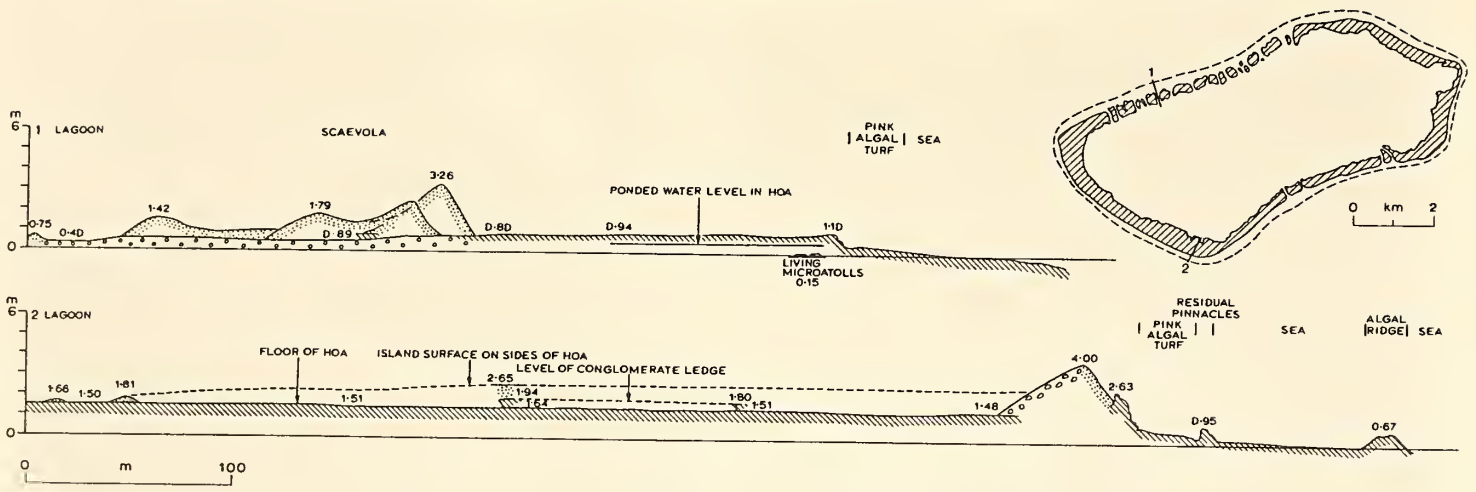


Figure 5. Topographic profiles 1 (through an active northern hoa) and 2 (through a southwestern paleohoa) at Hull Atoll. Datum is approximately MLW.

Figure 6 . View along the northern rim of Hull, looking southwest from the northernmost point of the atoll: normal rim in the foreground and active hoa beyond.

Figure 7 . Conglomerate platform dissected by active hoa and with small motu, northern rim of Hull; also shows well-developed groove and spur.

Figure 8. View toward the east of active hoa and motu on the northern rim at Hull.

Figure 9. Larger active hoa with through passage to the seaward side and well-developed sediment lobe on the lagoon side, northern rim of Hull.

Figure 10. Motu with adjacent functional and non-functional hoa, northern rim at Hull. This sector of conglomerate platform appears on hydrographic charts as a single island.

Figure 11. Conglomerate platform on the sides of a hoa, looking toward the lagoon, northern rim of Hull.

Figure 12. Conglomerate platform on the seaward side of a motu, northern rim of Hull.

Figure 13. Incompletely eroded (non-functional) hoa, blocked by the conglomerate platform.

Figure 14. Non-functional hoa which fails to transect the seaward conglomerate platform, northern rim of Hull.

channel is now closed by a steep high ridge of storm rubble (Figures 18 and 19). The top of the conglomerate platform along the channel walls stands at 1.8 to 1.94 m, and the level of the island surface above the platform at 2.65 m. These elevations may be compared with those of the active hoa in Profile 1, and with the crest of the algal ridge at 0.67 m, which may be taken to approximate a datum in the range of Mean Low Water/Mean Sea Level (i.e. a range of perhaps 30 cm).

DISCUSSION

We now consider the bearing of the hoa of Hull Atoll on the general questions of hoa previously discussed.

First: the distribution of the hoa. Active hoa of the kind found on Hull are not found elsewhere in the Phoenix Islands. They are notably absent from the other two 'typical' atolls of Canton and Gardner. Second, on Hull, the hoa are confined to a sector of the northern rim.

Figure 15. Sequence of paleohoa near the southwest point of Hull Atoll. The darker areas are vegetated former motu.

Figure 16. Detail of motu and paleohoa shown in the foreground on Figure 15.

Figure 17. Basally-eroded storm blocks on the dry floor of paleohoa at Hull.

Figure 18. The dry floor of a paleohoa blocked in the background by a vegetated seaward storm ridge, southwest rim of Hull.

Figure 19. Coarse coral rubble forming the storm ridge invading the seward ends of a paleohoa at Hull.

This indicates to us that their primary cause must be local rather than regional. For this reason we do not believe that a Holocene fall in sea-level, whether or not linked to diagenetic changes in reef-top sediments as proposed by Chevalier and Bourrouilh-Le Jan, is either a necessary or a sufficient condition for hoa formation. The most probable agency for eroding the hoa is overtopping storm water associated with hurricanes, the action of which has often been described. A higher Holocene sea-level may have been instrumental in making possible the stranding of extensive spreads of sediment on reef tops as sea-level fell, and which then became available for dissection into smaller motu by the cutting of hoa during overtopping storms. Bourrouilh-Le Jan and Talandier's (1985) suggestion of erosion by tsunami-generated waves seems less likely, both because these are more infrequent than hurricanes and also usually generate waves of negligible magnitude on open-ocean atolls (see Stoddart and Walsh, 1992, p. 13).

The close spatial association of hoa on the north side and paleohoa on the west side of Hull is also significant. The floors of the paleohoa and the upper surfaces of the conglomerate platforms which margin them and which underlie the motu are substantially higher (by the order of a meter) in the case of the paleohoa than in the case of the hoa. Comparable paleohoa have been identified at Canton Atoll (Guinther, 1978) and at Enderbury in the Phoenix Islands, and they thus appear to be a more widespread phenomenon than currently active hoa. While paleohoa could be broadly categorized as non-functional hoa in Chevalier's terms, and while at Hull they are conspicuously blocked on their seaward sides by a contemporary beach ridge of coarse storm sediments, their non-functioning nature stems from their elevation rather than from sediment-blocking: indeed the lodging of the beach ridge on the edge of the conglomerate platform was doubtless aided by its elevation. At Enderbury the paleohoa are associated with lagoonal emergent reefs of Holocene age (Tracey, 1972, 1980), and their floors stand at approximately the same level as those at Hull (Stoddart and Fosberg, unpublished surveys).

We suggest that these paleohoa were formed by the same kind of storm action that is responsible for the formation of contemporary hoa, but at a period when sea-level stood higher in the Holocene. They were subsequently abandoned when sea-level fell to its present level and storm beaches accumulated along the seaward edges of emergent conglomerate platforms and on emergent hoa floors.

We see no evidence that hoa are initiated by reef-flat fracturing, though doubtless their development may be guided by joints. If fissuring or fracturing is involved, the regional and local distribution of hoa raises considerable problems about surficial reef structure.

Hoa are thus characteristic of reef rims with high proportions of land exposed by the Holocene fall in sea-level and affected subsequently by major hurricanes. They are not characteristic of reefs outside the hurricane seas, e.g. Diego Garcia Atoll in the Chagos Archipelago, and indeed also Gardner and Canton Atolls in the Phoenix Islands. Historic hurricanes are in fact rare in the Phoenix group, and the storm which formed the hoa on the north side of Hull must have been an unusual event. Conversely both hurricanes and hoa are common in the Tuamotu.

The presence of paleohoa at Enderbury and Canton as well as Hull suggests that hurricanes may have been more frequent in this sector of the central Pacific in mid-Holocene times. It would be of interest to search for paleohoa on the margins of the modern hurricane belts to see if these features could serve as a general index of Holocene hurricane extension.

ACKNOWLEDGEMENTS

Observations on Hull Atoll were made possible at the invitation of the U.S. Air Force SAMTEC Project based on Canton Atoll. This provided transportation between and logistic support on each island in the group. Fosberg's participation was made possible by the Smithsonian Institution, Washington, D.C., and Stoddart's by the Royal Society of London. We were accompanied in the field for much of the time by Mr Roger Clapp, then of the U.S. Fish and Wildlife Service.

REFERENCES

Agassiz, A. 1900. Explorations of the "Albatross" in the Pacific Ocean. *American Journal of Science,* (4) 9, 33-43, 109-116, 193-198, 369-374.

Agassiz, A. 1903. The coral reefs of the tropical Pacific. *Memoirs of the Museum of Comparative Zoology, Harvard College*, 28, 1-410.

Bourrouilh-Le Jan, F. G. and Talandier, J. 1985. Sédimentation et fracturation de haute energie en milieu récifal: tsunamis, ouragens et cyclones et leurs effets sur la sédimentologie et la géomorphologie d'un atoll: motu et hoa, à Rangiroa, Tuamotu. *Marine Geology*, 67, 263-333.

Bourrouilh-Le Jan, F. G., Talandier, J. and Salvat, B. 1985. Early diagenesis from 6,000 years ago and the geomorphology of atoll rims in the Tuamotu. *Proceedings of the 5th International Coral Reef Congress*, 3, 235-240.

Bryan, E.H., Jr. 1942. *American Polynesia and the Hawaiian chain.* Honolulu: Tongg Publishing Company. 253 pp.

Chevalier, J.-P. 1972. Observations sur les chenaux incomplets appelés hoa dans les atolls des Tuamotu. *Proceedings of the Symposium on Corals and Coral Reefs 1969* [Mandapam Camp], 477-488.

Chevalier, J.-P. 1973. Geomorphology and geology of coral reefs in French Polynesia. O. A. Jones and R. Endean, eds.: *Biology and Geology of Coral Reefs* (New York: Academic Press), 1 [Geology, 1], 113-167.

Chevalier, J.-P., Denizot, M., Mougin, J.-L., Plessis, Y. and Salvat, B. 1968. Etude géomorphologique et bionomique de l'atoll de Mururoa (Tuamotu), *Cahiers du Pacifique*, 12, 1-144.

Chevalier, J.-P. and Salvat, B. 1976. Etude géomorphologique de l'atoll fermé de Taiaro. *Cahiers du Pacifique*, 19, 69-201.

Danielsson, B. 1954. Native topographical terms in Raroia, Tuamotus. *Atoll Research Bulletin*, 32, 92-96.

Guilcher, A. 1988. *Coral reef geomorphology.* Chichester: John Wiley. 228 pp.

Guilcher, A., Berthois, L., Doumenge, F., Michel, A., Saint-Requier, A. and Arnold, R. 1969. Les récifs et lagons coralliens de Mopelia et de Bora-Bora (Iles de la Société) et quelques autres récifs et lagons de comparaisons (Tahiti, Scilly, Tuamotu occidentales): morphologie, sédimentologie, fonctionnement hydrologique. *Mémoires ORSTOM*, 38, 1-105.

Guinther, E. B. 1978. Observations on terrestrial surfaces and subsurface water as related to island morphology at Canton Atoll. *Atoll Research Bulletin*, 221, 171-183.

Harmelin-Vivien, M., Charpy, L. and Morize, E. 1985. Atoll de Tikehau, Archipel des Tuamotu. *Proceedings of the 5th International Coral Reef Congress*, 1, 211-268.

Lenhardt, X. 1991. *Hydrodynamique des lagons d'atoll et d'île haute en Polynésie française*. Paris: Editions de l'ORSTOM (Collection Etudes et Thèses). 132 pp.

Newell, N. D. 1956. Geological reconnaissance of Raroia (Kon-Tiki) Atoll, Tuamotu Archipelago. *Bulletin of the American Museum of Natural History*, 109, 311-372.

Pirazzoli, P. A. 1987. A reconnnaissance and geomorphological survey of Temoe Atoll, Gambier Islands (South Pacific). *Journal of Coastal Research*, 3, 307-323.

Pirazzoli, P. A., Brousse, R., Delibrias, G., Montaggioni, L. F., Sachet, M.-F., Salvat, B. and Sinoto, Y. H. 1985. Leeward Islands: Maupiti, Tupai, Bora Bora, Huahine (Society Archipelago). *Proceedings of the 5th International Coral Reef Congress*, 1, 17-72.

Pirazzoli, P. A., Delibrias, G., Montaggioni, L. F., Saliège, J. F. and Vergnaud-Grazzini, C. 1987. Vitesse de croissance latérale des platiers et évolution morphologique récente de l'atoll de Reao, îles Tuamotu, Polynésie française. *Annales de l'Institut Océanographique*, 63(1), 57-68.

Pirazzoli, P.A., Koba, M., Montaggioni, L. F. and Person, A. 1988. Anaa (Tuamotu Islands, central Pacific): an incipient rising atoll? *Marine Geology*, 82, 261-269.

Pirazzoli, P.A. and Montaggioni, L. F. 1988. Holocene sea-level changes in French Polynesia. *Palaeogeography, Palaeoclimatology Palaeoecology*, 68, 153-175.

Ricard, M. *et al.* 1985. Rangiroa Atoll, Tuamotu Archipelago. *Proceedings of the 5th International Coral Reef Congress*, 1, 159-209.

Salvat, B., Chevalier, J.-P., Richard, G., Poli, G and Bagnis, R. 1977. Geomorphology and biology of Taiaro Atoll, Tuamotu Archipelago. *Proceedings of the 3rd International Coral Reef Symposium*, 2, 289-295.

Salvat, B. and Richard, G. 1985. Takapoto Atoll, Tuamotu Archipelago. *Proceedings of the 5th International Coral Reef Congress*, 1, 323-377.

Stoddart, D. R. 1969. Reconnaissance geomorphology of Rangiroa Atoll, Tuamotu Archipelago, with list of vascular flora by M.-H. Sachet. *Atoll Research Bulletin*, 125, 1-44.

Stoddart, D. R. 1975. Geomorphology of Aitutaki: geomorphology of reefs and islands. *Atoll Research Bulletin*, 190, 31-57.

Stoddart, D. R. and Walsh, R. P. D. 1992. Environmental variability and environmental extremes as factors in the island ecosystem. *Atoll Research Bulletin*, 356, 1-71.

Tracey, J. I., Jr. 1972. Holocene emergent reefs in the central Pacific. *Abstracts, 2nd National Conference, American Quaternary Association*, 51-52.

Tracey, J. I., Jr. 1980. Quaternary episodes of insular phosphatization in the central Pacific. R. P. Sheldon and W. C. Burnett, eds.: *Fertilizer mineral potential in Asia and the Pacific* (Honolulu: East-West Center), 247-261.

Vallaux, F. 1955, 1991. Toponymie et topographie polynésiennes. *Annales hydrographiques*. 1382, 1-51; reprinted in *Bulletin de la Société des Etudes Océaniennes (Polynésie orientale)*, 21 (5-6) [1991], 1-51.

Wilkes, C. 1845. *Narrative of the United States Exploring Expedition during the years 1838, 1839, 1840, 1841, 1842*. Philadelphia: Lea and Blanchard. 5 volumes.

ATOLL RESEARCH BULLETIN

NO. 395

STORY OF AN OCEANIC ARCHIPELAGO

BY

F. RAYMOND FOSBERG

ISSUED BY
NATIONAL MUSEUM OF NATURAL HISTORY
SMITHSONIAN INSTITUTION
WASHINGTON, D.C., U.S.A.
FEBRUARY 1994

STORY OF AN OCEANIC ARCHIPELAGO

BY

F. RAYMOND FOSBERG

[**Editor's note:** This was given as the Third Carl O. Sauer Memorial Lecture by Dr. Fosberg on Thursday 23 October 1980 in the Alumni House Lounge of the University of California at Berkeley. Carl Sauer (1890-1975) was Professor of Geography from 1923-1957 and Chairman of the Department for 31 years. A group of colleagues, students and friends established the fund to support the annual lectures.

The text was never published and is included here to show Dr. Fosberg's ideas about the past, present and future of oceanic islands. The text is from a typed copy corrected in Dr. Fosberg's hand. Among the corrections was a change of the announced title, "The story of an oceanic mountain range".]

From the time, at least several billions of years ago, when the outer layers of a molten, or at least somewhat fluid, earth became solid enough to be called a crust, the interior, or mantle on which this crust rested or floated, has apparently been in a state of extremely slow but constant convective motion. If the crust ever formed a continuous solid layer, it could not have persisted long with this slow-motion turbulence going on in the mantle beneath. Inevitably fragmentation took place. Segments of different sizes, but very large, formed, some with layers of lighter rock forming their upper surfaces. to be called continents, others without. Convection in the mantle very slowly moved these segments, or *plates*, of more rigid rock this way and that, jostling and grinding their edges together. Their margins slid over and under each other, causing local melting, volcanic and tectonic activity. Of the early eons of this stage in the planet's history we can know little or nothing, though recently a brash and scarcely convincing, but possibly not too far off, attempt has been made to reconstruct the pre-Mesozoic movements of the lighter or continental layers of those plates known to have such layers.

There seems to be some agreement that during the Permian period (280-225 million years ago) these continental plates were united into a single principal mass, now called Pangaea, leaving the remaining area of heavier, submerged crust as Panthalassa, the World-Ocean or Pre-Pacific Ocean. Continued motion in the mantle pulled Pangaea apart into major fragments corresponding in some slight
measure to the present continents or their precursors. Enclosed by them was a

Department of Botany, National Museum of National History, Smithsonian Institution, Washington, D.C., U.S.A.

major portion of the World Ocean which became our vast Pacific.

Bathymetric maps and diagrams of the sea-bottom suggest that this great body of water anything but deserved the name given it by Magellan. Great rifts, ridges, and fracture zones, evidence of movements of plates continuing even to the present time, can be seen. Some of these patterns on the sea-bottom show as ridges and chains of undersea volcanoes. Whether these mountain ranges represent cracks in the sea floor, through which vast amounts of molten rock have been extruded, or whether, as seems to be the latest idea, permanent stationary weak points or ''hot spots" in the mantle cause local melting of the plates as they slowly pass over them, resulting in successions of volcanoes, oriented in the direction of movement of the plates, is not for the non-geophysicist to say. Suffice it to know that outpourings of basaltic lava have slowly built enormous mountains on the sea-floor. Some of these became high enough to extend for thousands of meters above sea-level as, at first, bare, black, slaggy oceanic islands.

The present distribution of islands in the Pacific gives some idea of the widespread occurrence of volcanic activity on the sea-bottom through the later geologic ages. However, detailed study of the sea floor by means of echo-sounding apparatus reveals hundreds, if not thousands of other submarine mountains that do not, at present, show on the surface, even as reefs or banks. These are called *sea-mounts.* Many of them, given the special name of *guyots*, have curiously flat tops, off of some of which have been dredged the skeletons of shallow-water corals. These guyots are interpreted as volcanic islands, which have once extended above the sea surface, that have been eroded down and have gradually subsided, allowing coral reef platforms to grow on their tops. Continued subsidence has in some cases been faster than reef-growth and now some have their flat tops at 1000 to 2000 meters below present sea level, others still reach the surface as coral atolls. Few people are aware of how many sea-mounts and guyots are known, as the various navies of the world regard this as highly important strategic information and give it a high security classification.

It is essential to the further development of our story to understand that these enormous masses of volcanic material extruded on the sea-floor seem mostly to show a tendency toward very slow subsidence. While there is general agreement on the fact of this subsidence, its mechanism has been the subject of much controversy. Some authorities favor the idea, first proposed by Charles Darwin, in support of his theory of the formation of coral atolls, of widespread subsidence of large parts of the earth's crust. Others, such as Molengraaf and Davis, with perhaps more convincing arguments, favor the idea of local isostatic adjustment, to compensate for the great weight of volcanic material pressing on the immediate portion of the slightly fluid earth's mantle beneath a volcano. The result is very slow subsidence of each individual mountain or mountain range until an isostatic equilibrium is reached, as with an iceberg floating in the sea. Tectonic movement may, of course, elevate individual islands or portions of the crust so that occasional islands or areas of sea bottom show features indicating elevation rather than subsidence. Such exceptions to a general pattern do not necessarily invalidate the pattern. Most islands and oceanic mountain ranges, as well as continental mountains, show evidence of subsidence after early orogenic phases are over or slowed down.

For our story we could choose one of several existing Pacific island groups or mountain chains - the Hawaiian, Samoan, Society, Austral, Tuamotu, or Marianas, all of which show some of the features to be discussed. However, to make our story more complete maybe it is better to create an imaginary mountain range, extending northwest to southeast, somewhere on the Pacific sea-floor, that will exhibit all of the features and kinds of islands that we want to discuss. Suffice it to be reasonably sure that all of the phenomena to be described actually have existed or taken place somewhere. The thing to remember is that the high peaks of our mountain range tower above the sea-floor as the high Himalayas do over the Gangetic Plain, and that they emerge above the sea-surface as islands, some of them for thousands of meters. The geomorphological, biological, and cultural history of these islands is the subject of our lecture this evening.

We know all too little of the actual birth of submarine volcanoes, of the first extrusion of molten basalt from vents in the sea floor, to form "pillow" lavas, which pile up into masses of enormous volume and grow into eminences that herald their approaches to the surface by "sulfur boils" discolored steaming patches on the sea surface. Such occurrences have been witnessed a considerable number of times and even photographed. Breaking of the surface by lava, itself, has less often been seen, especially by geologists and volcanologists. The cream of Japanese volcanologists sailed forth to study one such occurrence, Myojin Volcano, south of Japan. They apparently got too close, as they did not return.

Myojin, and also Falcon island in the Tonga Group, have appeared above the surface and then disappeared several times. The sudden cooling of the molten rock on contact with sea-water causes a shattering of the glassy masses of material and the infant islands are loose, unstable piles of cinders, clinkers, and pumice, which are soon reduced to sea-level or below by wave-action, only to be pushed up again by more magma rising from below. Finally there may be a big enough mass of this material to resist the attacks of the waves long enough to build a permanently emergent subaerial volcano.

These basaltic oceanic volcanoes are usually of a gentler character than the explosive Vesuvius, Lamington, and St. Helens type, found on continental masses and along plate boundaries. Once a sufficiently broad base is built up a bit above sea-level, basalt flows can be poured out on its surface, weighing it down and compacting it. Flow after flow alternating with bed after bed of ash and cinders, added to the platform, gradually form a wide dome-shaped slaggy black surface.

We have no way of knowing what the oceanic climatic patterns were many millions of years ago, but given the vast expanse of the Pacific, then as now, uninterrupted by continents or very large islands, there seems no reason to think that the climate then was very different from now, except perhaps warmer during the Miocene. In all probability there were prevailing northeast and southeast trade-winds, dry doldrums and horse-latitudes, violent hurricanes, and powerful high elevation antitrades, and "jet-stream" winds blowing eastward. We can observe the effects of these now on islands and infer that they were similar a long time back. Trade-wind rains, latitudinal rainfall gradients, orographic rainfall, rain-shadows, convection rains, widespread "kona" rainfall, heavy rain that often accompanies hurricanes, occasional droughts, all doubtless occurred then as now, making the climatic patterns probably similar to those we can now observe.

It can be safely assumed, I think, that from the very beginning, some of the same dispersal agents as are active now brought occasional potential plant and animal colonists to our young volcanic islands. Strong winds would have carried small seeds with adaptations for wind dispersal, small flying insects, drifting spiders in their webs, from other islands and continents. Typhoons, hurricanes, and their included tornadoes would have picked up and carried heavier seeds and other propagules up to where the jet-streams could have scattered them to great distances.

Wide ranging sea-birds would have visited our islands from the very first, depositing guano and improving the habitats for plants, perhaps also bringing an occasional seed. Storm-carried or off-course migrating land-birds might be expected occasionally, judging by modern observations. They also may have occasionally brought seeds, either carried internally or clinging to feet or feathers. If conditions were right the birds may even have succeeded in establishing themselves, if they arrived in pairs or flocks. These events, of course, happened extremely infrequently. Certain lowland or strand species, especially plants, salt-tolerant and adapted to floating arrived, probably much more often carried by currents. Marine organisms with free-floating or free-swimming stages doubtless colonized as soon as suitable marine habitats were available, very shortly after stable consolidated lava shores had formed.

Since the complete history of an oceanic island can never be observed, we are forced to reconstruct its probable course from observation of many existing islands in various stages, a method that provides ample opportunity for error. However, extensive observation and experience, along with an element of judgment and estimation of probabilities, may yield a fairly plausible scenario.

The ages of existing islands are matters of great uncertainty. Many years ago, when I was concerned with the origin of the Hawaiian flora, I asked a Pacific geologist about the probable age of the Hawaiian Islands. He said the geologists had no reliable means of estimating this, except that, hopefully, the biologists might give some clues. He suggested a tentative 10,000,000 years, taking into account the probable age of the ancient, subsided northwest chain. For my own purposes, I "conservatively" adopted a figure of 5,000,000 years. Since then drill cores have given a suggested late Cretaceous age for the lowest levels of sediments in the Marshall Islands and at least earliest Miocene for Midway, in the Hawaiian Leeward Group.

In considering the time that has been available for the development of the biota of a closely associated group of islands it is essential to take into account the earliest land surfaces, as it was most likely there that the first successful colonizations took place and that the biota had its beginnings. Even islands now disappeared or reduced to sea-level coral cays or atolls may well have been, in their earlier histories, the sites of significant evolutionary events, of the origins of important lines of insular plants and animals. A pertinent observation is that many complexes of plants and animals in particular archipelagoes have related species on different islands in the groups that they inhabit. In other words, inter-island colonization has been a rather more frequent occurrence. The history of an island group must be looked at as an intricately connected and related series of events. Many things were happening simultaneously.

As mentioned above, as soon as a stable cool surface and shore line were available, colonization could begin. Planktonic larvae of benthic marine organisms could settle and develop on the hardened rock of the shore-line. Birds could use the islands as resting and nesting places, and initiate soil development with the nitrogen, calcium and phosphorus compounds in their guano. Weathering of the ash and rock surfaces would begin at once.

Very soon (in a geologic sense) water-borne strand-plants, bird- and wind-carried seeds and spores of pioneer rock-inhabiting plants could find a habitat. Ordinary rain showers would occur, and on the windward slopes, orographic rainfall would be more abundant the higher the island became. Plant-cover or *vegetation* would begin to appear. As soon as this took place it was possible for small-animal colonization to start. In addition to the sea-birds and their parasites, spiders and small insects probably came first, borne by the wind. Spiders could arrive but not survive until sufficient populations of insects had built up to provide them with food.

A feature of almost any early colonization would have been the extremely impoverished genetic stocks represented by the single or very few individual colonists. One might think that further evolution, requiring genetic variability as a base, would be most unlikely. Yet much evolution did take place. The key to this paradox is that these early habitats were completely open. In most or all species of organisms over repeated generations, mutations of various sorts occur. Because so few of the total offspring normally produced by an organism survive, the chances of even a beneficial mutation surviving are almost infinitesimal under ordinary conditions. In an open habitat, however, where almost any seed that falls in a favorable place is likely to produce a mature plant, non-lethal mutations can rapidly accumulate in a population, providing the variability requisite for evolution. The rigid control by competition that normally maintains the identity of species is temporarily relaxed until the population numbers reach the saturation point in a particular habitat and relative stability is achieved. By this time a normally variable or heterozygous (potentially genetically diverse) condition may have come about.

In the earliest stages of Pacific basaltic islands there was, judging by modern examples such as Mauna Loa, relatively little habitat diversity. Windward sides were wet, leeward sides dry. Temperatures were lower at higher elevations. There were rough and smooth lava surfaces and areas of ash and pumice. Strong winds occurred on high summits. Isolating factors within an island were presumably almost entirely ecological. Populations of organisms were free to spread over as much of the island surface as their ecological amplitude permitted, and large, relatively uniform, though often genetically heterozygous, populations may have been almost the rule.

However, the processes of weathering and soil-formation undoubtedly commenced as soon as the volcanic material cooled and was exposed to sun, air, water, and, at high elevations, frost. Loose material, whether ash and cinders or weathering products, immediately started to be moved downward by water and wind, and to serve as abrasive agents. This abrasion started to carve the volcanic land-forms and to produce erosion features.

Those in the audience who have seen the windward coasts of the Hawaiian Islands know that the heads and sides of valleys and gulches eroded in layered basalt are vertical cliffs. Ridges, peaks, plateaus, and valleys bounded by such escarpments serve as very effective isolation for most populations of plants and animals. Isolation of populations is, as is well-known, the first step toward, and one of the essential conditions for, speciation.

By this erosion the widely distributed populations that formed on the gentle slopes of the young volcanic domes were segregated into many isolated subpopulations. Inevitably differentiation took place. Since this isolation was geographic, and effective, the resulting varieties and species need not have developed genetic isolation or sterility barriers.

As this diversity of taxa developed, habitat diversification also proceeded. Where, in a continental situation, with its wide spectrum of families, genera, and species, pre-adapted forms would have been available for almost any habitat that developed, this was not true on an oceanic island. Many taxa were developing but as variations in relatively few families and genera. Dispersal was occurring and a new habitat sooner or later was colonized, not necessarily by a form especially well suited to it, but by one able to survive. Natural selection, even in a genetically relatively impoverished stock, would gradually result in better adaptation to the habitat, even eventually leading to the often strikingly well-adapted forms described in discussions of "adaptive radiation," a term applied to the evolution of differing populations to occupy different available habitats.

As the normal geomorphic cycle proceeded, the sharp topography that maintained the isolation of the small, mainly still interfertile, populations or taxa mentioned above, became gradually worn down. Slopes became gentler, isolation became less effective, and ranges of related taxa began to come together. Some of the previously discrete taxa hybridized in these zones of contact. Their distinctions began to become fuzzy. A new type of evolutionary process became prevalent. Occupation of existing habitats and newly formed ones became more complete, and the patterns of adaptive radiation became more intricate. By now the vegetation, except on new lava flows and landslide scars, had become closed forest except at very high elevations and on exposed crests.

The birth, growth, erosion, and gradual subsidence of an island, its slow colonization by organisms and the evolution and eventual decline of its biota are continuous, if incredibly slow, processes, not really episodic as my description may have suggested. We must remember that during the enormous span of time during which the first islands to appear in our mountain range reached the maximum development of their biotas, one after another, a whole series of younger islands emerged from the sea. Thus, at any one time all or most of the principal stages or conditions described earlier were in existence simultaneously. In addition to occasional successful new colonizations from outside the young archipelago, more frequently plants and animals from islands within the group succeeded in crossing the smaller water barriers between the islands. Thus the distinctive biota of the archipelago was evolved and maintained.

As the millions of years passed, new volcanoes arose, extending the mountain range to the southeast, and enlarging the archipelago as the Pacific plate slowly moved northwestward.

The oldest islands on the northwest end of the chain gradually eroded away and subsided, giving an opportunity for the myriads of calcium-carbonate-secreting, reef-building organisms to grow and build the wondrous structures and communities of organisms that we call coral-reefs. These reefs, at least ones of any large extent, are formed on slowly subsiding coast-lines. Darwin, in his well-known theory of atoll formation, showed the gradual change from fringing reefs, closely lining the island shores to more distant barrier reefs ringing the partly subsided, eroded remnants of volcanoes with coral just breaking the surface and carrying sand-cays and islets of coral sand and debris. Eventually, when the central volcanic peak or peaks had subsided out of sight, a ring of coral reef and coral islets, called an atoll, remained. The term atoll is modified from the language of the Maldive Islands, a notable archipelago of these coral rings or "necklaces" in the central Indian Ocean.

As this geological process took place, the relatively rich biota of the high island became attenuated and impoverished in species as the terrain became more flattened and simplified. The loss of diversity of habitats, as well as the increasing prevalence of salt-spray, resulted in a drastic reduction of the biota. This was more conspicuous on dry than on wet atolls. For example, the two driest of the Marshall Islands have only ninc flowering plant species each, while the wet southern atolls of the same group have up to five to eight times as many.

Occasional tectonic activity results in elevation of islands already ringed with reefs, and even of atolls. On elevated volcanoes fossil reefs may be seen as limestone terraces or benches on the slopes, or as dissected walls of rough coral limestone at the bases of the slopes. A few examples exist of elevated atolls and of extensive raised reef-tracts. The elevated atolls appear as flat- or concave-topped limestone plateaus, and more extensive tracts became eroded into weird karsts, often protruding ruggedly above the sea surface. Such may now be seen in the southern islands of Palau, Micronesia, and in the Lau Islands of Fiji. Elevated atolls may have vast deposits of calcium phosphate in their summit depressions, as seen on Makatea and Nauru, presumably derived from the guano of innumerable prehistoric seabirds.

In their pristine condition all of the variations of tropical oceanic islands described above, except a few of the very driest, were clothed with forests, largely made up of endemic species of trees and their accompanying endemic smaller plants, insects, and other invertebrate animals, as well as birds, bats, and a few reptiles. Many of these organisms had evolved weird and remarkable forms comparable to the tree lobelias and the silver-sword of Hawaii and the dodo of Mauritius.

Of particular importance from our viewpoint, looking back from the future, were several related features of the biota of these, and other oceanic islands. The plants and animals had mostly evolved in the absence of large herbivores. Except for features which the original colonists may have brought with them, the island plants had evolved no means to protect themselves from the normal continental hazards of grazing, browsing, or trampling by large animals. Even the thorns, spines, stinging hairs, bitter or poisonous substances that may have characterized the species which originally colonized the islands were mostly lost as the new biota evolved. Only some of the most recent arrivals were still prickly, acrid, or otherwise disagreeable.

Root systems were frequently very shallow and had no adaptations to deal with trampling, as there were no large animals to damage them by trampling.

The entire biota had evolved to take full advantage of a comparatively benign environment, harsh in some respects, but without many of the hazards and kinds of competition normal in continental situations. In many ways the equilibria achieved on the islands were very delicately adjusted to make maximum use of existing resources by the available range of organisms. Through adaptive radiation the limited original biota had diversified to fill most ecological niches. All of this took many millions of years and was prior to the arrival of man.

Humans clearly first came to oceanic islands in small parties, in sailing canoes, possibly blown far out to sea by storms, or merely wandering, to see what was there. The first-comers undoubtedly found very poor picking, except in the matter of sea-food and birds and their eggs. The vegetation of oceanic islands contains few edible plants, indeed.

The popular idea of south-sea islands fringed with coconut palms is, as to pre-human days, certainly a myth. Possibly the coconut is indigenous in the Seychelles, in the Indian Ocean, as Jonathan Sauer has suggested, but it certainly came with man to the oceanic Pacific islands.

Ancient Pacific peoples, probably even on casual canoe voyages, carried stocks of a few edible plants, at least as provisions. Any serious colonizing party undoubtedly brought an assortment of useful plants, and the knowledge of their culture. At least pigs, dogs, and chickens came, as domestic animals, not necessarily at the same time. Thus the early arrivals in our island group came well prepared to initiate the series of profound changes in the island geography and biology that followed their advent.

Dependent, at first, on the resources of reef and ocean, the early settlers established themselves near the sea, especially around the mouths of large valleys on the high islands, and probably along lagoon margins on barrier islets and on atolls. Coconuts, bananas, taro, breadfruit, and possibly sweet potatoes, were doubtless planted at once, as well as some other plants. This involved a certain amount of clearing of native vegetation, but for many years the effects were relatively minor. There were doubtless slight disturbances in the reef fauna. Small flat areas back of the beaches and in valley bottoms were cleared for villages, coconut and breadfruit groves, taro pits and other forms of garden culture. A few cultivated plants and some "camp-followers" or weeds were added to the floras of the islands. A few insects and other invertebrates (parasites on man and his domestic animals and plants), some commensals and incidental accompanying animals (possibly including rats) established themselves and become naturalized and part of the fauna.

While the human population remained small, changes in the island ecosystems were slow and the results mostly not catastrophic. Most plants and animals that came with the human colonists did not succeed in invading closed vegetation except where it was opened up by man. An exception, perhaps, was the candlenut or kukui tree, probably brought by man, which on some high, deeply dissected islands, occupied the 60-90 inch rainfall belt on steep slopes almost to the exclusion of other plants.

Characteristic of oceanic islands is that their resources useful to man are limited both in quantity and in kinds. Furthermore, islands of different geographical nature offer different assortments and proportions of resources. Volcanic islands with considerable ash in their composition weather more rapidly and yield richer soils than do those of hard flow-basalt. On dry islands water may be limiting. On very wet ones severe leaching and erosion may deplete soils more rapidly than soil-building processes develop them. Coral atolls, especially drier ones, present a poor terrestrial environment, but are likely to be rich in marine resources, especially if there is a good lagoon with active water circulation. Elevated atolls are so well drained that water may be scarce, although the phosphatic soils may be rich.

Cultural development and population growth depend both on the culture the colonists brought with them and on the nature and abundance of resources occurring on the island.

In all likelihood, limited resources if not too extreme, served as a stimulus to cultural development. To flourish it was necessary to learn to utilize fully and in diverse ways, the range of resources provided by the island. Many island cultures show remarkable ingenuity in their adaptations to their environments and utilization of everything available. The diversity shown by the cultures found on our chain of islands in varying stages of island "life histories" reflected the diversity of the islands. Settled by people of similar Polynesian stock as diverse, of course, as the islands from which they came, the nature of the island imposed each its own stamp on the further cultural evolution of its people. Peoples on fertile, moderately wet islands tended to emphasize agriculture, or, rather, horticulture, making a comfortable living. Populations grew rapidly. Atoll peoples developed great skill and ingenuity in catching and using reef animals and often pelagic fish. They also soon discovered the possibilities of pits excavated to the fresh-water lens lying a few feet below the island surface. Culture of the several taros, and even of bananas could be carried on in such pits, protected from salt-spray by windbreaks of natural vegetation left when clearing for coconut and breadfruit groves, and as gardens were established. The diversity of uses for coconuts and *Pandanus*, learned long before in their ancestral homes, was increased in various directions.

A phenomenon surprising to us, now, was the population size achieved on the more favorable islands. Since the colonists undoubtedly were a healthy lot, to be able to endure the vicissitudes of long voyages and the hardships of settling new islands, and since their numbers were small, the number of diseases they brought with them was small. The inherent biotic potential of man being high, dense populations were reached in relatively short periods. Undoubtedly the limits of carrying capacity of the different islands were soon reached. Then the obvious controlling factor in many islands was warfare. Some cultures, while able to defend themselves, found other means of population control. Contraception was apparently fairly widely known. Infanticide was certainly not unknown. Emigration and search for new island homes was a means of relieving population pressure and a factor in the almost complete settlement of the habitable islands in pre-European time. There were a few uninhabited Pacific islands at the time of arrival of Europeans, but in almost every such case, the island was for one reason or another unsuitable for habitation by Polynesians and Micronesians. Most of them showed signs of having been visited and temporarily occupied. Lack of dependable water-supply was the most frequent reason for lack of human habitation. Most populations on inhabited islands, by the time Europeans arrived, seem to have achieved, but by one means or another exceeded. reasonably sustainable levels. The few records made by the early Europeans visitors show little or no evidence of over-population, depletion of resources, or environmental degradation. For a few island cultures, such as that of the Marshall Islands, we have information on actual conservation practices, usually woven into the religious fabrics and apparently quite effective. What seems to have been a satisfactory, functioning blend of material and social culture had usually been achieved. The occasional very war-like societies may have been exceptions to this generality. Or, perhaps these warring tendencies may have been merely the means evolved for population control. We really know rather little of this period in island history.

One condition, very generally prevailing, was a lack of immunity to many of the important human diseases. Apparently the early colonists in the Pacific came from peoples who had enjoyed long isolation from the dense centers of human population where the common diseases developed. Lack of exposure to these maladies resulted in lack of selection pressure to evolve resistance to them. In a way this was comparable to the lack of defenses, in the indigenous island vegetation, against the effects of large grazing and trampling animals.

The centuries and millenia of presumably orderly and non-catastrophic evolution of island cultures and their adjustment to their insular environments came to an abrupt end in the second half of the Eighteenth Century. Up to that time, though European ships had crossed the Pacific in several directions, the only actual beach-head of European culture was the savagely destructive Spanish settlement in the Marianas Islands. The rest of Micronesia and all of Polynesia were almost completely uninfluenced. Iron was known to many island peoples but only as tiny bits presumably gleaned from rare floating ship-timbers and other wreckage. A few other suggested traces of continental civilization are known, such as the possible presence of pineapples, American in origin, and the existence of these is still very conjectural and controversial. The presence of the American sweet potato in Polynesia was certainly pre-European.

This slow evolution of highly developed cultures ended abruptly with the penetration by English, French, and other explorers, especially Wallis, Cook, Bougainville, and Vancouver, followed by traders, whalers, missionaries, and settlers. These brought domestic herbivorous animals, steel tools, guns, alcohol and diseases. The results were catastrophic.

A steady flow of exotic plants, both cultivated and weeds, followed. The domestic herbivores escaped and became feral on most islands, opening up, eating and degrading the highly vulnerable vegetation, providing new habitats for the exotic species. The steel tools and the trading rewards for provisions for ships encouraged the clearing of more land than had been needed to support the native populations; great changes in the landscape became apparent. Tuberculosis, measles, colds, influenza, as well as over-indulgence in alcohol decimated many populations. Mosquitoes, fleas, and lice came in, and the diseases they spread became established.

Missionary activity destroyed the religious fabric that supported the indigenous cultures. Fanatical new beliefs were introduced that altered vital features of these cultures.

Sailors and other visitors mixed with the natives and greatly altered the genetic composition of the island populations. At the same time they brought venereal diseases to further contribute to the population decline that was an outstanding feature of this period. Some islands were virtually depopulated.

Meanwhile, land, the basis of the island civilizations, came more and more into the hands of settlers from outside. Plantation agriculture, especially coconuts and sugar cane, became widespread, usually on the best of the land. The children of the missionaries and other settlers saw opportunities for Western-style enterprise and eagerly grasped them. The second Missionary generation became sugar planters.

These events and activities had profound effects on the landscape, the biota, and the social structure of the human populations of our islands. The low-island landscape, even in its undisturbed state not very diverse or varied, changed from an appearance of pleasant informality, dominated by groves of coconut palms and stately breadfruit trees, with thatched huts, to a monotony of coconut plantations. The trees were planted in strictly orderly rows, the houses had sheet-iron roofs, the ground kept free of undergrowth, with all trash and humus neatly burned. Soil fertility tended to decline, as the nuts were turned to copra and exported, taking nutrients along. Little attention was given to replacing them. The humus content of the already poor soils became lower, both from natural causes and from burning.

The level lowlands and gentle lower slopes of the high islands were likewise covered by plantations, both sugar cane and coconut, later also pineapple. Towns and, later, cities appeared, attracting the natives away from the villages, to populate the poor parts of the cities, while the well-to-do outsiders built exclusive, beautiful homes in the better parts, away from the crowded and ugly down-town sections.

The mountainous or hilly areas were devastated by the charcoal burners, feral goats, sheep, cattle, horses and pigs. The forests were cut and degraded to poor scrub increasingly dominated by lantana, guava, kiawe (*Prosopis*), and other weedy shrubs and small trees. Fires became frequent in the drier leeward areas. Erosion was accelerated, exposing bedrock on steeper slopes, and depositing fine red silt in the shallow water, smothering the corals and degrading the reefs. Soil covering, with its important soil-biota and accumulated nutrients that took millenia to develop, were lost in a few decades. The capacity to support, not just humans, but populations of many kinds of organisms was seriously reduced.

On each high island, a wondrous biota, largely composed of unique species, even genera endemic to one or a few islands, suffered depletion and impoverishment. Many of these species disappeared before they were known to science, or even known to man. Such a loss is both an ecological tragedy of reduced diversity, and an impoverishment of the interest and the aesthetic quality of the habitat of man. Some might say that if man did not know what he lost it made no difference to him. I do not subscribe to this notion.

Loss of native species was not the only change in the biota brought about by the stepped-up human activity and by the new human immigrants. People have a tendency to introduce plants wherever they go. Economic or possible economic plants, food, forage, fiber, timber plants, ornamentals, and "camp-followers" or weeds, came in, in great numbers. Most were planted or established in fields, gardens, orchards, and around dwellings. However, many plants have effective means of dispersal, mechanisms to take advantage of wind, birds, people, and feral animals. The native vegetation tends to resist invasion by exotic plants while in good condition. The degradation and opening up of this closed forest vegetation by feral herbivores, fire, clearing, road-building and other kinds of disturbance so effectively provided opportunities and habitats for exotics that, before many years, the vegetation at low and moderate elevations on many of our islands was dominated by these immigrants. Scrubby forests of kiawe (*Prosopis*), opiuma (*Pithecellobium*), guava (*Psidium*), ironwood (*Casuarina*), mango (*Mangifera*), and *Eucalyptus*, scrub of *Lantana*, *Acacia*, *Melastoma*, *Leucaena*, and *Schinus*, and rank grasses (*Pennisetum*, *Panicum*, *Andropogon*, *Saccharum*, *Melinis*, and *Sorghum*) covered vast areas in the lowlands and lower slopes, wherever the land was left uncultivated or fallow. It soon became a fact that a visitor could travel in the islands for months without seeing a native plant. The habitats of native species of both plants and animals were usurped by these aliens, and the native biota, just as the native peoples, declined rapidly. Hundreds of native plants, as well as snails, insects, and other invertebrates, along with numbers of bird species, disappeared, mostly never to be seen again. Gentler upper slopes were converted to pasture, making large livestock ranches. Even on steeper slopes, native forests were invaded by exotic vines (*Passiflora*, *Paederia*) and aggressive shrubs (*Eupatorium*, *Lantana*, *Clidemia*), or logged off and replaced by *Eucalyptus* or *Pinus*. The landscape was altered beyond recognition and the natural diversity seriously reduced.

Due to erosion, water became scarcer. Irrigation of plantations became more and more expensive. During dry cycles and on some of the drier islands, droughts occurred. Even domestic water consumption at times had to be regulated. As the native vegetation, a superb mechanism for absorbing and holding rain-water, became reduced, the water supplies for the constantly augmented populations became more uncertain and precarious.

What of the native peoples? With introduced public-health measures, sanitation and available medical services, the population decline was, in most islands, arrested, and native peoples, mostly now of mixed blood, began to increase. However, because of their period of decline, and often because of their disinterest in working for the plantation owner, workers were scarce and the planters had to look elsewhere for their field and factory labor. Large numbers of foreign workers were brought in. They stayed and multiplied, in time becoming majorities of island human populations. They rapidly adopted the dominant western cultures; the native peoples tended to do likewise. Thus the remarkable local cultures that had evolved in the islands, disappeared. The peoples tended to be more or less effectively amalgamated, but much of what had made them unique was lost. A monotonous tropical version of western "civilization," with a few artificial, imitated "native" forms of entertainment were what remained of the fabulous "South Seas" for the tourists to flock to see.

We will pass over the period of war, with its profound and traumatic effects and accelerated change.

Much of the scenery remains beautiful. Much of the planted exotic vegetation is showy. The swimming is good. Away from the cities the pace and the atmosphere are relaxing. The climate is pleasant. Visitors who come tend to want to stay.

In the cities the pace is frantic. Traffic is worse than in many continental cities. The people are money-mad. Taxes are high. Everything is expensive. There seems to be no limit to the engineering projects and construction of all sorts. Sky-scrapers sprout up everywhere. Nothing is too beautiful to be sacrificed if it happens to be in the way of "progress." Entertainment and comfort are provided for the tourists and retirees. If they stopped coming, the metabolism of this frenetic society, fueled by tourist money, would fall to a subsistence level that would barely be sustained by such plantation agriculture as survived the immigration and tourist floods. So far, this has not happened, and fuel energy has not yet become so expensive as to bring the mechanized civilization to a stop.

The South Sea idyll, which attracts the tourists and retired people, is now an artificial and false counterfeit, but still convincing. Hordes of visitors come, many stay, and the population grows. There are not small islands enough to supply the demands of the wealthy who want private islands of their own. Solitude is becoming a memory only, but it is not what the crowds want, though it is what the advertising promises. Air-travel makes practically every island accessible.

What of the future? If energy supplies remain adequate, even though expensive, I can see no future except that the islands will become more and more uniform, a tropical version of standard western civilization. The diversity that still makes them fascinating will more and more rapidly become lost. People will become even more ubiquitous than now, as they will everywhere else.

If energy supplies fail, as they very well may, travel and communication will become difficult and isolation will result. The amenities that have become necessities will become more and more scarce, and more and more concentrated in the hands of fewer and fewer people. The social structure will become more and more unstable. Local strong-men will probably emerge. Violence and repression will prevail. Island versions of Ibanez' *Four Horsemen* may appear. Sooner or later the isolated, now impoverished and degraded island ecosystems will have their human, animal, and plant populations reduced to the levels of the real carrying capacities of their habitats. Perhaps limited but stable subsistence societies may again become the rule. Or perhaps man may eliminate himself and nature may start a new experiment.

PERTINENT LITERATURE

Carlquist, S. 1965. *Island Life*. Amer. Mus. Nat. Hist., Garden City, N.Y. 451 pp.

Carlquist, S. 1974. *Island Biology*. Columbia Univ. Pr., N.Y., London. 660 pp.

Dalrymple, G. B., E. A. Silver & E. D. Jackson. 1973. Origin of the Hawaiian Islands. *Amer. Scientist* 61: 294-308.

Darwin, C. 1896. *The Structure and Distribution of Coral Reefs*. Appleton, N. Y. 344 pp.

Davis, W. M. 1928. *The Coral Reef Problem*. Amer. Geogr. Soc. Sp. Pub. 9, 344 pp.

Fosberg, F. R., ed. 1963. *Man's Place in the Island Ecosystem.* Bishop Mus. Press, Honolulu, 264 pp.

Gressitt, J. L., ed. 1963. *Pacific Basin Biogeography*. Bishop Mus. Press, Honolulu, 563 pp.

MacDonald, G. A. & W. Kyselkon. 1967. *Anatomy of an Island.* Bishop Mus. Press, Honolulu, 36 pp.

MacDonald, G. A. & A. T. Abbott. 1970. *Volcanoes in the Sea...* Univ. Hawaii Pr., Honolulu, 441 pp.

McKenzie, D. P. 1972. Plate Tectonics and Sea Floor Spreading. *Amer. Scientist* 60: 425-435.

Moore, J. G. 1975. Mechanism of Formation of Pillow Lava. *Amer. Scientist* 63: 269-277.

Sauer, J. 1967. *Plants and Man on the Seychelles Coast*. Univ. Wisconsin Press, Madison, 132 pp.

Zimmerman, E. C. 1948. *Insects of Hawaii, vol. 1: Introduction.* Univ. Hawaii Press, Honolulu, 206 pp.

ATOLL RESEARCH BULLETIN

NO. 396

COMMENTS ON ATOLL PHOSPHATE ROCK

BY

F. RAYMOND FOSBERG

ISSUED BY
NATIONAL MUSEUM OF NATURAL HISTORY
SMITHSONIAN INSTITUTION
WASHINGTON, D.C., U.S.A.
FEBRUARY 1994

COMMENTS ON ATOLL PHOSPHATE ROCK

BY

F. RAYMOND FOSBERG

Dr. K. A. Rodgers, in a series of previous articles (1987, 1989a, 1992), has gathered together what is known, published or previously unpublished, on the occurrence of terrestrial phosphate rock and phosphatic soil on the Tuvalu (Ellice) Archipelago of coral atolls in the central Pacific, (the southern extension of the Marshall-Gilbert Chain). These are typical low oceanic atolls, with no indication of any former connection with continental land or large islands. From his text and maps of the individual atolls it is evident that substantial areas of the "coral" sands and gravels that cover the surfaces of these atolls have been phosphatized by whatever process or processes. This is the most thorough treatment of phosphate occurrence on any non-elevated coral island group anywhere. It is of great value in demonstrating the existence and importance of what is a widespread geological and pedological phenomenon throughout the Indo-Pacific coral island region.

Rodgers' descriptions of the phosphatic material, though not always expressed in terms completely familiar to me, indicate that all or most of the phosphate in Tuvalu corresponds to what I have earlier (Fosberg, 1954, 1957; Fosberg and Carroll, 1965) termed atoll phosphate rock, phosphatic hard-pan, or the Jemo Soil Series. In the above cited papers, I presented a description of the bedded phosphatic rock or hard-pan found commonly on all but the driest low coral islands in the Indo-Pacific. To account for the origin and existence of this rock, I described a most interesting situation involving one of the (formerly) most common forest types on these islands, a practically pure stand forest of the large tree, Pisonia grandis R. Br. Under this forest, where its canopy is closed, and where there is little or no admixture of other tree species, is found a surface layer or horizon of "raw humus" similar to the "mor" of northern conifer forests, with an acidity of pH 6 to pH 4.5, or even lower. This occurrence of this type of "mor" is otherwise very uncommon at low elevations in the tropics. Pure stands of any tree species in the lowland tropics are also uncommon.

Sea-birds of several sorts tend to nest or roost gregariously in this forest, and where this happens, the surface of the humus layer is stained white by the bird droppings, or "guano". This is composed principally of finely comminuted fish-bones, largely a calcium phosphate mixture. Beneath such white patches is commonly found an uppermost layer of the coral-sand substrate cemented together, to varying degrees, by a bright brown phosphatic cement, giving a very characteristic brown surface abundantly speckled with white, the coarse sand or fine gravel carbonate particles. This hard-pan, when broken up, can be detected by being notably lighter in weight than similar fragments of lithified coral

Department of Botany, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560, U.S.A.

sand or gravel. These observations suggested a process where the fine phosphatic powder in the bird excrement was washed down into the porous acid raw-humus, acidified and dissolved, the solution percolating down until it reached the alkaline calcareous sand underlying the humus layer. It then, neutralized, precipitated out, forming a hardening deposit, holding the sand-particles together. All degrees of this lithification were observed, even involving small pebbles of carbonate, which tended to become friable under the influence of the acid percolate, where part of the carbonate may have been replaced by phosphate, rather than being washed off by the rain-water where no acid humus was present.

Since this phenomenon was first observed by me on Jemo Island, northern Marshalls, in 1951, I have, by watching for it in likely situations, seen it many times, in localities from Polynesia to the Seychelle Islands, and occasionally in places where no Pisonia remained. In such places, questioning the local people, I sometimes found that there had formerly been Pisonia. In one or two instances, questions as to where there had formerly been Pisonia, revealed unsuspected deposits of the speckled phosphatic rock, the surfaces weathered to a dull gray color.

The earliest case of the association of such phosphate, mis-called "guano", to come to my attention, was in a paper by Lipman and Taylor (1924), on Rose Atoll, where the material was collected by A.G. Mayor (Setchell, 1924) and studied by C.B. Lipman and J.K. Taylor. Lipman misinterpreted the nature of the phosphatic material, but there is little doubt that it belonged to what I have called the Jemo Soil Series.

In 1970 I spent a few days on Cousin Island, in the Seychelles, Western Indian Ocean (Fosberg, 1983). Over half of the 68 acre surface is a flat area, just about 2 m above sea-level, now planted with coconuts growing in holes excavated to 1 m depth. Examination of many of these holes and much of the flat surface showed this entire flat portion to be a continuous layer of brown, white speckled, rather soft rock, exactly like the atoll phosphate rock described from the Marshall Islands. Abundant young Pisonia grandis, sprouting after clearing of what must have been an imposing forest, suggests that this entire flat is a "beheaded" Jemo soil, the humus layer decomposed away after clearing. The only other occurrence of atoll phosphate comparable in thickness to this to come to my attention is a 5-foot-deep layer on Gaferut Island, Western Carolines, mentioned by Niering (1961).

Sea-birds have been observed nesting in large numbers in forests of other tree species than Pisonia, in bushes, and on the ground, on coral sand substrates. In no such situation has there been found a raw-humus layer, or any brown, white speckled rock. One exception to this was a description by Catala (1957) of a similar situation in the Gilbert Islands, where the trees were cited as Guettarda speciosa forests, but none with a raw-humus soil horizon. I can only assume that Catala, who is no botanist, mistakenly identified Pisonia as Guettarda.

Rodgers (1992), mentions Pisonia trees wherever they occur in connection with the phosphate deposits he describes. However, in only one place does he mention Pisonia as dominant in the plant cover, on Nui Atoll, quoting Woodroffe (1985). He discusses the problem in his section on geobotany, admitting that there may have been a Pisonia-phosphate association in Tuvalu in the past, "man-induced changes make it impossible to recognize such a relationship today throughout most of the archipelago, or indeed to ascertain whether it was present in the virgin environment." He makes a considerable point of the nonoccurrence of Pisonia on five islands today, also of the lack of bird colonies associated with any known phosphate deposit in Tuvalu. One might expect 2000 years of human occupation to have obscured most evidences of natural conditions. He concludes in this section, as well as in his abstract, that "the presence or absence of Pisonia in the present day should not be taken as a geobotanical indicator." One can only agree with this, without argument.

However, he says nothing about whether the presence of atoll phosphate rock can be taken as an indicator of former Pisonia forests with colonies of roosting or nesting sea-birds. I have in a number of instances assumed that the presence of such rock, as for example, on Canton Island, Phoenix Group, a bed of weathered atoll phosphate rock, as a very good indicator of former Pisona forests, where none occur today. This I maintain even to the extent that a single well rounded, but unmistakable atoll phosphate pebble, collected by the late Wayne Gagné on Laysan Island, indicates to me than a Pisonia forest formerly existed on Laysan. Until recently, Pisonia qrandis was not even considered to be a member of the Hawaiian flora, but recent collections from Pearl and Hermes Atoll, as well as two very old specimens in the Kew herbarium show that the species does occur in the Hawaiian group.

One further observation, just to round out this discussion, and to indicate the need for caution about sweeping generalizations, follows. That I can not insist, categorically that Pisonia qrandis is essential for the formation of atoll phosphate rock is shown by the following. Samples collected by David Stoddart in 1961, on Lighthouse Reef, an atoll off Belize, where Pisonia qrandis is not even known in the same hemisphere, do not seem to differ substantially from the atoll phosphates in the Pacific. And, in 1971, on Glover's Reef, another atoll off Belize, in the interior of Long Cay, in an area long ago cleared and planted to coconuts, I located an area of many square meters of a weathered, but when broken, bright orange brown white-speckled rock. The bed was not thick, but was firm (Stoddart, Fosberg, and Sachet, 1982). Later, on Northeast Cay, I found small boulders of similar rock in a pile of boulders, but none in place.

This Belize phosphate merits further study, but I have no doubt as to its nature. My only suggestion as to its origin is that Neea choriophylla Standl., a small tree related to the genus Pisonia, is fairly common to locally abundant on these Belize sand cays. I did not see it forming pure stands, but before the cays were cleared and changed to coconut plantations, such stands may have existed, and conceivably may have formed raw-humus horizons on the soil.

Finally, to give some idea of how much change has taken place in recent years on atolls throughout Polynesia, observations recorded in the voluminous reports of the U.S. Fisheries Commission Albatross cruises written by Alexander Agassiz (1903), show that around the beginning of the twentieth century Pisonia qrandis forests were one of the commonest and most conspicuous forest types on coral islands throughout the areas of ocean visited by these expeditions. It would be surprising , indeed, if there were not "fossil" occurrences of atoll phosphate rock on almost any of the not-too-dry Pacific atolls.

Mention should be made of the very comprehensive review of Phosphate Rock on Coral Reef Islands, by Stoddart and Scoffin (1983). This surveys the nature, occurrence and petrology of phosphate rocks of a number of kinds, and undoubtedly of various origins, on coral islands both high and low. These authors discuss what I have called "atoll phosphate rock" along with several other forms of lithified phosphate under their heading "recent phosphate rock". They discuss these deposits at considerable length, but, in my opinion, do not clearly indicate whether rocks of one, several, or even many origins are discussed in their two sections headed "Recent phosphate rock" (pp. 376-378, and 380-382). Nowhere do they indicate that acidity is an essential factor in the process of formation, nor do they emphasize the bright brown color of the matrix or cement in which the white limestone grains are embedded. To me, the presence of acidity is essential for the solution of the comminuted fish-bones of the guano and its downward percolation through the soil. There also seems to be no other obvious origin for the bright orange-brown color of the cement than the brown raw-humus produced under the Pisonia forest. I would restrict the definition of atoll phosphate rock to occurrences where the matrix is brown and inclusions are white or pale calcareous particles, or their pseudomorphs in very altered examples.

With this restricted definition, I strongly maintain that such rock is an indicator of a practically pure stand of Pisonia qrandis (or equivalent such as Neca) with nesting or roosting gregarious sea-birds, on "coral" sand or gravel. None of the other suggested processes of origin than that described above seems adequate, or necessary, to explain the origin and occurrence of the rock (or soil) under discussion.

Also, I would scarcely expect to find, on atolls as long and densely populated by humans as Tuvalu, more than casual persisting remnants of Pisonia vegetation. I have noted a strong inverse correlation of present-day seabird rookeries with human populations. Finally I have seen few, if any, uninhabited coral islands that do not have large or enormous colonies of fish-eating birds. Lack of birds, and only a few remnant occurrences of Pisonia qrandis, are exactly what Rodgers describes for Tuvalu, where persisting beds of what seems to be typical atoll phosphate rock seem to be common. To me, this suggests that dense stands of Pisonia and vast numbers of seabirds were characteristic of the Tuvalu atolls in pre-human times.

References

Agassiz, A. 1903. The coral reefs of the Tropical Pacific. Mem. Mus. Comp. Zool. Harvard. 28: 1-410, (3 vol. plates)

Catala, R.L.A. 1957. Report on the Gilbert Islands: Some aspects of human ecology. Atoll Res. Bull 5: 1-187.

Fosberg, F.R. 1954. Soils of the Northern Marshall Atolls, with special reference to the Jemo Series. Soil Sci. 78: 99-107.

Fosberg, F.R. 1957. Description and occurrence of atoll phosphate rock in Micronesia. Amer. J. Sci. 255: 584-592.

Fosberg, F.R. 1983, Natural History of Cousin Island. In Sachet, Stoddart, and Fosberg, eds., Floristics and ecology of Western Indian Ocean islands. Atoll Res. Bull. 273:7-38.

Fosberg, F.R. and D. Carroll. 1965. Terrestrial sediments and soils of the northern Marshall Islands. Atoll Res. Bull. 113: 1-156.

Lipman, C.B. and J.K. Taylor. 1924. Bacteriological studies on Rose Islet soils. Carnegie Inst. Marine Biol. Pap. 19: 201-208.

Niering, W.A. 1961. Observations on Puluwat and Gaferut, Caroline Islands, with historical and climatic information of Gaferut Island by M.H. Sachet. Atoll Res. Bull. 76: 115.

Rodgers, K.A. 1987. The mineralogy of a phosphatic horizon, Amatuku islet, Funafuti atoll, Tuvalu. S. Pac. J. Nat. Sci. 9: 49-56.

Rodgers, K.A. 1989a. Phosphatic limestones from Tuvalu (Ellice islands). Econ. Geol. 84: 2252-2226 [sic].

Rodgers, K.A. 1989b. Dahlite and Whitlockite from Amatuku, Tuvalu. Mineral Mag. 53: 123-125.

Rodgers, K.A. 1992. Occurrences of phosphate rock and associated soil in Tuvalu, Central Pacific. Atoll Res. Bull. 360:1-31.

Setchell, W.A. 1924. American Samoa. Part III. Vegetation of Rose Atoll. Carnegie Inst. Pub. 341: 225-261.

Stoddart, D.R., F.R. Fosberg, and M.H. Sachet. 1982. Ten years of change on the Glover's Reef cays. Atoll Res. Bull. 257: I-II, 1-17, f. 1-15, pl. 1-18.

Stoddart, D.R. and T.P. Scoffin 1983. Phosphate rock on coral reef islands in Goudie, A.G. and K. Pye eds. Chemical sediments and geomorphology. Academic Press, London pp. 369-400.

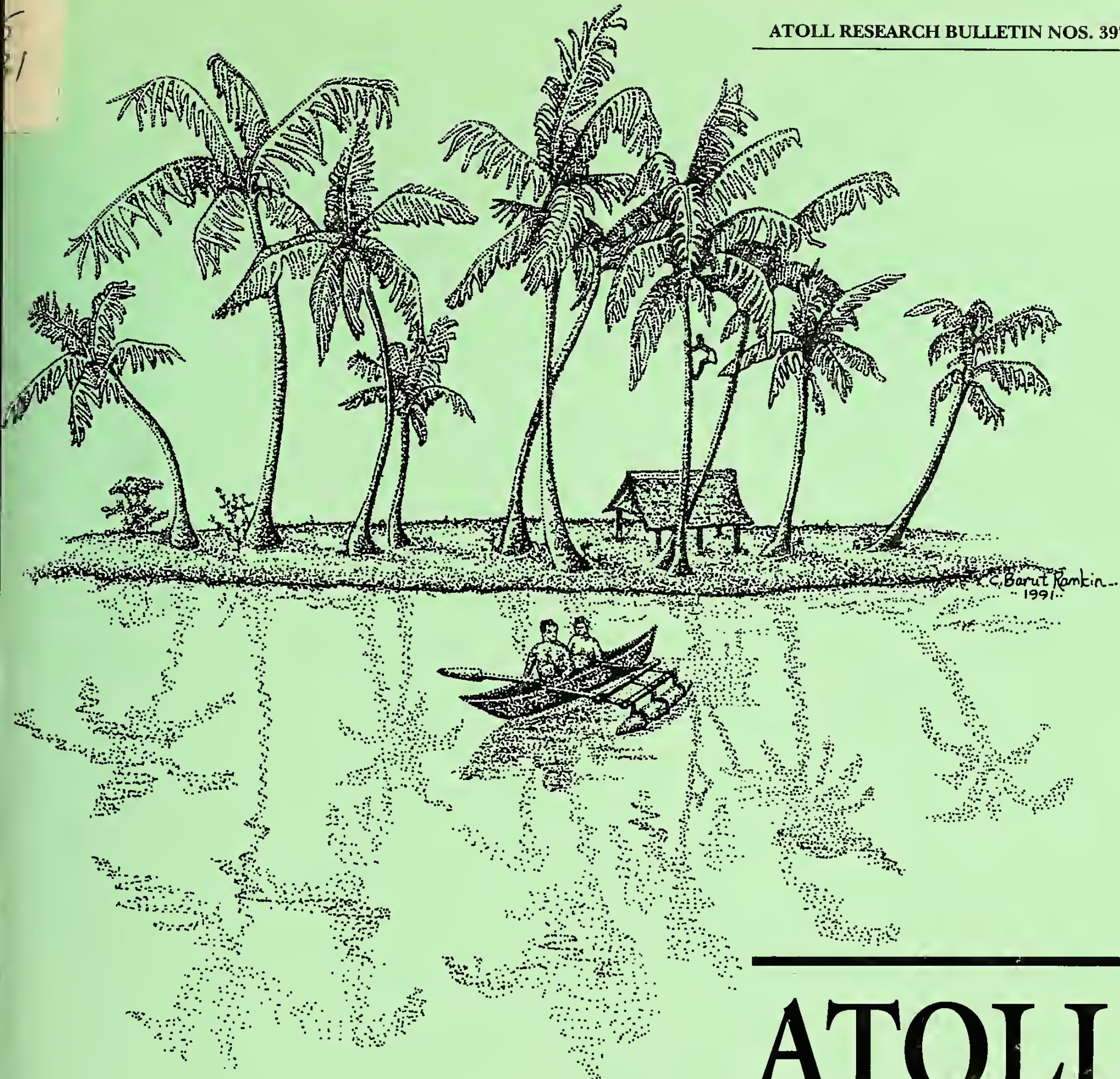
Woodroffe, C.D. 1985. Vegetation and flora of Nui Atoll, Tuvalu. Atoll Res. Bull. 283: 1-18.

☆U.S. GOVERNMENT PRINTING OFFICE: 1994 368-004

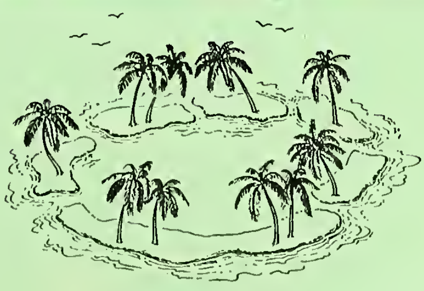
ATOLL RESEARCH BULLETIN

NOS. 390-396

ATOLL RESEARCH BULLETIN NOS. 397-398



ATOLL RESEARCH BULLETIN



THE NATURAL HISTORY OF CAROLINE ATOLL, SOUTHERN LINE ISLANDS

Issued by

NATIONAL MUSEUM OF NATURAL HISTORY
SMITHSONIAN INSTITUTION
WASHINGTON, D.C. U.S.A.
FEBRUARY 1994

ATOLL RESEARCH BULLETIN

NOS. 397-398

THE NATURAL HISTORY OF CAROLINE ATOLL, SOUTHERN LINE ISLANDS

EDITED BY

ANGELA K. KEPLER AND CAMERON B. KEPLER

ISSUED BY
NATIONAL MUSEUM OF NATURAL HISTORY
SMITHSONIAN INSTITUTION
WASHINGTON, D.C., U.S.A.
FEBRUARY 1994

ATOLL RESEARCH BULLETIN

NOS. 397-398

NO. 397. PART I. HISTORY, PHYSIOGRAPHY, BOTANY, AND ISLET DESCRIPTIONS
BY ANGELA K. KEPLER AND CAMERON B. KEPLER

NO. 398. PART II. SEABIRDS, OTHER TERRESTRIAL ANIMALS, AND CONSERVATION
BY CAMERON B. KEPLER, ANGELA K. KEPLER, AND DAVID H. ELLIS

ISSUED BY
NATIONAL MUSEUM OF NATURAL HISTORY
SMITHSONIAN INSTITUTION
WASHINGTON, D.C., U.S.A.
FEBRUARY 1994

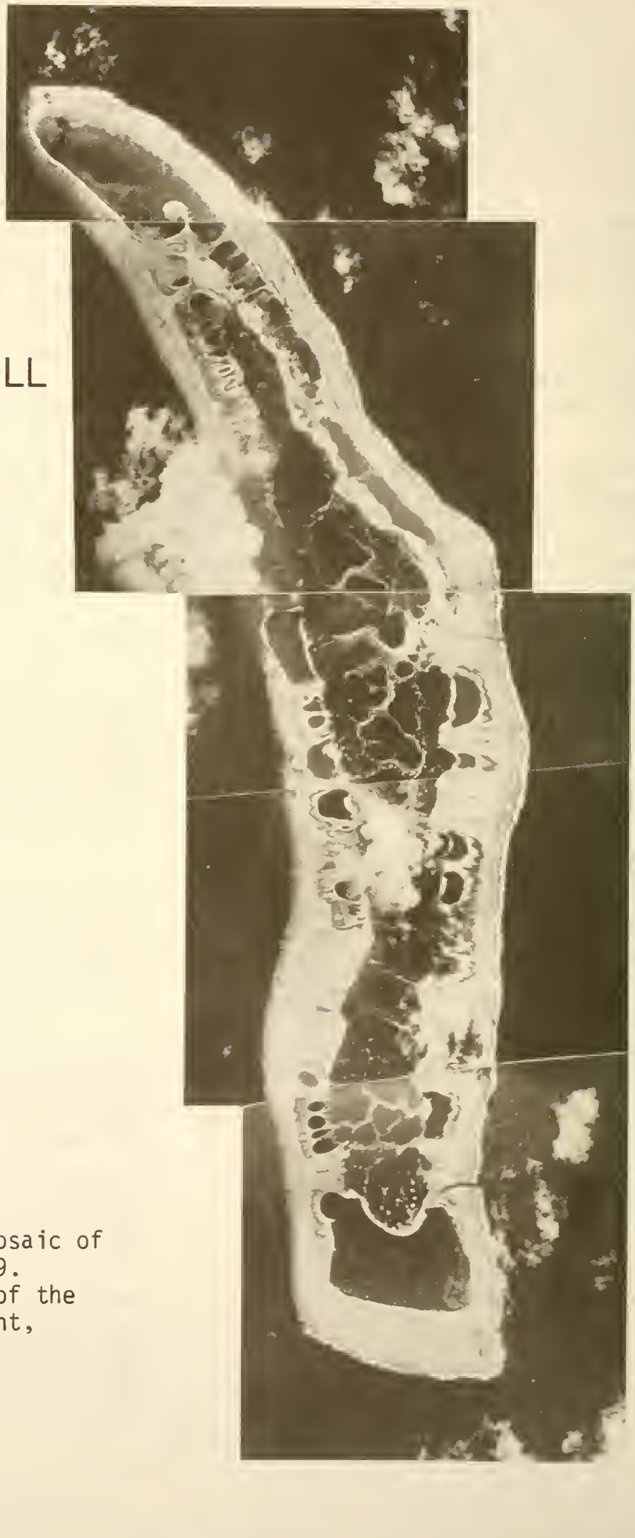
ACKNOWLEDGMENT

The Atoll Research Bulletin is issued by the Smithsonian Institution to provide an outlet for information on the biota of tropical islands and reefs and on the environment that supports the biota. The Bulletin is supported by the National Museum of Natural History and is produced by the Smithsonian Press. This special issue is financed and distributed with funds from the National Biological Survey and from Atoll Research Bulletin readers.

The Bulletin was founded in 1951 and the first 117 numbers were issued by the Pacific Science Board, National Academy of Sciences, with financial support from the Office of Naval Research. Its pages were devoted largely to reports resulting from the Pacific Science Board's Coral Atoll Program.

Articles submitted for publication in the Atoll Research Bulletin should be original papers in a format similar to that found in recent issues of the Bulletin. First drafts of manuscripts should be typewritten double spaced and can be sent to any of the editors. After the manuscript has been reviewed and accepted, the author will be provided with a page format with which to prepare a single-spaced camera-ready copy of the manuscript.

CAROLINE ATOLL



Frontispiece. Airphoto mosaic of
Caroline Atoll, RNZAF 6569.
Reproduced by permission of the
Lands and Survey Department,
New Zealand.

Preface

This study is primarily a result of the research efforts of the First Joint US-USSR Central Pacific Expedition (Line and Phoenix Groups, Gilbert Islands, Micronesia, inland Philippine seas, and South China Sea). In turn, it was part of the second phase of a longer expedition from Vladivostok, USSR, via Dutch Harbor, Unalaska, Aleutian Islands to Singapore (26 July to 31 October 1988), which included oceanographic and seabird investigations in arctic, temperate and tropical waters.

The authors boarded the Soviet Research Vessel (R/V) *Akademik Korolev* (7,000 tons, 124 m in length) in Hilo, Hawaii, bound for Christmas Island (02°N, 157°W), where we picked up Katino Teeb'aki, a conservation officer for the Republic of Kiribati, who represented his government and helped our land-based research efforts. The next stop was at little-known Caroline Atoll (10°S, 150°W), on the southeastern edge of the Line Group. After landing on Caroline on 22 September, we camped in 2 locations for 7 nights, surveying the terrestrial plants and animals on all 39 islets.

A small amount of data was also added from 2 visits of the ICBP (International Council for Bird Preservation) 1990 Line and Phoenix Islands Expedition (2 March to 31 May 1990) aboard the New Zealand cutter, R/V *Te Manu* (7.5 tons, 10.5 m).

Caroline is a relatively untouched atoll with its native plant communities nearly intact on all but 3 islets, and teeming seabird communities that, collectively, are second in the Line Group only to Christmas Island (Kiribati) in diversity. For several historical reasons, the natural values of this spectacular blend of marine and terrestrial resources have been overlooked.

These papers attempt to synthesize what is known about the atoll. We have analyzed our own data in the light of several important historical accounts from the "gray literature," including records from early navigators, guano and copra enterprises, incidental travellers, and a solar eclipse expedition, some of which were critical to understanding the present situation. We include a new map of the atoll (the first for over 100 years, with additional islets and shoals), the first descriptions of physiography, plant communities and floristics, and individual islets, the first published climatic records and the first photograph and measurements of its intact, ancient Tuamotuan *marae* (religious site). We also report 14 new species records (5 plants, 2 seabirds, 1 shorebird, 1 land bird, 3 lizards, 1 possible turtle, 1 marine mammal).

In Part I we have attempted to reconstruct and describe Caroline's botanical history, including ecological succession, species-area relationships, and the remarkable recovery of its indigenous forests (*Pisonia grandis*, *Cordia subcordata*, *Tournefortia argentea*). In Part II, discussions of seabirds and coconut crabs are rounded off by bringing to light current threats to the atoll's well-being, and ongoing conservation efforts.

An expedition of this magnitude entailed the help of many people, and it gives us great pleasure to thank them. We are indebted to Hal O'Connor and Randy Perry, Patuxent Wildlife Research Center, for making possible our participation. Steve Kohl, FWS Office of International Affairs, and Terry Whitledge aided immensely by handling innumerable details with their Soviet colleagues. Members of the Fish and Wildlife Service Mauna Loa Field Station, especially Jim Jacobi, Julie Williams, Jack Jeffrey, and Martha Moore, provided welcomed logistical support in Hilo, and Paul Sykes willingly shouldered additional responsibility that freed CBK to join the expedition.

On the Soviet side, we thank Professor Alla V. Tsyban, Chief Scientist of the expedition, for extensive help and friendship during the voyage, Capt. Oleg Rostovtsev, Yevgeniy Nelepov, Yuri Volodkovich, and the crew for ship-to-shore transport, and Svetlana Petrovskaya and Valeriya Vronskaya for translation. We thank Greg Smith and Chuck Stafford for Zodiac transport at Caroline.

Katino Teeb'aki shared the transect work; his skills at obtaining and opening coconuts often energized us. Abureti Takaio, former Minister for the Line and Phoenix Groups, permitted us to work on Caroline and, with the residents of Christmas Island, arranged a memorable evening of dancing and food, despite the fact that their last supply ship was 10 months previous.

Financial assistance for the 1988 expedition and for writing the manuscript was provided by the U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center, and the Natural Environment and Climate Monitoring Laboratory, Goskomgidromet USSR.

Grateful thanks are extended to Derral Herbst for identifying and preparing plant specimens (deposited in the B. P. Bishop Museum, Honolulu, Hawaii) and George Zug for identifying lizards (deposited in the U.S. National Museum). The Royal New Zealand Air Force supplied the aerial photos. Roger Clapp, Ray Fosberg, Gene Helfman, Ernst Reese, and David Stoddart shared unpublished manuscripts and other information. We are grateful to Lynda Garrett and Wanda Manning (Patuxent Wildlife Research Center Library, Laurel, Maryland) for digging out obscure historical references. Harry Maude of the Australian National University supplied plantation records and other literature indispensable in understanding Caroline's past and present ecology. The libraries and herbarium at the University of Georgia were also helpful. Thanks to Dorothy Schaumberg, Mary Lea Shane Archives of the Lick Observatory, University of California, Santa Cruz, for the letter from W. W. Campbell (1908) and extracts from E. B. Campbell's unpublished diary (1908). We especially thank Bonnie Fancher for her efficiency, enthusiasm, and hard work, often late at night and on weekends, on the computer and in other clerical matters in preparing the monograph. The manuscript has benefitted from reviews by Roger Clapp, Ron and Anne Falconer, Ray Fosberg, Ian Macintyre, Mark Merlin, Pat Roscigno, Betty Ann Schreiber, Fred Sibley, Thomas Spencer, Terry Whitledge, and Stephen Zeeman.

AKK, as co-leader of the ICBP 1990 expedition, expresses much gratitude to Christoff Imboden, International Council for Bird Preservation, Cambridge, U.K., and co-leader/expedition initiator Martin Garnett, for sharing finances. Thanks also to Annie Garnett, John Phillips, and Mark Linsley for help with field work, and to Alve Henricson for his sailing skills. The expedition would not have been successful without the dedication of Capt. Graham Wragg, skipper/owner of *Te Manu*, who transported us 7,585 km in the central Pacific (including 2 visits to Caroline), helped with field work, shared finances, and whose competence and consideration in many areas eased the varied hardships associated with 3 months at sea in a 10.5-m ketch. Thanks also to Sandy Bartle, National Museum, Wellington, New Zealand, for support, and to Scott Miller for providing insect vials, and David Preston for preparing and depositing insect specimens in the Bishop Museum, Hawaii.

On remote Caroline, the Falconers were exceptionally hospitable hosts, helping us with field work during, and after, the expedition. Special thanks go to 7-year old Alexandre, who discovered the first Blue-gray Noddy nest for the island and 3 new plant records. French Polynesian residents who assisted in various ways include Jacques Florence, Les and Gloria Whiteley, Rick Steger, Michael Poole, Jean Roudeix, and friends who supplied us with fresh provisions.

We particularly thank those who have aided us in follow-up conservation efforts: Kelvin Taketa, Jim Maragos and staff of The Nature Conservancy-Hawaii, Christoff Imboden and staff at ICBP, Alex du Prel, Jean-Michael Chazine, Philippe Siu, George Monet, Graham Wragg, Papeete Customs, George Ariyoshi, Kaiarake Taburuea of the Ministry of the Line and Phoenix Islands, John Claasen, New Zealand High Commission, Tarawa, and Peter Timeon, Ministry of Foreign Affairs, Tarawa.

AKK, CBK, DHE

ATOLL RESEARCH BULLETIN

NO. 397

PART I. HISTORY, PHYSIOGRAPHY, BOTANY, AND ISLE DESCRIPTIONS

BY

ANGELA K. KEPLER AND CAMERON B. KEPLER

ISSUED BY
NATIONAL MUSEUM OF NATURAL HISTORY
SMITHSONIAN INSTITUTION
WASHINGTON, D.C., U.S.A.
FEBRUARY 1994

Table of Contents

List of Figures

List of Plates

List of Tables

PART I. HISTORY, PHYSIOGRAPHY, BOTANY, AND ISLET DESCRIPTIONS

BY

ANGELA K. KEPLER[1] AND CAMERON B. KEPLER[2]

ABSTRACT

Caroline Atoll (Frontispiece) is situated at 10°00'S latitude and 150°13'W longitude in the south-central Pacific Ocean. Caroline is the southeasternmost of the Southern Line Islands, a group of 3 islands which also includes Vostok and Flint, lying 230 km to its west and southwest, respectively. Although archaeologically and geographically within Polynesia, Caroline is owned by the Republic of Kiribati (formerly Gilbert Islands).

Caroline, 9.7 km long, 2.3 km wide at its widest point, and 26.9 km in circumference, is a crescentic coral ring with 39 islets (motus) centered on a continuous reef enclosing a relatively shallow lagoon. Its total land area above high water is 399 ha., with motus ranging in size from 0.02 to 107.5 ha. Motus extend along 55% of the reef perimeter. The closed lagoon, rich in marine life, contains a maze of patch reefs and impeccably clear water.

The atoll, uninhabited, was "discovered" by de Quiros in 1606. Although traces of an ancient Tuamotuan culture still exist, the atoll apparently never supported a long-term permanent population and has been less affected by man than most Pacific islands. Its European history includes guano export, a multinational expedition to observe a solar eclipse, and copra production. It has been uninhabited since the early 1930s (a factor contributing to its relatively undisturbed ecology), except for the presence of one family from 1987 to 1991. The primary factors responsible for its lack of permanent settlement are remoteness, apparent absence of usable ground water, repeated failure of its coconut plantations (diseases, destruction by coconut crabs, rats and seabirds, smothering by vines), absence of a passage into the lagoon, and a paucity of safe boat anchorages.

Until the 1988 USSR/USA expedition, only an 1883 chart was available, which named 7 islets. We drafted an accurate map based on field work and recent aerial photographs, naming 32 previously unnamed islets, 4 islet groups and an inlet. During 8 days' intensive field work, we surveyed 38 islets, walking 33 km in systematic cross-islet transects and around islet perimeters. This paper presents much new data on Caroline from 3 visits in 1988 and 1990, and attempts to summarize, expand and synthesize previous information in the light of new findings.

1 400 Snapfinger Drive, Athens, Georgia, 30605, USA

2 National Biological Survey, School of Forest Resources
The University of Georgia, Athens, Georgia, 30602, USA

Manuscript received 8 April 1991; revised 26 October 1993

Soils, principally of coral, mollusc, and algal origin, are categorized into 5 types, from barren coral rubble to rubble mixed with humus and guano. Caroline provides an excellent example of soil development through different age and size classes of motus.

Preliminary descriptions of the atoll's reef, motu and lagoon morphology are given, including the background geological setting of the Line Islands. Physiographic features include inland upraised reefs (*feo*) and deep sand deposits, coalesced islets, exposed older reefs, lithified beachrock, a conglomerate platform, a "perched lagoon," a nonfunctional *hoa*, and changes in motu size and shape during the past century.

Caroline's lush vegetation supports 26 species of plants organized into 7 plant communities, 6 natural and one anthropogenic. The atoll-wide distribution of each plant species is mapped. Plant species (including 5 new island records) and communities are detailed, emphasizing the atoll's past history. The atoll's insular flora, although impoverished due to its geographical location, is *89% indigenous* (possibly 92%), an extremely high figure for anywhere in the world. Although Caroline's motus are covered with extensive tracts of indigenous plant communities, the *Pisonia grandis* forests, up to 21 m high and covering 22% of the woodlands, are particularly notable as they constitute some of the best groves left in the Pacific. *Pisonia* is treated in detail, including data on rapid recovery and growth rates during the past 70-odd years. *Tournefortia argentea* (43% of the woodlands) is abundant, and *Cordia subcordata*, becoming quite rare elsewhere, occurs on 21 motus (54%). *Cocos* is present, but only dominates one islet; 22 islets harbor wholly indigenous vegetation.

Motus of varied age and size classes provide excellent examples of substrate and vegetation development, accompanied by an increasing diversity of bird life. On account of its relatively low human disturbance and rapid forest recovery to a more natural state, especially since 1920, Caroline is one of the few Pacific islands that is truly an "outdoor ecological laboratory": many motus have recovered so remarkably they are almost indistinguishable from those that have remained pristine, while others are in different stages of recovery resulting from varied management (or non-management) practices. Exotic plant species are very few: ancient Polynesian-introduced (*Cocos*, possibly *Pandanus*), recent Polynesian-introduced (*Hibiscus tiliaceus, Thespesia populnea, Tacca leontopetaloides, Ximenia americana*), 20th century exotics (*Phyllanthus amarus*, in one small area). Some garden species, cultivated from 1987-1990 have an uncertain future and are not treated as part of the atoll's viable flora.

An analysis of ecological succession on motus of increasing size reveals that by the time a motu reaches 0.8 ha in size, all the natural plant communities, most plant species, and most species of seabirds are present. This is in striking contrast to species-area relationships on inhabited atolls with more introduced plant species, for example Kapingamarangi.

Each motu is individually mapped and the main physiographic features, known history, vegetation patterns (including species-area relationships), seabirds, and miscellaneous biota (coconut crabs, rats, lizards) are detailed. Appendices provide weather data and describe the practicalities of anchoring boats, landing, and moving small boats around the reefs and lagoon.

Permanent protection of Caroline is currently underway as The Nature Conservancy of Hawaii negotiates with the government of Kiribati for a Southern Line Islands Wildlife Preserve, which includes Caroline, Vostok and Flint.

A. INTRODUCTION

Caroline Atoll[1] (Frontispiece; Figs. 1, 2) is a small, low coral island situated at 10°00'S latitude, 150°13'W longitude in the south-central Pacific Ocean. Its maximum height is less than 3 m above MSL. It lies 2,800 km south of Hawaii, 830 km north of Tahiti, and 1,030 km west of the Marquesas Islands. Its nearest neighbors are Vostok and Flint, 230 km to the west and southwest, respectively.

Recent measurements by the ICBP 1990 Line and Phoenix Islands Expedition, using a compact satellite navigation computer "Magellan" NAV 1000, indicate that the atoll lies one nautical mile east of its previously charted longitude position, 150°14'W. Its range of coordinates are: 09°54' to 10°01'S latitude, 150°12' to 150°14' W longitude. The given coordinates, 10°00'S and 150°13'W, intersect in the lower lagoon just west of the "blind passage."

Although archaeologically and geographically within Polynesia, the Line Group was uninhabited when discovered by Europeans; its islands were variously claimed by the United States and England. With the exception of U.S.-owned Jarvis, Palmyra, Johnston and Kingman Reef, all are now governed by the Republic of Kiribati (formerly Gilbert Islands).

Caroline, 9.7 km long by 2.3 km wide at its widest point, is a crescentic coral ring 26.9 km in circumference. Composed of 39 islets (Fig. 2, Table 9) and three incipient islets, it is centered on a continuous reef flat, submerged at high tide, that encloses a relatively shallow lagoon. Most are well-wooded, but 4 tiny ones, less than 0.1 ha in size, are scarcely more than coral rubble piled on the reef, supporting sparse patches of *Tournefortia* and *Heliotropium*. One islet, Noddy Rock (Pl. 18), is a vestige of a former reef segment. The total land area above high water is 399 ha. One of the oceanic islands contributing to Darwin's theory of atoll formation (Darwin 1842), its

---

[1]Caroline Atoll is neither physically, geographically, nor politically associated with the Caroline Islands, now part of the Federated States of Micronesia, more than 6,000 km to the northwest. Because of this confusion, we use the name "Caroline Atoll" instead of "Caroline Island."

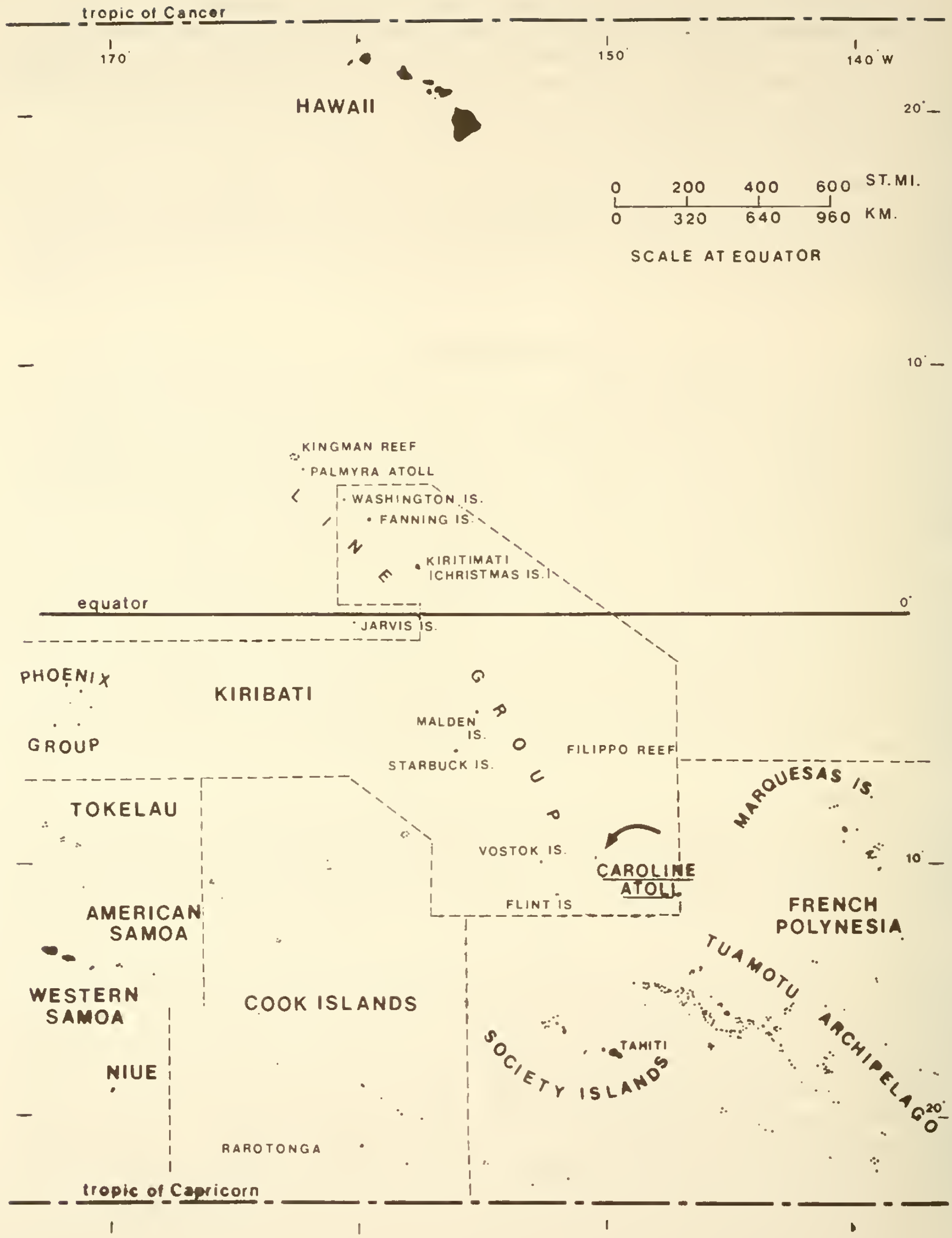


Figure 1. Line Islands: geographic location in the Pacific Ocean. After map by the Hawaii Geographic Society (1981).

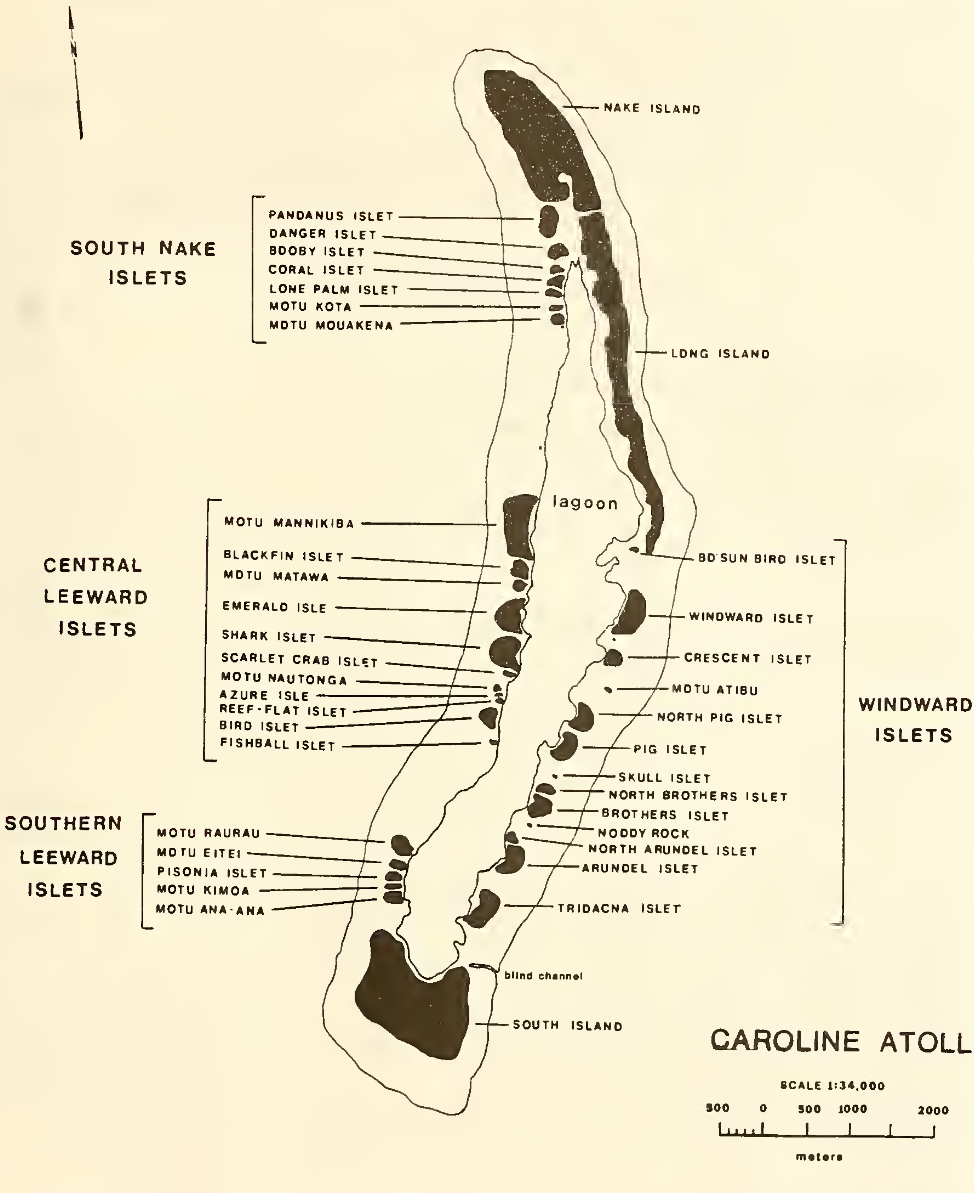


Figure 2. Caroline Atoll, Republic of Kiribati, with newly-named islets. Based on photos by the Royal New Zealand Air Force (RNZAF 1986).

geology, soils, climate, and vegetation are typical of low latitude atolls and are relatively unmodified by man.

This paper presents much new data on Caroline from 3 visits in 1988 (September) and 1990 (March, May) and attempts to summarize, expand and synthesize widely scattered information in the light of new findings. The only significant previous biological information on Caroline was from the Smithsonian's Pacific Island Biological Survey Program's 2-day visit in 1965 (Clapp & Sibley 1971).

B. HISTORY OF CAROLINE ATOLL

Pre-European History: Tuamotuan Period

Centuries before Europeans encountered Caroline, the atoll was inhabited by Polynesians. No oral traditions of this occupation are known, but evidence of former habitation was evident when de Quiros found the atoll in 1606. He noted "an old canoe, lying on her side," and a small grove of coconuts planted on South Island (Bennett 1840, Markham 1904).

No further clues were unearthed until Messrs. Brown, Brothers, and Arundel exposed about 50 ancient Polynesian sites in the 1870s while digging for guano (Holden 1884, Arundel 1890). Polynesian inhabitants at that time called them "marai" (*marae*). Arundel photographed and drew plans of them (Fig. 3): depicted are a platform of coral and conglomerate rock, surrounded by 10 smaller slabs resembling gravestones, all arranged in a rectangular plan. Although the largest 2 were marked as "graves" on Arundel's 1883 map (Fig. 4), no bones, ashes or human remains were found. Their findings were later identified as Tuamotuan *marae* (Emory 1947). *Marae*, according to ancient belief, "bound the ancestral spirits and gods of the kindred to the land, putting it under their eternal guardianship" (Emory 1947). The largest *marae* was on northwest Nake Island, and a smaller one was found near the southern tip of Long Island. Both locations conform to such prerequisites for building *marae* as nearby shorelines and birds (see Sect. H.1), which Tuamotuans believed housed divine spirits (Emory 1947, p. 123). Although AKK, G. Wragg and R. Falconer located, photographed (Pl. 36), and measured these in 1990 (A. Kepler 1990d), no field work by archaeologists has been conducted. Our data and numerous photographs have been sent to Dr. Jeff Irwin, Auckland University, New Zealand.

Post-European History: 17th to 19th Centuries

On 21 February 1606, the Portuguese explorer Pedro Fernandez de Quiros, employed by Spain, "discovered" Caroline Atoll (Markham 1904, Stevens & Barwick 1930), naming it San Bernardo. Despite its remoteness, Caroline was encountered early in Pacific history, long before Tahiti, Rarotonga, and Hawaii. This is possibly due to its location, for early navigators tended to sail due west from South

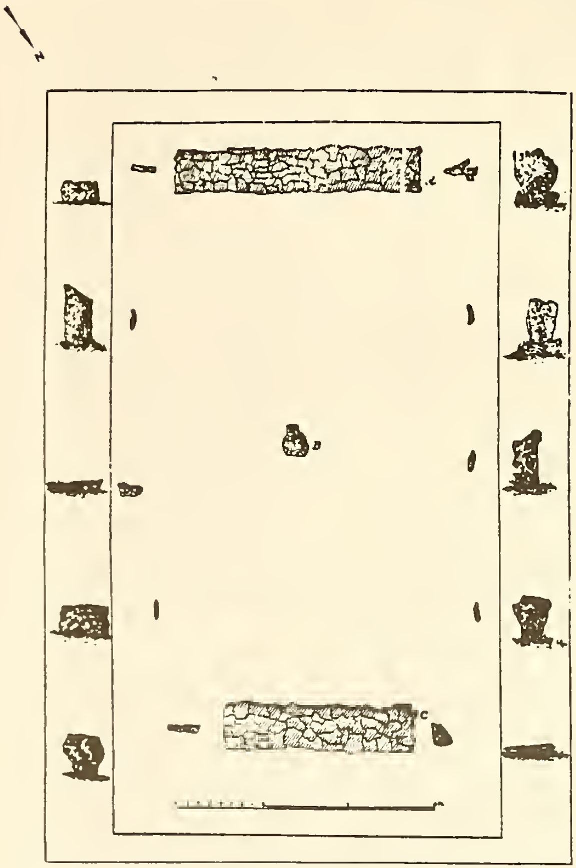


Figure 3. Main *marae* on Nake Island, Caroline Atoll, based on a plan published by the Solar Eclipse Expedition (Holden & Qualtrough 1884). Figures in the margins show side views of the peripheral blocks shown in the plan. The 2 end walls are represented in ground plan.

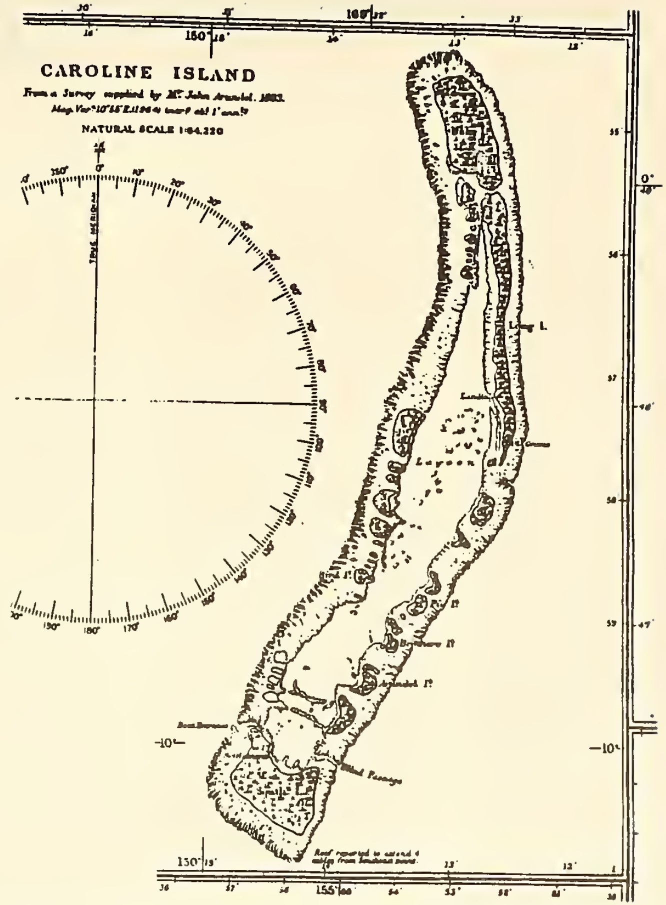


Figure 4. Caroline Atoll, as surveyed by John Arundel, 1883. This is still the standard hydrological chart for the atoll (Admiralty Chart No. 979). Though quite accurate, it has never been used in scientific publications.

America along lines of latitude, and 10°S was an obvious choice. De Quiros, the last adventurer in the Spanish age of discovery, was leading his second major trans-Pacific expedition with 3 ships and 150 men obsessed with finding the fabled "Terra Australis Incognito." The descriptions of Caroline by his crew, although at variance with one another, still apply today (Pl. 1). Their first at-sea impression was that it was "divided into four or five hummocks, and all the rest submerged. Its circumference appeared to be ten leagues" (Markham 1904). After landing, they found that

> "There was a great number of fish inshore, and, owing to the water being very shallow, they were killed with swords and poles. There were great numbers of lobster and crawfish, and other kinds of marine animals. They found a great quantity of cocoa-nuts in a heap at the foot of the palm trees, many large, and of different sizes. There were a great quantity of sea birds of several kinds, and so importunate that they seemed to want to attack the men. We took plenty of all these things...It seemed to the Captain that on an island where there are so many trees there could not fail to be water" (Markham 1904).

Fresh water was crucial to de Quiros and his crew, who were suffering from lack of food and water. Despite their efforts, however, they failed to obtain water. Disappointed and lacking energy, they continued their voyage the following morning. Their demoralized state may explain one statement that Caroline "consisted of twenty-two islets, uninhabited and without water, trees or scrub for wood."

In 1795, Capt. W. R. Broughton, on the British sloop *Providence*, rediscovered and named the atoll while voyaging from Tahiti to Hawaii (Broughton 1804):

> "The southern extremity was the highest part, covered with trees, most probably cocoa-nut from their appearance, as they stood in detached clumps along the shore. The island... appeared to be low, and covered with trees, and if I am right in its estimated distance, its length will be about five miles in a north and south direction. I named it Carolina Island in compliment to the daughter of Sir P. Stephens of the Admiralty."

Because early navigation techniques and communication were far less sophisticated than today, especially with regards to longitude, Caroline was sighted or "discovered" by several more explorers who were unsure of its identity. By 1821 the atoll had amassed a collection of coordinates and names: San Bernardo, Island of Fish, Thornton, Hurst's, Clark's, Independence, and Carolina (which later became Caroline). Some navigators equated Caroline with an island named "San Bernardo" by the Spanish explorer Mendaña in 1595. "San Bernardo" has recently been verified as Puka-Puka, northern Cook Islands (Maude 1968).

The best early description of the atoll comes from an 1835 visit by F. D. Bennett, who was reasonably well versed in natural history (Bennett 1840). He noted that the islets then, as now, were "covered with verdure...surprisingly luxuriant, when compared to the arid soil it covers." Although Bennett had visited many atolls, he was particularly impressed with the quality of Caroline's coral reefs. His party observed "rats of a red-brown color" and various birds but no reptiles (Pt. II). Although he discusses "land lobsters (*Coenobita* species)," no mention is made of coconut crabs (*Birgus latro*): perhaps the latter were lumped with the former.

First Occupation: The existence of 2 small coconut groves on Caroline prompted 2 British entrepreneurs, representing the Tahitian firm Collie and Lucett, to establish a stock raising venture there in 1846. This first known settlement was located adjacent to the main coconut grove on the northwest peninsula of South Island; a smaller grove evidently existed "on the south-south-west side" of the same island (Lucett 1851). Tahitian laborers tended pigs, hens, turkeys, and grew many food plants, including pumpkins and melons. They dried and salted fish, planted coconuts, and extracted coconut oil (Maude 1942, Garnett 1983), and were evidently still there in May 1852 (Ellsworth 1990).

Political Annexation: Though inhabited in prehistory by Tuamotuans, officially "discovered" by the Spanish, and visited by British, French, and American ships, it took centuries for Caroline to acquire a political identity. It was formally annexed to Britain by Captain Nares, R. N., who arrived in the H.M.S. *Reindeer* in 1868, finding 27 residents.

Caroline was under the control of various merchants in the late 19th century: Lionel Brown, Captain Brothers, and later John Arundel, a well-known businessman, trader, and guano merchant in the Pacific. Arundel's 1883 map (Fig. 4) of Caroline is the only reasonably correct chart published prior to this paper.

The Guano Era

Though bonded under the American Guano Act in 1860, no phosphate was dug on Caroline until Arundel was granted a 7-year license in 1874. A few months earlier, a set of moorings were laid off the lee side of South Island, allowing ships of up to 1,000 tons to lie safely during trade wind weather. Guano was the only successful business venture at Caroline: approximately 10,000 tons were shipped to California and Australia between 1873 and 1895, when supplies became exhausted (Young ca. 1922). We have no direct information on which islands were mined except South and Nake. We strongly suspect that Tridacna, Arundel, Mannikiba, and perhaps others also yielded guano. The tonnage extracted from Caroline was small compared to that from dry, barren, more northerly islands with little vegetation, where populations of Sooty Terns, an important guano species (Hague 1862), number in the millions.

Solar Eclipse Expedition

In 1883 Caroline received international publicity when astronomers calculated that it lay directly under the path of a pending solar eclipse. Three parties of astronomers (American, British, French) arrived in the U.S.S. *Hartford* and set up camp on South Island, making detailed observations of this celestial event (Pl. 2). At that time Caroline was more famous, and housed more people, than before or since: 7 "natives," scientists and crewmen totalled 51 occupants. Legacies from former inhabitants included 3 houses (Pl. 3), 2 sheds, 3 huts on smaller motus, nautical flotsam and jetsam, and 2 shallow wells. To this they added tents, observatory frames, a marble slab, flagpole, and brick "piers" for their telescopes, most of which remained temporarily as technological litter.

This expedition (Dixon 1884, Holden 1884, Holden & Qualtrough 1884, Trelease 1884, Young 1884) also marked the first attempt to describe the topography, climate, flora, and fauna of the atoll. Drawings included an artist's rendering of Caroline, "settlement" map (Pl. 5) and views along South Island's lagoon shore (Pls. 6, 7). An atoll map was drafted but is highly inaccurate. Their biological observations were sketchy (Dixon 1884, Butler & Strecker 1884). For example, Dixon, the zoologist, listed such organisms as "shrimp," "hermit crabs," "gnat." As with Bennett, there was no mention of coconut crabs, even though they were evidently abundant on South Island in 1910 (Young ca. 1922).

The Late 19th and 20th Centuries

In 1875, C. D. Voy, a naturalist from California, visited Caroline, collecting molluscs (Pilsbry & Vanatta 1905a, b) and fish (Fowler 1901).

In 1885, Arundel began to clear land and plant coconuts, but his planned copra industry was unsuccessful. In 1897 he sold his business to the Pacific Islands Company, Ltd., which also failed. The plantations suffered from disease and poor vitality, coconut crabs chewed on seedlings, seabirds destroyed the developing nuts, *Ipomoea* vines strangled young trees, and populations of Polynesian rats apparently exploded, causing further damage to both intact nuts and drying copra (Young ca. 1922, Maude ca. 1938, 1942). By 1904, when the H.M.S. *Icarus* visited Caroline, only 6 Polynesians lived there. A few months later they were repatriated to Niue, and Caroline remained uninhabited until 1916, when a new effort was made to develop the coconut plantation by Messrs. S. R. Maxwell and Co., Ltd.

During the uninhabited years, South Island's vegetation and wildlife began to recover from the earlier forest felling (Pls. 2-6). When Mr. J. L. Young, then managing director for S. R. Maxwell and Co., Ltd. (Young ca. 1922), visited the atoll in July 1910, he described it as a wilderness, teeming with Sooty Terns, fish and coconut crabs:

"The ground was covered with nests of seabirds which latter rose like a cloud when disturbed: the noise of their shrieking was so great that one had to shout to enable oneself to be heard by his companions. Hundreds of great Coconut Crabs were seen: 40 large ones were caught by the crew of the schooner in an hour. The reef and the lagoon swarmed with fish and small sharks."

From 1916 to 1929, Caroline was altered more than before or since. All the available land on South was deforested to make room for thousands of palms, and laborers demolished huge numbers of coconut crabs and seabirds (Young ca. 1922). In addition, coconuts were planted on all of the main windward islets, southern Nake, and on Mannikiba. (The windward islets recovered their forests remarkably quickly, see Sect. G). Plantation workers in great part lived off the land, feasting on fresh fish, seabirds, seabird eggs, turtles, and coconut crabs. Most of the leeward islets escaped alteration for plantations.

Copra exports averaged around 14 tons per year from 1929 to 1934, after which the company ran into debt. Concurrently, the French government forbade further recruitment from Tahiti; by 1936 only a few families were left (N.I.D. 1943). In 1941 the atoll carried a price tag of 600 English pounds (Maude, pers. comm.), but was never purchased.

Occupation leases for Caroline were cancelled in 1943, after which the British Western Pacific High Commission repossessed it (Maude 1953). However, new "queen's leases" were granted to M. P. A. Bainbridge of Papeete, Tahiti, 1951-1964 (Nicholson & Douglas 1969), then to Capt. Omer Darr of Moorea, French Polynesia, from 1964 to 1989. When the British granted independence to the Gilbert and Ellice Islands in 1979, a new country, the Republic of Kiribati, assumed ownership of Caroline, along with most of the Line and Phoenix Islands.

Apart from occasional parties of Tahitians cutting copra and a shipwrecked sailor in the early 1980s, the atoll remained uninhabited for over 50 years. During this time Caroline's vegetation and wildlife recovered to such an extent that, were it not for unpublished manuscripts (Maude ca. 1938, ca. 1942, and no date, Young ca. 1922) and comparisons with Flint and Vostok (St. John & Fosberg 1937, A. Kepler 1990b-d, and Kepler, in prep.), we would have been unaware of the extent of previous human interference or of the rapidity of forest recovery (the fact that 60% of Caroline's motus harbored wholly indigenous vegetation, and the presence of one small patch of one exotic plant aside from a few standard Polynesian-introduced plants, seemed to indicate a relatively pristine atoll).

In 1987, the Office de la Recherche Scientifique et Technique Outre-Mer (ORSTOM, a French scientific research agency) was requested by the Kiribati government to conduct a short study at Caroline on the feasibility of pearl-shell culture (G. Monet, pers. comm.). Their results concluded that the atoll would be inappropriate for this type of development.

Also from 1987 to 1991, a Scotsman, Ron Falconer, his French wife Anne, and 2 small children settled on Caroline. From October 1989 to November 1990 a new lease was under negotiation by Felix Urima, a French businessman, who planned to blast a channel through the reef, construct an airstrip, build a small hotel, cut timber, and engage in various commercial ventures including fishing, a turtle farm and pearl-shell culture. In April 1990, Urima's workers began commercial fishing, killing turtles and coconut crabs, and clearing land (A. Kepler 1990a). This was a major new insult to the atoll which, in spite of its long history of intermittent human occupation, remains to this day "possibly one of the least spoiled of true atolls in the Pacific" (Stoddart 1976). Reports from our expeditions to Caroline (Kepler & Kepler 1989, A. Kepler 1990a and d) resulted in the short-lived cancellation of Urima's tentative lease in November 1990 by the government of Kiribati. As of this writing, Urima has returned to unlimited fishing of Caroline's reefs. Since 1988, conservation efforts have been underway for Caroline to become part of a triple-island wildlife preserve with Vostok and Flint (Pt. II, Sect. G).

20th Century Scientific Studies

In June 1965, a field party from the Smithsonian Institution's Pacific Ocean Biological Survey Program (POBSP) visited Caroline for 2 days (Clapp & Sibley 1971a). Their survey and specimens added much to the previous botanical and ornithological knowledge of the island. Other quick visits were made by Gilbert and Ellice Island officials and Drs. H. & H. Grossman, ornithologists from Germany, and Mr. W. Cooke, a graduate student in corals from the University of Hawaii, comprising the Line Islands Expedition on 9-10 September 1974, and by Roger Perry, then Wildlife Warden of the Line and Phoenix Islands, on 12-13 November 1977, from which no reports can be found other than a short popular account of the Southern Line Islands (Perry 1978).

In 1990, AKK also visited Caroline twice with the ICBP 1990 Line and Phoenix Islands Expedition (A. Kepler 1990d). These visits were primarily to discuss conservation matters with the Falconers; introduce Caroline to Dr. and Mrs. M. Garnett, representatives from ICBP; confirm the illegal taking of fish, turtles, and coconut crabs; collect invertebrates; and fill in gaps from the 1988 expedition.

C. METHODS

Field Techniques

From 22-29 September 1988, Drs. A. K. Kepler, C. B. Kepler, D. H. Ellis (U.S.A.) and Mr. Katino Teeb'aki (Republic of Kiribati) surveyed all 39 motus at Caroline Atoll (Fig. 2), gathering detailed information on plants, seabirds, land birds, mammals, reptiles, coconut crabs, and human disturbance. Some incidental data have been added from the 2 visits in 1990 (10-13 March, 18-28 May) by Dr. A. K. Kepler, Capt. G. Wragg, A. Garnett, M. Linsley, J. Phillips (March), and Dr. M. Garnett (May).

Prior to the first expedition, a series of transects and known botanical information were mapped to ensure that 5% of each motu was sampled, and to maximize our chances of encountering all known plant species. Transects on the 3 larger motus were spaced approximately 400 m apart and, with one exception, were perpendicular to the long axes of each islet (Tr. 3 on Nake extended first from east to west, then ran south parallel to the west coast). On motus longer than 400 m, we used 2 transects. Transects on the smaller motus passed through their widest points. Their lengths ranged from 77 m (Azure) to 2,000 m (Tr. 3, Nake).

Considerable modifications were required when we realized that all previous maps (Figs. 4-7) were incorrect. We redrew the transects on Arundel's 1883 map (Figs. 4, 8), secured just prior to the expedition. On South Island, due to impenetrable draperies of *Ipomoea* vines, Transect 3 was omitted, Transect 5 ran only from the lagoon south to the *Ipomoea* curtain (75 m), and Transects 4 and 6 ran north and south until we reached an impasse (Pl. 8).

Compass headings were determined by the configuration of each island. Beginning at high water mark, all distances (islet dimensions, widths of reef flats and substrates, and plant communities) were measured using hip chains with biodegradable cotton thread. These parameters were later checked against aerial photographs in stereoscopic pairs (RNZAF 1986), which provided 3-dimensional overviews of most islets. Vegetation maps, reef and islet areas, and areas of plant communities were derived by outlining on graph paper, enlarging, then counting dots.

Data were collected in a 30 m swath along each transect (15 m to each side) and recorded on field forms. Within each plant community we took photographs, assessed the relative abundance of each plant species (see Sect. E), measured notable trees, and recorded plant community width, plants collected, and substrate type. We also estimated the maximum height of the dominant vegetation and percentage of ground area covered by each species. Data on seabirds, land birds, reptiles, mammals and coconut crabs is reported in Part II.

In addition to the linear transects, an additional 19,300 m of perimeter surveys were conducted on 21 islets (Fig. 9). The combined distance for linear and perimeter transects was 32.6 km. Seven tiny islets (Noddy Rock, Skull, Atibu, Bo'sun Bird, Coral, Reef-flat, Fishball) were surveyed completely.

In 1988 we camped on the atoll for 7 nights, establishing base camps (Fig. 8; Pl. 9) on the northwest point of South (22-24 September) and southwest Long (25-28 September). We relocated camps using a Zodiac with outboard motor, and an inflatable Sevylor canoe. All transects were surveyed during daylight hours, beginning at dawn. Walking the interislet channels was relatively easy at low tide, but became

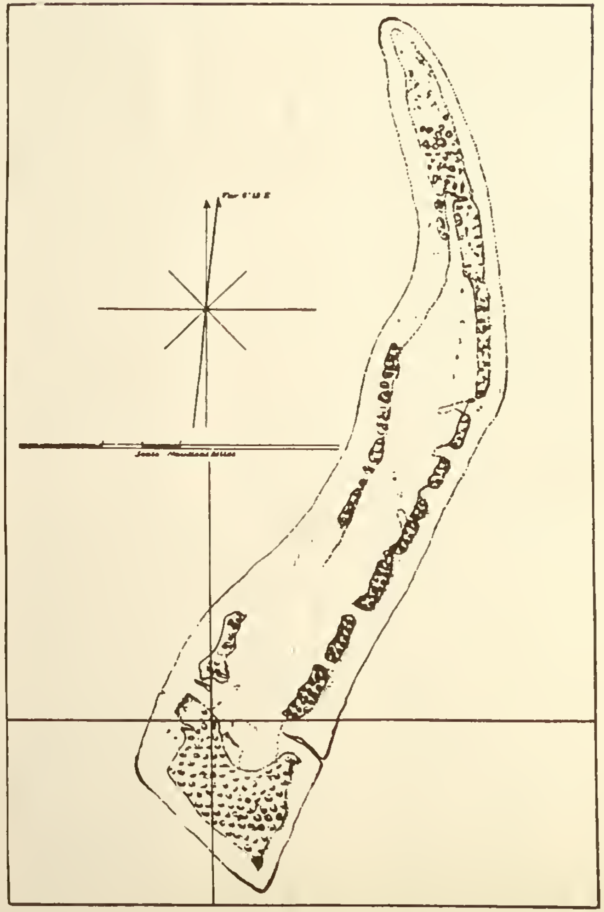


Figure 5. Caroline Atoll, as charted by the Solar Eclipse Party, also in 1883 (Holden & Qualtrough 1884).

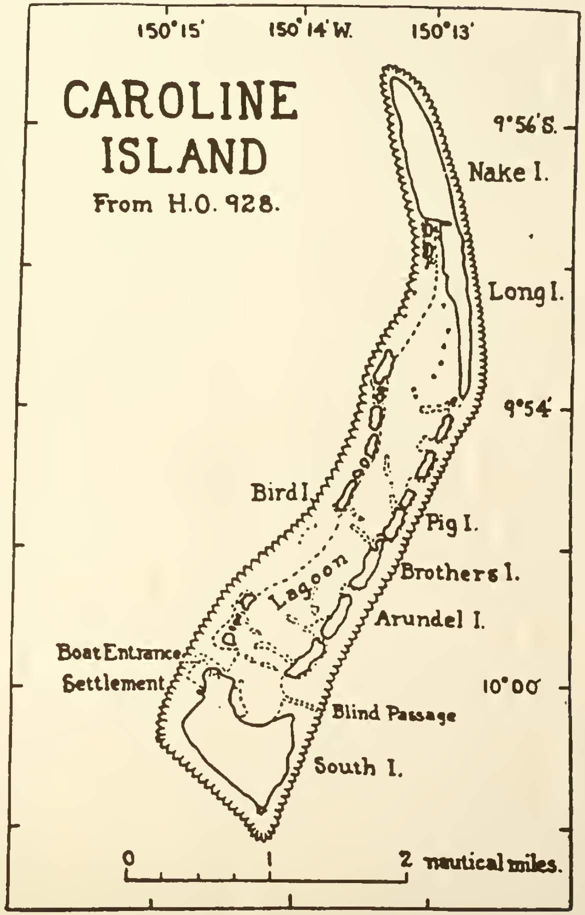


Figure 6. Caroline Atoll, a modified version of the Solar Eclipse Party's map (1883) as portrayed by Bryan (1942). Though highly inaccurate, modifications of this map have been used in all publications since Bryan (1942).

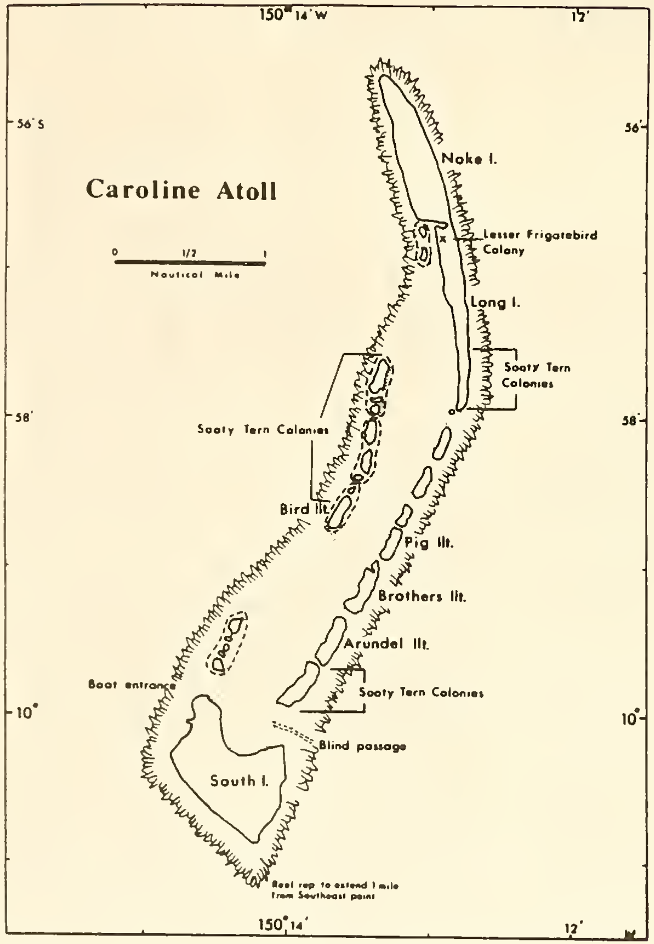


Figure 7. This map, by Clapp & Sibley (1971a), was based on Figure 6.

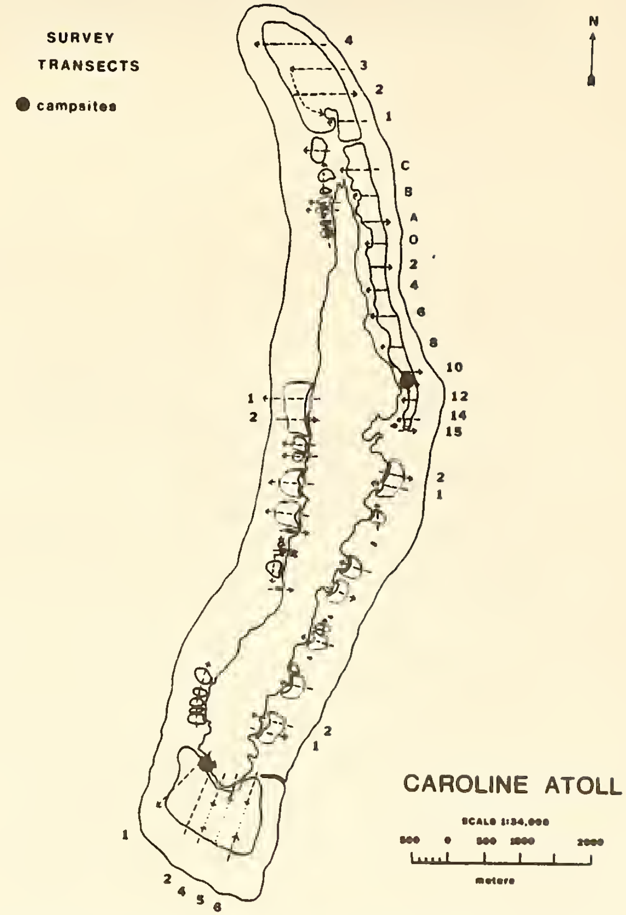


Figure 8. Caroline Atoll: survey transects. The distance covered was 13.3 km.

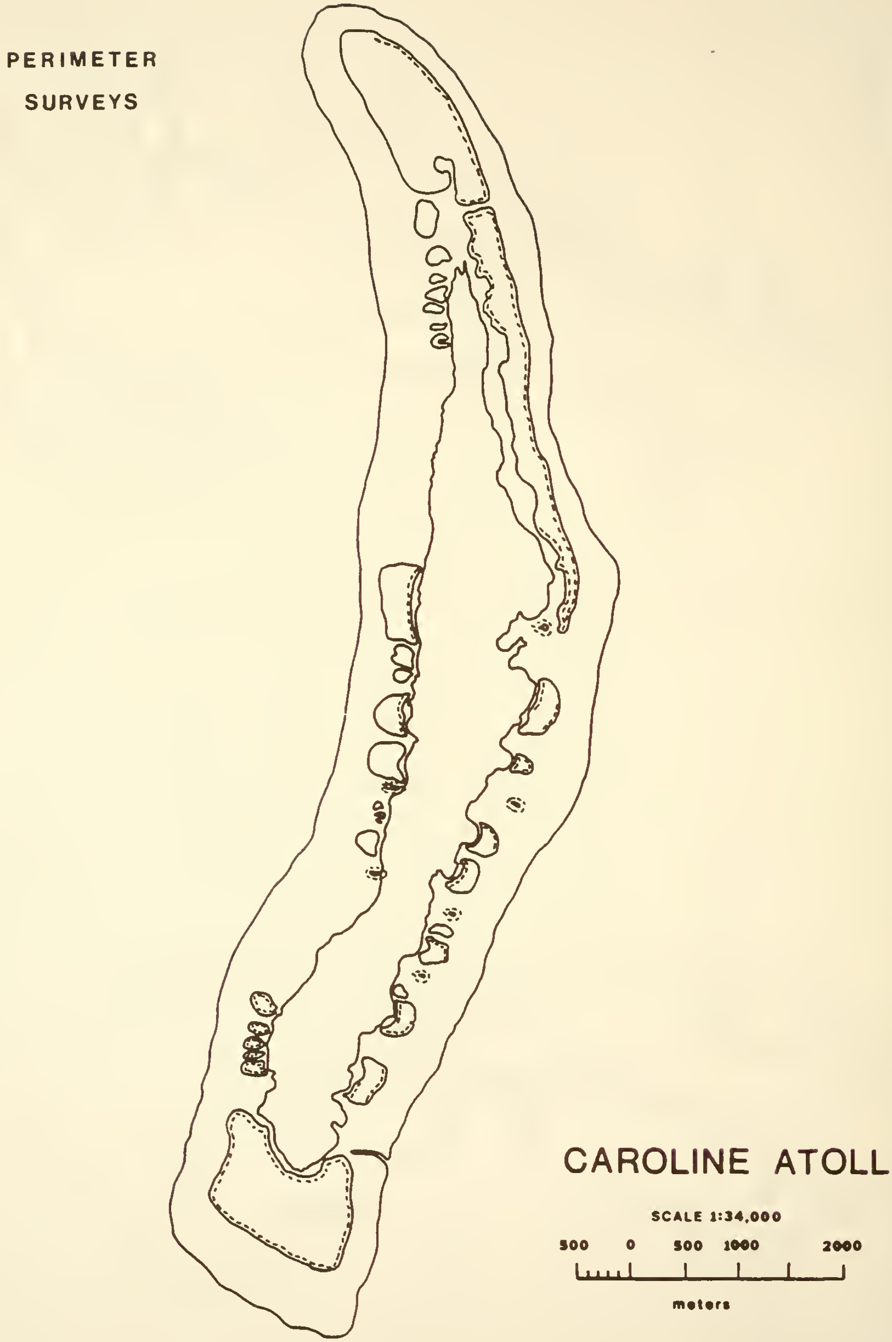


Figure 9. Caroline Atoll: perimeter surveys. The distance covered was 19.3 km.

hazardous at incoming or high tide on account of numerous aggressive black-tipped reef sharks, *Carcharhinus melanopterus* (Pl. 10).

During the 1990 visits, we stayed on Motu Ana-Ana with the Falconers. Work was not intensive, as in 1988. We walked or motored an inflatable Lancer, visiting 20 motus gathering incidental data, locating the *marae*, etc.: Ana-Ana, Kimoa, Pisonia, Eitei, South, North Arundel, Noddy Rock, Brothers, North Brothers, Skull, Pig, North Pig, Bo'sun Bird, Long, Nake, Mouakena, Shark, Scarlet Crab, Bird, and Fishball. Insects were preserved in ethyl alcohol. We used a "Magellan" NAV 1000 to obtain accurate geographical coordinates of Caroline.

Naming Caroline's Motus

Previous literature has provided vague or incomplete data on Caroline's constituent motus (Bennett 1840, Markham 1904, Stevens & Barwick 1930, Holden & Qualtrough 1884, Bryan 1942, Clapp & Sibley 1971a, Garnett 1983). This confusion resulted because most previous visits had been brief. The only charts available were a quite accurate survey by Arundel, a guano merchant who mapped the atoll in 1883 (Fig. 4, Admiralty Chart, No. 979, 1965), and a map, greatly in error, drafted by an international Solar Eclipse Party, also in 1883 (Fig. 5). There are no hydrological navigation charts. Unfortunately, the astronomers' map has been used in all subsequent scientific, historical, military and sociological publications [N.I.D. 1941, Bryan 1942 (Fig. 6), Maude 1968, Clapp & Sibley 1971a (Fig. 7), Garnett 1983]. It shows only 25 of the 39 motus and many shapes are distorted. The 38 motus on Arundel's map are similar to those in the RNZAF (1986) aerial photographs. Only a few appear to have changed in minor ways since 1883: major discrepancies in Arundel's map, we believe, are due to difficulties involved in the accurate rendition of small land areas (i.e. the South Nake Islets). Maude (ca. 1938) counted 36 islets, but never published his information.

To aid our survey we named 32 islets and 4 islet groups (Fig. 2). Our names reflect appropriate aspects of islet biology. Etymology is provided in Section H. Gilbertese names are prefixed with *motu* (see next section). Any name not appearing on Arundel's map (Fig. 4) was given to the islets by us. They have been sent to the British Admiralty and U.S. Hydrographic Office (along with corrections to the Pacific Pilot) for official recognition.

D. PRELIMINARY STRUCTURE AND TOPOGRAPHY

Our geological terminology is based on Tracey et al. (1955) as cited by Wiens (1962), to which we add *motu* (Polynesian for "islet"), now a technical term for detrital reef islands (Danielsson 1954, Stoddart & Steers 1977). In this paper the terms *motu* and islet are used interchangeably.

Background Geological Setting

Caroline is the southeasternmost of the Line Group (Fig. 1), a major volcanic lineament in the Pacific, comparable in size to the Hawaiian-Emperor chain to the north and the Marshall-Gilbert-Ellice chain to the west. This quasi-linear chain, 4200 km long, is composed of dozens of simple and complex seamounts and linear ridges, 6 atolls, 5 islands, and 2 submerged reefs. The Line Islands are now considered to include Johnston Atoll (Duncan 1983, Schlanger et al. 1984), and thus lie between 17°N and 12°S latitude, and 169° and 150°W longitude. The name, Line Group, reflects its equator-straddling location.

The geological complexities of the East Pacific in general and Line Islands in particular were poorly understood until a few years ago. However, recent remote-sensing technologies, deep-drilling techniques, improved sea-floor mapping and multidisciplinary studies of sea-level changes have clarified much previous speculation (Jarrard & Clague 1977, Orwig & Kroenke 1980, Montaggioni & Pirazzoli 1984, Schlanger et al. 1984, Pirazzoli & Montaggioni 1988, Spencer 1989).

The Line Islands are now known to exhibit changing geomorphology from north to south: elongated submarine ridges and coalesced seamounts merge into a broad central high plateau, then progress to scattered isolated seamounts in the south (Duncan 1983, Schlanger et al. 1984).

This long chain of geologically related and unrelated islands exhibits a complex history of volcanism involving activity from multiple "hotspots" and overprinting events dating as far back as 93 million years (Jarrard & Clague 1977, Orwig & Kroenke 1980, Crough & Jarrard 1981, Haggerty 1982, Duncan 1983, Schlanger et al. 1984). Furthermore, although numerous studies, using high technology, have been conducted from oceanographic vessels, very little data has been gathered from the islands themselves (M. O. Garcia & J. A. Haggerty, pers. comm.), and a clear understanding of the myriad interacting processes which formed the Line Islands has not yet emerged. This is particularly true of the central and southern Line Islands.

However, recent palaeoecological research in the Tuamotu Archipelago includes generalities which are applicable to the Line Islands (Montaggioni & Pirazzoli 1984, Pirazzoli & Montaggioni 1988).

The known geological history of the Line Islands can be summarized as follows:

1) During the Cretaceous period (140-65 m.y. B.P.), ridge-building volcanic events occurred, giving rise to scattered volcanoes, older in the north. This period of mountain-building was a worldwide phenomenon, in the eastern Pacific supported by hotspot activity in the vicinity of Easter Island.

2) A second eruptive phase during the Palaeocene-Eocene period (65-38 m.y. B.P.), and age-progressive from north to south, overprinted

earlier volcanoes. This was either a result of "hotspot" activity along the Line-Marquesan Swell or part of Pacific-wide volcanism.

3) The history of reef growth and subsidence is complex and has not been studied in detail. The Line chain was in latitudes amenable to reef growth throughout its history from the Late Cretaceous (100 m.y. B.P.) to the present (Schlanger et al. 1984). A general pattern for the northwest Tuamotus, close to the southern Line Islands, shows primarily Holocene reefs 6000-3000 years old (Pirazzoli & Montaggioni 1988). However, a few older reefs do exist, and dredge hauls near Caroline (Schlanger et al. 1984) recovered reef limestones of Eocene through Pleistocene age (54 m.y. to 10,000 years B.P.).

We found no visible fragments of Caroline's volcanic heritage, summarized above.

Sea Level Changes

Data on the history of sea levels for the Southern Line Islands is lacking. However, studies in French Polynesia (Pirazzoli & Montaggioni 1988), and which appear to have been a general phenomenon in the South Pacific, indicate that:

1) A stable sea level occurred, slightly less than 1 m above its present level, from 5000-1500 B.P. This peaked at approximately +1.0 m between 2000 and 1500 years ago.

2) Since then the level has been dropping gradually to its present position, reached only recently (Pirazzoli & Montaggioni 1988).

General Account

No geomorphological or geophysical studies have been carried out at Caroline. However, 2 deep undersea dredge hauls near the atoll uncovered reef limestones dated at Eocene through Plio-Pleistocene (Schlanger et al. 1984), and recent studies in the northwestern Tuamotus date the exposed coral reefs in the Holocene around 6000 to 3000 years B.P. (Pirazzoli & Montaggioni 1988). There is much scope for research within Caroline's reef matrix, varied shorelines and upraised reefs.

Caroline's overall shape resembles a flattened crescent, 9.7 km long on its north-south axis (Fig. 2), with outer perimeter 26.9 km and greatest breadth 2.3 km. The longest islet, Long, extends 4.23 km north-south, while South Island, extending 1.2 km east-west, claims the widest stretch of land.

The motus, lying upon a wide, continuous reef flat which encloses an elongated, relatively shallow lagoon, fall naturally into groupings of 3 large islands (South, Nake, Long) and 4 groups of smaller islets (13 Windwards, 5 Southern Leewards, 11 Central Leewards, 7 South Nakes).

There are 4 basic motu shapes, molded by the prevailing easterly winds and currents, periodic storms, overall atoll shape, etc:

1) long, linear, and parallel to the reef axis, e.g. Long Island.

2) small, linear or oval, and perpendicular to the reef axis, e.g. Southern Leeward Islets.

3) triangular or crescentic, with the apex facing the seaward reef, e.g. most of the Windward Islets.

4) large and quadrangular, occupying the ends of the atoll, e.g. South, Nake.

Caroline's motus have similar length-width ratios as those elsewhere (Stoddart & Steers 1977) and are similarly situated on the inner half of the reef flat, having their lagoon beaches close to the lagoon reef slope. Individual motus are discussed in detail in Section H.

It is hoped that the following preliminary observations of Caroline Atoll will inspire further research. As well as exhibiting features similar to many atolls, its 39 islets also present individual details that pose interesting questions which may help in deciphering sea-level changes in the Eastern Pacific and in unraveling the somewhat speculative geological history of the Line Islands (Jarrard & Clague 1977, Schlanger et al. 1984). Examples include the presence of an inland, vegetated reef substrate on Long; deep inland sand on Nake; conglomerate rock on South; hardpan on Mannikiba, Nake and Long; an emergent reef platform (Noddy Rock); and exposed older reefs of uniform height (Nake). Aerial photographs have indicated that Long Islet has been formed most recently from the coalescence of 5 former islets, which show even older subdivisions. Nake, previously at least 2 islets, has changed shape on both its north and south ends by the addition of gravel ridges and silt, respectively, in the past 100 years. Brothers Islet has incorporated a small motu within its confines since 1883; several other motus have also added bars and spits, and the lagoon has filled in further during that short time period. The questions of phosphatic hardpan beneath *Pisonia* forest and the extent of ground water lenses need attention.

Reef Flats

Caroline's peripheral reefs, which completely surround the lagoon, and upon which the motus rest, are consistently wide (average 562 m, range 396-759 m, N = 100). The windward and leeward reefs differ in structure and dimensions. Neither are entirely dry, even at the lowest tides. They consist primarily of barren calcareous rock, frequently smooth, which on other atolls generally represents the erosional surface of an older reef. Jagged "mushrooms" of exposed newer (but dead) reef framework dot the leeward reefs, forming an open platform off southwestern Nake (Pl. 11). Their structure and uniform height (~0.3 m) are similar to those on Hikueru Atoll, Tuamotus, which have been dated as 2565 ± 55 years B.P. (Pirazzoli & Montaggioni 1988). There are no passes from ocean to lagoon, a typical feature of central Pacific atolls (Wiens 1962). In the Southern Hemisphere, reef flats tend to be widest in the southwest sector and narrowest in the northeast (Wiens 1962), a generality which Caroline fits (Pls. 12, 13).

The reef rim, irregularly dentate and 26.9 km in circumference, is surmounted by motus for 55% of its length. On 72% of all Pacific atolls, less than half the reef circumference is occupied by land (Wiens 1962); Caroline lies within a 28% minority in which one-half to two-thirds of the reef rim contains land. Corresponding values for 2 Tuamotuan atolls, Rangiroa and Raroia, are 33% and 35% (Stoddart & Sachet 1969). Where motus exist, the reef flat is divided into the seaward reef flat (Pl. 12), motu, and lagoon reef flat (Pl. 14).

At low tide all reef flats can be waded. Black-tipped reef sharks were highly aggressive in 1988 but by 1990 dozens had been killed. The South Nake and Central Leeward channels were particularly hazardous, reflected in motu names such as Blackfin, Shark, and Danger.

<u>Windward Reef Flats</u>: Constantly pounded by surf, the windward reefs are typically narrower than those to leeward, averaging 519 m (range 396-759 m), though this is less evident from a map than in the field.

The windward reef is 13.5 km long, surmounted by 16 motus that total 63% of its length. This fits a recurrent pattern on central Pacific and Tuamotuan atolls where motus are more frequent along windward reef rims (Thomas 1961, Wiens 1962), due to active movement of debris associated with the prevailing easterly winds, waves and storms. The longest islets are Nake (1,980 m) and Long (4,226 m), both formed from the coalescence of 2 or more smaller islets. The rest vary from 18 m to 858 m in length.

The character of these reef flats differs, depending on the presence or absence of land, interisland distances, lagoon depth, and recent weather conditions. In February 1990, severe cyclonic weather rearranged tons of sediments, especially to windward, uprooting *Tournefortia* scrub, obliterating extensive sections of herb mats, exposing beachrock, depositing storm blocks, and altering the shape and slope of the beach crests. Since Caroline has been essentially uninhabited for 60 years, no data exists on the frequency of such storms, although it is well-known that windward beaches worldwide are undergoing erosion and retreat, and are thus characterized by beachrock outcrops and other lithified sediments (Stoddart & Steers 1977).

<u>Reef Rim with Motu</u>: The width of the seaward flats is quite uniform, averaging 307 m (range 193-396 m), occupying 57% of the rim width. It consists of a slightly raised algal ridge bearing the brunt of incessant wave action, and a rubbly reef flat, partly drying at low water, which sweeps up to the motu's beach (Pl. 13).

The motus differ considerably in width, ranging from the narrow tip of Long, merely 30 m wide, to Windward, 290 m wide. Nake and South Islands, forming "caps" to the atoll at its upper and lower ends, respectively, exhibit characteristics more typical of windward than leeward motus. Whenever atoll reefs turn sharply, debris-loaded waves become deflected around the points, thus depositing more gravel than on a straight shoreline. Hence, these 2 motus are the widest on the atoll (Pl. 16). A comparison of maps a century apart (Figs. 2, 4) indicates that several layered ridges of coral debris have accumulated on northern Nake since 1883.

<u>Reef Rim without Motu</u>: Zonation within the reef flat is less marked where there is no land. Within these interislet reef flats, however, areas of high water transport have carved surge channels and erosional grooves, and tidal fans extend into the lagoon, especially at its northern end where sedimentation is most active. Caroline has no deep pass or navigable channels into the lagoon, nor a ship anchorage beyond the reef, though small boats may anchor within the close lee of South Island during normal trade winds and low seas. Landing in an inflatable is best made across the reef slightly north of the "boat entrance," marked by an upright anchor (App. I).

The reef flat between Tridacna and South Island, serrated with 6 erosional grooves, one labelled "blind passage," is of particular importance to navigators (App. I). The blind passage, the most southerly channel, is a narrow diverticulum 380 m long within a reef 430 m wide. On all previously published maps this passage is drawn as though it completely connects ocean and lagoon (Figs. 4-7). However, it is a nonfunctional *hoa* or *tairua*, an erosional channel cut only partly across a continuous atoll rim. Its lagoon end (Fig. 50, Pl. 72) serves as a sheltered anchorage for motored yachts, but it can only be entered or exited during high winds or moderate-to-high surf. Chevalier (in Stoddart & Steers 1977, p. 77) has suggested that *hoa* features are partly a result of sea-level changes altering the balance of sedimentation and erosion.

<u>Leeward Reef Flats</u>: These are wider, flatter, gentler, more consolidated, and less filled with rubble than the windward reefs (Pl. 11). An orange, semi-transparent alga, blanketing the coralheads, chunks of upraised coral (Pl. 11), carbonate rock, and giant clams, is abundant. This alga is found on many atolls, for example Enewetak and Rangiroa (U.S. Department of Energy 1987, Stoddart & Sachet 1969). Living coral is sparse.

<u>Surge Channels</u>: These occur in a variety of shapes and sizes, depending on the distances between motus, the extent and buildup of reef flats adjacent to land, and lagoon depth. Surge channels and reef grooves are deeper on the windward side. The vigorous currents washing daily into Caroline's lagoon have created larger debris fans between windward motus than between those to leeward (Frontispiece).

<u>Beaches</u>

Caroline's beaches--the zones lying between low water mark and the inland limit of wave-deposited debris--are entirely of reef origin. There is, however, considerable variation in their composition. The windward beaches and surge channels, in a constant state of erosion or deposition, support the greatest variety of sediments: well sorted sands (indicated by grain-size distribution); gravels of coralline, algal (including *Halimeda*) and molluscan origin; and a wide assortment of coral fragments. The atoll's prime stretch of sand (Shark Islet) is thickly overlain with pink granules, possibly Foraminifera tests, which are abundant in the Tuamotus (Stoddart & Steers 1977).

Almost all exposed rubble on Caroline is colored gray, a consequence of penetration by cyanobacteria. Typically the oldest rubbles, highest up the beach and extending into the interior, are darkest. A marked beach crest rises, gently or abruptly, from the windward beaches, at the crest of which is deposited an assortment of flotsam and jetsam: bottles, plastic, wood, coconuts, etc. (Pl. 19). No storm blocks were found in 1988, but in 1990 many littered the windward reefs and shores, the result of recent cyclonic weather. Similarly, in 1990, thick deposits of coarse sand had overlain the rubbly windward beaches and interislet channels of 1988 (Pl. 33).

Alterations to Caroline's beaches provide the major changes in motu shape. Aggradation occurs principally on the lagoonward points of the larger windward islets, for example, Brothers (which is now joined with a separate islet mapped by Arundel), and Windward and Tridacna (which have added more sediments to their southwest points during the last century).

<u>Beachrock</u>: These elongated strata of eroded reef, brown consolidated sands and reef detritus, from one to a few meters wide, are not abundant on Caroline. Occurring as seaward dipping strips at the low water mark, they flank the windward beaches of Nake, Long and South (Figs. 37, 38, 50; Pl. 54) and a few of the leeward islets. Beachrock results from lithification of tropical intertidal sediments by calcium carbonates, in part due to seawater evaporation during low tide (Scoffin & Stoddart 1983). Beachrock outcrops become more exposed after storms, indicating that some cementation may occur beneath a shallow sediment cover. A coarser conglomerate platform (Pl. 20), possibly a relic of a former, high sea level, occurs on the northwest point of South Island, creating the "landing" (Pl. 20). This appears to be of similar age to the remnant reefs of southwest Nake, which are less consolidated (Pl. 11). Although the platform's upper surface rests slightly above high water level, we do not know if it represents a former reef exposed by a recent fall in sea level. The origins of such platforms are controversial (Stoddart & Steers 1977).

<u>Upraised Reef</u>: In a few areas, jagged, eroded upraised reef (*feo*) comprises some of the islet's interior--for example, the lower quarter of Long. A thin soil cover supports a forest of lower stature than would otherwise be expected. The rocky substrate is pitted with

cavities and undermined with subterranean tunnels in which at least 2 species of land crabs (*Birgus latro, Cardisoma* spp.) shelter (Pl. 21). Noddy Rock (Pl. 18), the smallest motu (0.02 ha), and many jagged coralline "mushrooms" found on the reef flats (Pl. 11) are probably remnants of former reef flats formed when sea levels were several feet higher than present. It is hoped that further investigation will determine whether these older limestones are from the Holocene or Pleistocene.

Lagoon

Caroline's lagoon, 8.9 km long, is closed; its total area is less than that of the combined reef flats. The lagoon is relatively shallow, tapering in shape and depth at each end, containing both reticulate and patch reefs of living coral. Its bathymetry is unknown.

In the north the lagoon is more sheltered, as the presence of continuous vegetated land buffers the easterly trades, and silty sediments increase. At its northern extremity, merging reef flats squeeze the lagoon until it disappears east of Pandanus Islet. A filled-in portion of the former lagoon penetrates Nake for 300 m as a fishhook-shaped mudflat, Sandy Inlet (Fig. 37, Pl. 22), before succumbing to encircling vegetation. At the lagoon's southern end, where winds whip through the "blind channel," it is choppy, having more sediment and slightly less visibility. However, within the lee of South Island's north-central curve the lagoon is frequently quiet and reflective (Pl. 23).

Lagoon Hydrology

Although Caroline's hydrology has not been studied, the south end of the lagoon and "blind passage" (Fig. 50, Pl. 72) were closely observed for 2 years by Ron Falconer. He noticed that the lagoon is typically "perched" at a level above that of all but the daily high tides. High tide water flows rapidly over the reef flats into the lagoon, but is held back by the reefs as the tide lowers. Lagoon water at low tide is about 0.3 m higher than water in the "blind passage." Water moves out of the lagoon through a few channels that, although deep in places, form broad, shallow troughs over the reef flats. A major channel with a current flowing west at several knots passes along the northwest point of South Island, although water passage is impeded by the reef flats west of South Island. If a channel were to be blasted through the reef flats, as has been proposed, this delicate hydrology would be disrupted. For example, the high tide water is never more than 20 cm above the coral heads and reefs in the lagoon. A man-made reef channel for vessels could lower water levels 30-40 cm, thereby exposing and killing the extensive *Acropora-Tridacna* reefs within the lagoon.

The "blind passage" is sustained by a powerful northward flow of water along the east coast of South Island and a strong southward flow of water along the seaward reefs of Tridacna Islet. The South Island flow is augmented by water draining from a large shallow basin on its windward reef flats. Water spills into the "blind passage" and drains east at about 4 knots against the prevailing trade winds and surf. There is minimal current at the west (inner) end of the passage, where less water is collected, and throughout the passage at low tide when there is essentially no water flow out of the lagoon.

Patch Reefs

Darwin (1842) recognized 3 basic reef types (fringing and barrier reefs, atolls). A fourth type, patch reef, is now widely accepted. Patch reefs are smaller than the other 3 reef types, lack a lagoon but are located within lagoons, are submerged up to low tide level, and, unlike other oceanic reefs, have foundations of sediments or sedimentary rocks. They are subcircular to irregular in shape when viewed from above, and in their smaller sizes merge with coral knolls, coral thickets, or coral heads (Ladd 1977, Fagerstrom 1987).

A complex series of patch reefs and coral knolls (primarily *Acropora* spp.), circular and elongated, flank the smaller motus and crisscross much of Caroline's lagoon (see Frontispiece). They are particularly evident in the southern two-thirds of the lagoon. Coral limestone bedrock, surmounted by abundant living coral, molluscs, and other invertebrates, provides their basic structure (Sirenko & Koltun, in press). The atoll's perimeter reefs provide shelter from storms, surf, and excessive erosion. In shallow areas they tend to be curvilinear (Central Leeward Islets), while in deeper water, coral knolls and pinnacles are more characteristic (Pl. 63).

Caroline's lagoon is gradually filling in with ever-expanding patch reefs and debris washed in from the fringing reefs. Since Arundel's time, the effects of detrital deposition can be discerned as changes in the shapes of islets such as Nake, Danger, and Arundel (compare Figs. 2 and 4).

Such change is typical of atoll evolution. Geologically, Caroline is a few steps behind one of its "neighbor" Line Islands, Christmas, where sediments and coral growth have converted the original lagoon into a maze of supersaline, mini-lagoons and tiny islets, mostly cut off from the sea. Further steps in evolution are exemplified by completely filled-in atolls such as Jarvis and Vostok, where not even salty pools remain.

Tridacna-Acropora Reefs

Though the giant clam (*Tridacna maxima*) is an abundant component of Caroline's lagoonside reefs, exceptional aggregations flank the most southerly windward motus (Brothers through Tridacna, Figs. 44 to 48). Two especially outstanding reefs extend across the lagoon from Tridacna to Ana-Ana (Fig. 10, Pl. 25) and Tridacna to Kimoa (Fig. 48), where *Tridacna* attach to *Acropora* spp. corals, a favored substrate (Braley

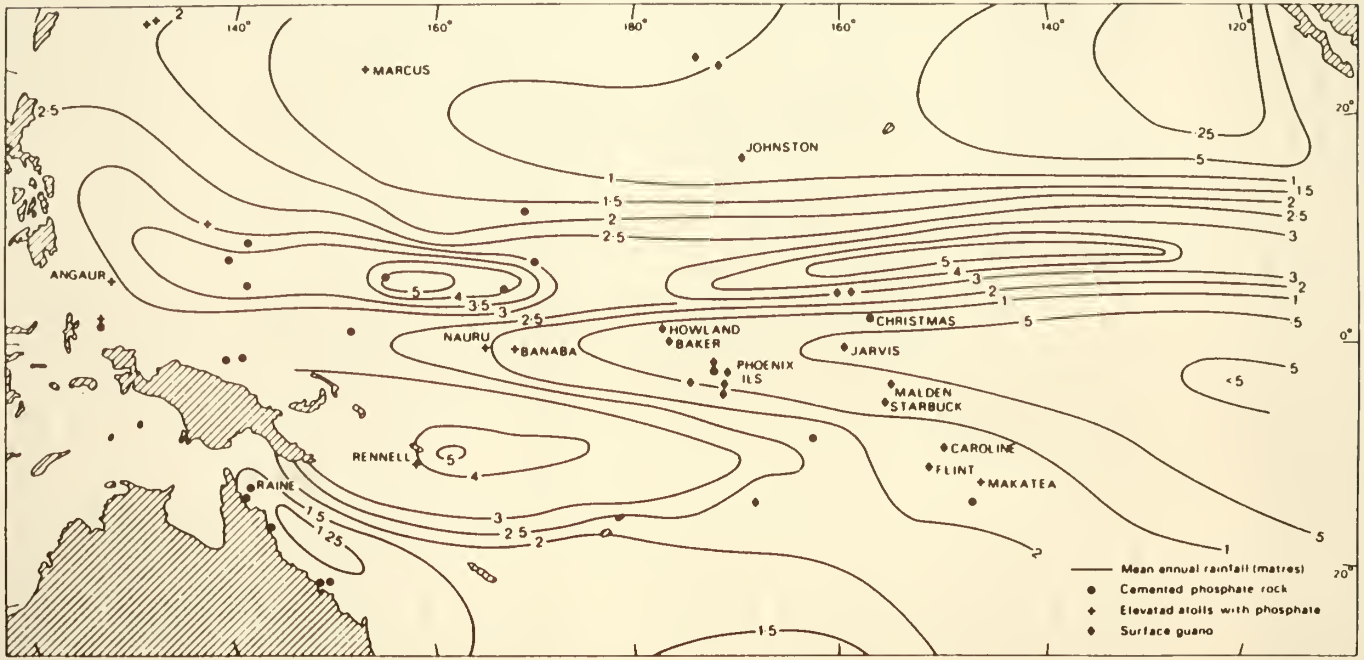


Figure 10. Relationship between mean annual rainfall and distribution of phosphate islands in the tropical Pacific (Fig. 13.1, Stoddart & Scoffin 1983).

1987). Abundant inshore *Tridacna* on all these islets suggest that their density is similar to that on the main reef: up to 20/.25 m^2 (i.e. 80/m^2), averaging 35/m^2 for the entire area surveyed (Sirenko & Koltun, in press). This density exceeds the highest known aggregations of *Tridacna*: up to 60/m^2 at Reao Atoll, Tuamotu Archipelago (Richard 1985). Densities of 6-20 clams per square meter, as found at Takapoto Atoll (Tuamotus), are considered high. Throughout Caroline, the clams averaged 18 x 10 cm in size. Several species of Indo-Pacific *Tridacna* have suffered greatly from poaching and overharvesting, leaving few undisturbed populations (Braley 1987). Caroline is thus a special refuge for *T. maxima*.

Lagoon Reef Flats

These vary considerably but are narrower and more gently sloping than the seaward reef flats. They are typically covered with fine coral gravel and coarse sand. In sheltered areas (lower Long, Windward, Crescent, South, upper end of lagoon) lush shrubbery--*Cordia*, *Tournefortia*, *Pisonia*, *Cocos*--overhangs the lagoon. Here fine silt, sand and/or an algal slime are common (Pl. 27). In 1988, narrow, sandy beaches were limited to northern South (Pl. 23) and eastern Shark (Pl. 28), but in 1990, sand occurred throughout Caroline.

Where the lagoon shorelines are less sheltered and vegetation does not overhang the lagoon, unvegetated rubble and sparse herb mats are typical. Here, lagoonside rubble averages less than 2 m wide (Pl. 30). This contrasts with their seaward reef flats, which average 21 m wide (Pl. 11).

Lagoon Reef Fauna: A Brief Summary

Caroline's marine environment is rich yet essentially undocumented: knowledge is limited to preliminary lists of fish, invertebrates and lagoon plankton (Dixon 1884; Fowler 1901; Pilsbry & Vanatta 1905a, b; Tsyban & Smith 1988, Sirenko & Koltun, in press). All early travelers remarked on the beauty, abundance and variety of Caroline's reefs (Markham 1904, Bennett 1840); today they are still relatively untouched.

The usual assemblage of reef invertebrates--echinoderms, molluscs (*Turbo*, *Nerita*, *Cypraea*), crustaceans, porifera, tunicates, etc.--are present. Corals include several important Holocene reef-constructors: *Acropora*, *Pocillopora*, *Porites*, and *Montipora*. Calcareous algae include *Halimeda*, *Porolithon* and *Lithothamnion* (Sirenko & Koltun, in press). Large numbers of black sea cucumbers (*Ludwigothuria* sp.), about 20 cm long, are particularly abundant lagoonward of the southern windward islands (Pl. 10). Conspicuous fish families include parrot fish (Scaridae), butterfly fish (Chaetodontidae), surgeonfish (Acanthuridae), damselfish (Pomacentridae), pufferfish (Tetraodontidae), and wrasses (Labridae).

Substrata

Throughout the atoll, substrates reflect a reef origin. There is little "soil" in the accepted sense. Various grades of jagged, eroded coral and molluscan rubble (from fist-sized to tiny pebbles), together with sand, coralline algae, and relatively small proportions of organic litter, humus and guano, are present. Such accumulations of reef and terrestrial debris are similar to those of other low, coral atolls (Fosberg 1953, Stone 1953, Wiens 1962, Niering 1963, Stoddart & Sachet 1969, Garnett 1983, Reese 1987, Gessel & Walker 1992).

Generally speaking, atoll soils are calcareous and extremely immature, a consequence of their limited age and frequent disturbance by storms. Barely modified beyond the reef that spawned their presence, they are rich in calcium and magnesium carbonates. Water retention, if any, is due to accumulated organic matter and its associated chemical changes. Accumulations of guano react with the calcium carbonate of reef sands and elevated limestones to form nitrogen-rich "soils" and phosphatic hardpan (Hutchinson 1950, Fosberg 1953, Stoddart & Scoffin 1983).

Reese (1987) categorizes atoll "soils" into 5 types, all of which occur, in different proportions, at Caroline. The degree of organic matter, decomposition, amount of humus, and the depth of the "soil" strata are directly correlated with age and size of Caroline's motus.

1) *Accumulations of coral rubble, mainly of stone size.* These youngest of "soils" are most evident around the edges of the motus, acting as a substrate for natural herb mats. Often extending well inland, they can support surprisingly lush *Tournefortia* scrub.

2) *Unaltered coral sand and gravel.* Although exposed sand was uncommon at Caroline in 1988, this substrate occurred intertidally where the lagoon was filling in and on actively growing sandbars, primarily in the upper lagoon (Pls. 22, 27), northeast and northwest South (Pls. 23, 31), and the lagoonward edge of Shark (Pl. 28). In 1990, a single storm deposited tons of sand on Caroline.

3) *Soils with a weakly developed A-horizon, with color only slightly darker than the unaltered sand below, but with no evidence of structural development.* Especially evident in 1988 within the ancient interislet channels that compose Long Island (Pl. 32), much of this substrate is now storm-eroded and overlain by fresh sand (Pl. 33).

4) *Soils with a more developed A-horizon, deeper and darker than above, with some structural development.* This stage defines areas where the rubbly/sandy substrate approaches a true, but poor, "soil." As such, it represents older, more stable parts of each island. It is common within the islet interiors where *Pisonia* is (or was) present. Its composition may be likened to a coarse mixture of gravel, sand, bones, humus, eroded coral and shells, all mixed with sparse amounts

of partly-decomposed litter. Land crabs are particularly numerous, further breaking down organic matter into finer particles.

5) *Soils with an accumulation of raw humus on the surface and with a relatively deep A-horizon. During this stage phosphatic hardpan may develop.* These true soils, though somewhat depleted by guano diggers, cover significant areas on South and Nake. *Cocos* and/or *Pisonia* debris heightens their dark coloration and moisture content. This earthy substrate is composed primarily of rotting *Cocos* fronds and nut fibers shredded by coconut crabs. Patches of blackish muck on South Island support local patches of *Tacca leontopetaloides*.

On Caroline, we noticed a type of hardpan (Pl. 67) in several areas (primarily South, Nake, Long, Emerald, and Mannikiba). In each case it resembled a flat sheet of old asphalt road, present within, or adjacent to, herb mats and peripheral *Tournefortia* scrub. Since hardpan forms when phosphatic derivatives from guano interact with permeable, reef-derived carbonate sediments (Stoddart & Scoffin 1983), it is possible that these barren clearings represent areas of high guano concentration. Worldwide, the major guano-producing seabirds are boobies, terns and frigatebirds (Hutchinson 1950). Adjacent to, or nesting on, these areas of hardpan which we observed were Red-footed Boobies (all motus), Great Frigatebirds (all except South), Lesser Frigatebirds (Nake), Masked Boobies (Long), and Sooty Terns (only 1990 on Long, but recorded from open areas of Emerald and Mannikiba, June 1965 and July 1990, see Pt. II, Fig. 11).

We did not take soil profiles within *Pisonia* forests to ascertain the presence of subsurface phosphatic hardpan. However, AKK and John Phillips found both surface and subsurface phosphatic hardpan on nearby Vostok, having the typical "pepper-and-salt," coloration and crumbly texture characterized by the Jemo soils found in the Marshall Islands (Fosberg, 1954 and pers. comm.).

Caroline provides an excellent example of the progression of soil development through islets of different age and size classes (see Sect. F). From a wave-washed mound of coral rubble, barely above sea level (Fig. 5), the substrate gradually improves in texture and fertility as the emerging islet ages and organic matter accumulates. Pioneer plants are hardy, salt-tolerant, low-lying mats consisting primarily of *Heliotropium*, and later, *Tournefortia*. Increasing numbers of shrubs provide shade and branches for nesting seabirds. Larger trees (*Pisonia*, *Cordia*, *Morinda*) add more shade and thereby increase humidity, as well as provide opportunities for additional organic "fallout": leaves and bird remains (nests, eggs, chicks, droppings, regurgitated food, dead adults).

Each stage of substrate development accelerates the accumulation of organic material and helps to define an emerging, deeper A-horizon. Soil maturity is indicated by more organic matter, improved soil texture, and a lowered volume of coralline and molluscan debris. Caroline's soils barely exceed several centimeters in depth and are always intermingled with coral fragments. As a result, they are unsuitable for burrowing seabirds such as petrels and shearwaters.

Hydrology

Hydrological information is essentially lacking. No standing fresh water exists. The quality, extent, and salinity of the freshwater lenses, as well as their variability according to tide, season, and rainfall, are unknown. At the time of Caroline's "discovery" (1606), de Quiros and his party were desperate for fresh water. After noting how lush and green Caroline was, they expected to find good water supplies, but there was "nothing but salt water in the holes they dug" (Markham 1904). Maude (1968) suggested, in hindsight, that had they waited longer the salt water in their shallow wells might have run fresh, as has been his experience on some other atolls. During the 19th century, 3 wells were used--one on Nake and 2 on South (Holden & Qualtrough 1884). One South Island well contained fresh water at 1.5 m depth in 1974 (Garnett 1983). We saw no wells, but located 2 concrete cisterns, one built in 1937 near the "landing" and rebuilt by the Falconers in 1989, and another uncovered one (dating from 1938) within a *Cocos-Pisonia* grove along Transect 2, about 200 m east of the southwest corner of Nake.

Caroline's paucity of fresh water may be partly responsible for the lack of a permanent population. The annual rainfall in 1989 (App. II) was 1,242 mm (48.9"). However, like the similarly lush Nikumaroro and Orona (Phoenix Islands), Caroline's rainfall may vary greatly from year to year, resulting in undependable water supplies. Residents always relied on rainfall catchment for fresh water (Maude ca. 1938; R. Falconer, pers. comm.).

The relationships between fresh water and *Pisonia* forests are uncertain (see Wiens 1962 and Sect. F).

Climate

Meteorological records for Caroline were sparse until 1989, when Ron Falconer began daily records of rainfall and wind direction (App. II). Some data is available from the plantation years 1916-1920 (Young ca. 1922) and during the 1883 Solar Eclipse Expedition (20 April - 8 May) (Upton 1884), when 203.2 mm (8") fell. Generalizations on regional weather conditions are found in N.I.D. (1943), Seelye (1950), Fosberg (1956), Newell (1956), Wiens (1962), Taylor (1973), Stoddart & Scoffin (1983), and various papers on the Tuamotus (Stoddart & Sachet 1969, Sachet 1983). Islands in the Line Group experience a wide range of climates. In general, those near the equator are dry, with rainfall increasing with increasing latitude north or south (Fig. 10).

Caroline experiences a tropical oceanic climate with little annual variation. Temperatures are uniformly warm to hot, normally tempered by trade winds from the southeast to northeast. Falconer (pers. comm.) did not record daily temperatures but estimated an annual average of 29° C (range 26°-31° C). Mean annual temperatures for the Central Equatorial Islands lie between 24° and 29° C. Surface temperatures increase rapidly in early morning and remain hot throughout the day. Forest interiors are humid. The daily range of temperatures exceeds the annual fluctuation in the daily mean.

Atmospheric pressure, sunshine, and cloud cover are probably similar to the northern Tuamotus, uniform except during storms.

Wind and Rainfall

Caroline is dominated by trade winds. As on all low atolls, land topography has very little appreciable effect on weather. Although it lies within an area primarily influenced by southeast trades, there is a small annual oscillatory movement northward and southward. Appendix II indicates that, at least for 1989 and 1990, winds blow primarily from the north and northeast, and rarely from the southeast (April - August).

The atoll lies within a belt of variable rainfall, along with Vostok, Flint, and the Northern Tuamotus. Young (ca. 1922) measured rainfall for 1919 (2,172 mm) and 1920 (1,854 mm), noting that Caroline's rainfall is "certainly less than that of Flint." He estimated "probably not more than 50" (1270 mm)" during 1916, 1917 and 1918, figures extrapolated from Flint (1,600, 1,346, 1,295 mm, respectively). Falconer measured 1,242.1 mm (48.9") in 1989 and 2,209.8 mm (87") in 1990. An unusually wet February in 1990 brought 640 mm (25.2") of rain, due to cyclones "Peni" (centered near Vostok) and "Ofu" (centered further west). Rainfall distribution isohyets (Taylor 1973, Stoddart & Scoffin 1983) assign Caroline an approximate annual precipitation of 1,500 mm (60"), a perfect average of the above 6 years ($\bar{x}$ = 1,513 mm). In general, "winter" (May - October) corresponds roughly to a dry season, and "summer" (November - April) to a wet season.

Cyclonic Storms

Atoll motus are active structures, undergoing repeated death and rebirth. Violent storms contribute to ongoing erosional and rebuilding processes. Storms deposit debris along windward shores (Pls. 17, 19), into the lagoon and often far inland.

Although the south-central Pacific is relatively free of cyclonic storms (cyclones, typhoons, hurricanes), they occur with enough frequency and devastating force that any discussion on climate should include them. Although detailed records of hurricanes and tropical storms exist for the inhabited Tuamotus since European discovery, we know little of those that have affected Caroline. The following evidence suggests that Caroline experienced 3 major hurricanes since the 1820s and that periodic violent storms modify the atoll substantially:

1) <u>Between 1822 and 1825</u>. When de Quiros visited Caroline in 1606, the northwesterly *Cocos* plantation on South Island was healthy. When Bennett arrived in 1834, he noted that all the palms were "of dwarf stature," and that "amidst the original groves, the number of vigorous seedlings fully confirmed Captain Stavers' statement [who had visited the atoll in 1828] that these palms had increased greatly since his last visit to the spot" (Bennett 1840).

A few years before 1828, therefore, something had affected the palms. By 1834 they were all of an even height and quite short, yet bore nuts. French records indicate that 2 devastating storms whipped through the Tuamotus during this time--in 1822 and 1825 (Sachet 1983). At least one of these could have affected Caroline.

2) <u>The 1878 cyclone</u>. The first unambiguous record of major devastation at Caroline comes from the letter of a certain J. M. Salmon, dated 1883 and reproduced in Holden (1884). Speaking of the time when Messrs. Brown and Brothers took possession of Caroline (somewhere between 1865 and 1872), he stated that "it seemed as if there had been a storm or hurricane at some short period previous, which had desolated the place." Arundel (1890) attributed this to a tidal wave that swept across the Pacific from South America to New Zealand and Australia in 1868 (Arundel 1890), but atolls do not generally suffer greatly from tsunamis because they lack focusing relief. The Hydrographer of the Navy (1931, Vol. III, p. 154), however, referring to Caroline, clearly states that in "1878 a cyclone passed over the islands, destroying most of the coconut trees."

The Great Britain Naval Intelligence Division (N.I.D. 1943, p. 490), in reference to Caroline, also states that "in 1878 a hurricane wrought great destruction." This was possibly the violent storm of 6-7 February 1878, which killed 117 persons on Kaukura Atoll, 750 km southeast of Caroline in the Tuamotus (Sachet 1983).

3) <u>The 1906 hurricane</u>. Serious storms occurred in the Tuamotus during 1903 and 1906 (T. Spencer, pers. comm.). There is no record of the effects of the latter storm on Caroline. However, it affected Flint Island (Campbell 1908, p. 2), hence must have passed over Caroline as it passed westward from the Tuamotus. Campbell, leader of the Solar Eclipse Expedition to Flint (1907-1908) states that "the great hurricane of 1906 February or March drove water to (the manager's residence, native huts and copra warehouses, all located 22 feet ASL and slightly inland) and the water threw the warehouses off their post foundations."

Ten or more coconut palms on Flint were struck by lightning in March of 1917 and 1918 (Young ca. 1922).

4) <u>The 1990 storms</u>. Our second visit to Caroline was 2 weeks after cyclone "Peni," centered near Vostok (February 1990), affected the atoll. Violent winds, torrential rain, and high seas had defoliated and uprooted vegetation in some windward areas (Pl. 33) and greatly altered Caroline's shorelines, interislet channels, tidal fans, and incipient islets from our 1988 visit. Tons of sand and rubble were rearranged on

both windward and leeward islets, Motu Atibu virtually disappeared, and the main interislet channel that divides Long Island lost its herb mats and many *Tournefortia* shrubs, becoming smothered with fresh sand.

We note here that nothing is known of the effects of the 1982-83 El Niño Southern Oscillation at Caroline. This phenomenon is characterized by the appearance and persistence, for 6 to 18 months, of anomalously warm water in the equatorial waters of Peru and Ecuador. Its biological consequences are dramatic and large-scale, extending far into the central Pacific Ocean: diminished plankton production, reduced fish stocks, starvation and mass breeding failure of seabirds, heavy rainfall, growth of vegetation and disappearance of nest sites (Barber & Chavez 1983, Cane 1983, Stoddart & Scoffin 1983, Schreiber & Schreiber 1984). Our only comments are that our seabird population figures were either similar to or greater than those in 1965 (Pt. II) and that the only dead birds we saw were in March 1990, victims of the cyclonic weather described above.

Because islets on coral atolls rarely exceed 5 m in elevation, the tidal surges associated with Class IV or Class V hurricanes, often exceeding 5 m in depth, can overwhelm them, not only altering or destroying the vegetation, but in extreme cases completely removing them from the coral rim (Frisbie 1944). It is essential to consider the ephemeral nature of Caroline's motus in the discussions that follow.

Sea Conditions

Because the most extensive coral rubble deposits occur around northern Nake and southern South Island, and because the *Cocos* plantation of northwest South was so badly hit by storms last century, the following Tuamotuan generalities (Newell 1956) probably also apply to Caroline:

1) Prevailing trade winds from the east give heavy seas on the northeast or windward side;

2) Southern ocean swells generated in the sub-Antarctic break heavily on the south or seaward side; and

3) Occasional hurricanes or tropical storms strike in the northwest or stormward quarter.

Tides

Only scanty data are available. In May 1883 (Holden & Qualtrough 1884), the greatest daily variation ranged from 475 mm (1'7") to 125 mm (5"), i.e. 350 mm (1'2"). The standard hydrological chart (Fig. 4) states 1.5 feet (0.5 m), which we use in the schematic profiles (Figs. 32, 35, 36) as the difference between low and high spring tidal levels. For Flint, W. Campbell (1908) guesses "about two feet" (0.6 m), while Ward (1974) estimates 1.5 feet (0.5 m). Tidal fluctuations are similar to those occurring in the Tuamotus, around 0.7 m (2′) (Newell 1956, Stoddart & Sachet 1969).

E. FLORA: VASCULAR PLANTS AND FLORISTICS

Botanical History

All early visitors to Caroline described a well-wooded atoll with numerous islets whose vegetation extended to the shoreline. It has changed little in the 384 years since its Western discovery. The first botanical collection and notes were those of Bennett in 1835 (Bennett 1840), who recorded 10 flowering plants and a fern, and planted Tahitian chestnut, sweet potato, and Polynesian arrowroot. He noted that "some of the loftier trees" on South Island and the Southern Leewards, were 20 feet high, perhaps a consequence of cyclonic weather in the 1820s. The location of his plant collection, if it still exists, is unknown (Clapp & Sibley 1971a).

The only indication of tall, native forests is given by Arundel (who mined guano and later cleared land for coconuts) in an unpublished manuscript to shipowners, where he states that "the trees on the extreme northern and southern islets (i.e. Nake, South) are about 80 to 100 feet high" (Arundel 1875). Beginning in 1885, coconuts were planted on about half of the motus, but the copra industry failed twice, and from 1929 to 1987 the atoll was essentially uninhabited.

Dixon made the first true botanical collection in 1883 during the Solar Eclipse Expedition (in Trelease 1884). All specimens were from South Island except *Laportea ruderalis*. His collection included several ornamentals and vegetables grown by early settlers (Lucett 1851) but not reported since, an important point as these temporary introductions have since been cited in the literature as part of Caroline's 35 plant species. Many were not found by the POBSP party, yet because no scientific investigations had been conducted for 80 years, they were counted as part of the atoll flora (Clapp & Sibley 1971a). Two more visits to Caroline, plus periodic searching by the Falconers, have also failed to uncover most of these ornamentals.

Vascular Plants of Caroline Atoll

Plant Collections

To avoid duplicating Long's plant collection (Clapp & Sibley 1971a), we collected only 5 specimens in 1988 and 33 in 1990. Dr. D. Herbst assisted with identification, prepared and deposited the specimens with Long's in the Bernice P. Bishop Museum, Honolulu, Hawaii. Collection numbers preceded by 'K' were collected by A. Kay Kepler; those preceded by 'L' are those of the late C. R. Long. Earlier collections of Bennett in 1835 (Bennett 1840) and Dixon in 1883 (in Trelease 1884) are noted by date only.

Working with Long's location records for some species has proven difficult. He was working with an incorrect map (Fig. 7), which showed only 25 islets instead of thirty-nine. Much of his work was done at night, which in some places would have made it hard for him to determine his exact location. His references to South, Long, and Nake are undoubtedly correct, and presumably the following: "second islet south of Long" = Crescent; "islet northeast of South Island" = Tridacna; and "fourth islet north of Bird Islet" = Emerald. Long records *Pandanus* on the "second islet south of Nake Island," which lacked *Pandanus* when we surveyed the island. Moreover, the first islet south of Nake supports an extensive grove of large *Pandanus* trees on its eastern (lagoon) shore, and we feel confident in ascribing Long's specimen to this island, which we had named "Pandanus" because of this grove. To be consistent, we have ascribed all his other "second islet" specimens to Pandanus Islet as well, and assume he made no collections on the actual second islet (Danger). However, Sibley (pers. comm.), the ornithologist, told us that the party visited every islet.

Species Lists, Annotated Checklist and Maps of Terrestrial Vascular Plants

Following recent authors (Lamberson 1987, Sachet & Fosberg 1983), we do not consider Caroline's transient or extinct vascular species (Table 1) or the vegetables and ornamentals in the Falconer's garden as part of Caroline's viable flora. Table 2 summarizes the current flora, detailing the relative abundance of each species within each plant community. These tables are based on sight records supplemented by all collections, past and present. No beach drift seeds are known from Caroline apart from those species already represented. English and Gilbertese names in Tables 1 and 2 are from Thaman (1987), St. John (1973), and Perry & Garnett (n.d.). If no common name is available, the Hawaiian name, familiar to many students of Pacific botany, is used.

Table 3 lists the distribution and abundance of plant species (with subdivisions into tree, shrub and herb components) on all motus. Figs. 11-25 map the entire atoll distribution of each species according to data from transects and aerial maps.

Families are arranged phylogenetically, according to Fosberg & Sachet (1987), with species arranged alphabetically within each family. The taxonomy of vascular plants follows W. Wagner et al. (1990), and ferns H. Wagner (pers. comm.). "% cover" means the percentage of the ground area covered by a particular plant species. In all text and tables the following symbols apply:

° New record for Caroline

* Indigenous--plants native but also occurring elsewhere (I)

Table 1. Plants reported from Caroline Atoll, but considered to be transient or extinct members of the flora.[1]

Scientific Name	English and Gilbertese Names	Date Last Reported	Comments
CLASS ANGIOSPERMAE			
Family Gramінae			
Eleusine indica (L.) Gaertn.	goosegrass, te uteute	1884	Introduced weed
Eragrostis amabilis (L.) H. & A.	lovegrass, te uteute	1884	Introduced weed
Family Cyperaceae			
*Kyllinga brevifolia Rottb.	kyllinga		One clump by cistern, South Is., on recently disturbed ground
Family Bromeliaceae			
Ananas comosa L.	pineapple, te bainaboro	1884	Introduced for cultivated fruit
Family Liliaceae			
Crinum sp.	lily, te kiebu	1884 Presently cultivated	Introduced ornamental. One small specimen found on South Is. by Anne Falconer, 1990. Collection no. K-90-14
Family Moraceae			
*Artocarpus altilis (Park.) Fosb.	breadfruit, te mai	Presently cultivated	Not yet established, 2 trees on South and Ana-Ana
Ficus carica L.	common fig, te biku	1884	Introduced for cultivated fruit
Family Basellaceae			
Boussingaultia gracilis Miers	Madeira vine	1884	Introduced "vine climbing over portico" (Trelease 1884)
Family Leguminosae			
Inocarpus fagifer (Parkins. ex Z) Fosb. (= I. fagiferus)	Tahitian or Pacific chestnut, mape (Tahiti), te ibi	1840	Unsuccessful introduction in 1834. Food plant
Vigna marina (?)	beach pea		"Vigna luteola in clearings on South Island" (Line Island Expedition Report 1974). Not noted or collected otherwise. Perhaps a misidentification of Ipomoea macrantha?
Family Euphorbiaceae			
Euphorbia hirta (= E. pilulifera)	garden spurge, sleeping plant, te kaimatu	1884	Introduced weed, unsuccessful
Family Guttiferae			
Calophyllum inophyllum L.	Alexandrian laurel, tamanu (Tahiti), te itai	1884	In the 1940s, a "few taller Calophyllum and Pisonia" (N.I.D. 1943). No other reference; did observer confuse Calophyllum with Cordia?
Family Caricaceae			
Carica papaya	Papaya, pawpaw, te babaia, te mwemwera	Presently cultivated	Cultivated for fruit in 1884, not seen in 1965. In garden on Ana-Ana, one on South Is. by cistern
Family Cucurbitaceae			
Cucurbita pepo L.	Pumpkin, te baukin, te bamakin	Presently cultivated	Cultivated in 1884, not found in 1965
Family Convolvulaceae			
Ipomoea batatas L.	Sweet potato, te kumara	Presently cultivated	Introduced in 1840, not reported again until this expedition (tubers brought in 1988). Collection nos. K-159, -160
I. pes-caprae brasiliensis (L.) v. Ooststr.	beach morning glory, pohuehue (Hawaii), te ruku		Found in 1965 by copra shed; extensive searching on 3 expeditions in 1988 and 1990 failed to find it
Family Scrophulariaceae			
Russelia equisetiformis Schlecht.	Coral plant, te kaibaun ("golden plant")	1884	Unsuccessful introduction in 19th century

[1] Since 1988, the Falconers have added more vegetables and ornamentals to their ever-expanding garden: green beans, lemon grass, peppermint, okra, banana, Tahitian gardenia (tiare), tomato, breadfruit, red hibiscus, etc.

*Not previously reported from Caroline Atoll.

Table 2. Vascular flora of Caroline Atoll: relative abundance of each species within the major ecosystems, with data on seabird utilization.[1]

Scientific Name	Common & Gilbertese Names	Seabird Utilization: Breeding	Seabird Utilization: Roosting	Natural Ecosystems, Coastal: Natural Herb Mat	Natural Ecosystems, Coastal: Beach Scrub With Suriana	Natural Ecosystems, Coastal: Tournefortia Scrub	Natural Ecosystems, Inland: Tournefortia Forest	Natural Ecosystems, Inland: Pisonia Forest	Anthropogenic Ecosystem: Coconut Woodlands: Cocos Plantation	Anthropogenic Ecosystem: Coconut Woodlands: Dying Cocos/Ipomoea Plantation	Anthropogenic Ecosystem: Coconut Woodlands: Mixed Forest With Cocos
TREES											
Pisonia grandis	pisonia, puka tree, te buka	X	X		R	UC	C	A	L,UC	L,UC	R-C
Morinda citrifolia	Indian mulberry, te non			O	C	R-C	R-VC	R-A	R-C	C	O
Cocos nucifera	coconut, te ni	X	X			R-O	UC	O	A	A	C-A
Cordia subcordata	sea trumpet, kou (Hawaii), te kanawa	X	X			UC	UC-C	R-VC		L,UC	R
Pandanus tectorius	pandanus, screwpine, te aroka, te kaina	X	X		O	C	C	O	O		A
Hibiscus tiliaceus	beach hibiscus, hau (Hawaii) te rau								L,R		
Thespesia populnea	milo (Hawaii), te bingibing								L,R		
SHRUBS											
Tournefortia argentea	tree heliotrope, te ren	X	X	O-UC	VC	A	A	UC-A	UC		C
Suriana maritima	bay cedar, te aroa, te marou			O	VC-A	O					
Ximenia americana	monkeyplum					S			LA		
•Scaevola taccada	scaevola, saltbush, half-flower, te mao			R							
HERBS											
Heliotropium anomalum	"sand rose," hinahina (Hawaii)	X	X	A	UC	VC					
Boerhavia repens	pigvine, te wao			R-UC	R-C	R-A	R-A	R-A	UC-A	UC	C-A
Portulaca lutea	yellow portulaca, seaside purslane, te bointari, te boi			O-A	R-UC	UC-C	O	L,O		R-C	R
Laportea ruderalis	"nettle," te ukeuke, te nekeneke			R-VC	UC	C-A	C	LC	LC	R-UC	UC-C
Achyranthes canescens						R-C	C	C	O		A
Phymatosorus scolopendria	maile-scented fern, laua'e or lawai fern, te raukota, te keang				R	LC	LC	C-A,L	R-A	R-UC	C-A
Lepturus repens	bunchgrass, te uteute			R-UC	UC-A	L,R-A			R		
Ipomoea macrantha	morning glory, wild moon-flower, te ruku					R	R	R-UC	UC	A	
Tacca leontopetaloides	Polynesian or island arrowroot, pia (Hawaii & Tahiti), te makemake								LA		
Lepidium bidentatum	peppergrass			LR		LR					
Psilotum nudum	upright psilotum, "reed fern," te kimarawa								LR		
Phyllanthus amarus									LR		
Sida fallax	'ilima (Hawaii), te kaura								LR		
+Digitaria sp.	crabgrass, te uteute								(S)		
Tribulus cistoides	puncture vine, te kiebu			R							

[1] Excludes transient and extinct species (Table 1). Species arranged according to their overall abundance on the atoll.
•New records for Caroline.
+Not seen on this expedition, last seen 1965 (Clapp and Sibley 1971a).

** Aboriginal introduction--useful plants brought by Polynesians in pre-historical times (AI)

Recent introduction--plants of accidental or deliberate introduction after Western discovery of the atoll (RI)

A Abundant--the major or dominant species in a given area

VC Very common--often seen but not quite as abundantly as above

C Common--generally distributed in large numbers

UC Uncommon--observed uncommonly but >10 times in a given area

O Occasional--here and there, often widely scattered but not forming a major component of the vegetation

R Rare--observed 2-10 times in a given area

S Single--only one specimen observed

L Local--found only or principally in one or more restricted areas

D Drift seedling--plant derived from a water-borne seed

+ Not seen 1988-1990 but probably still present

PSILOTACEAE

* *Psilotum nudum* (L.) Beauv Fig. 11

Formerly Known Distribution: L-3233 from Nake.

Present Distribution: Cosmopolitan, common on remote islands, rare on Caroline. K-90-15 from South. In 1965 common on wet base of *Cocos* only on Nake. In 1988 and 1990 a few clumps found similarly on South in shady, damp locations, close to lagoon, under 18 m canopy, northwest sector.

POLYPODIACEAE

* *Phymatosorus scolopendria* (Burm. *f*) Pichi-Sermolli Fig. 12, Pl. 34
Phymatodes scolopendria (Burm. *f.*) Ching
Polypodium phymatodes L.
Polypodium scolopendria Burm. *f.*
Microsorium scolopendria (Burm.) Pichi-Sermolli

Formerly Known Distribution: Recorded 1840, collected 1884; L-3244, L-3250, L-3287 from Nake, Long and South Islands.

Table 3. Distribution and abundance of plant species on Caroline Atoll.[1] Motus are arranged geographically from north to south (windward), then similarly on the leeward side.

	Nake	Long	Bo'sun Bird	Windward	Crescent	Atibu	North Pig	Pig	Skull	North Brothers	Brothers	Noddy Rock	North Arundel	Arundel	Tridacna	South	Pandanus	Danger	Booby	Coral	Lone Palm	Kota	Mouakena
			Windward Motus														South Nake Motus						
TREES (7 spp.)																							
Pisonia grandis	A	VC		A	A		A	A		A	A		VC	A	R	R	VC	A	VC	UC	R	R	R
Morinda citrifolia	UC	UC		UC	O		R	UC		R	O		O	UC	VC	C	R	R	R	R	R	R	
Cocos nucifera	LA	LA						LR			LO		R			A					LR	LR	
Cordia subcordata	UC	UC		C	LA		C	VC		C	VC		C	UC		R		LA					
Pandanus tectorius	LA															LO	LA						
•Hibiscus tiliaceus																LR							
•Thespesia populnea																LR							
SHRUBS (4 spp.)																							
Tournefortia argentea	A	A	VC	A	A	O	A	A	O	A	A	O	A	A	A	C	A	A	A	A	A	C	A
Suriana maritima		LR									LR				LC	UC,LC							
•Scaevola taccada				S																			
•Ximenia americana								S								LA							
HERBS (15 spp.)																							
Heliotropium anomalum	C	VC	UC	C	C	UC	UC	UC	R	UC	C		O	UC	VC	C	C	O	UC	UC	UC	UC	R
Boerhavia repens	C	LC		C	C		C	C		UC	C		A	UC	C	VC	C	O	O	R	R	R	R
Portulaca lutea	C	C	C	C	C	UC	UC	C	C	A	A	A	A	C	C	C	C	UC	O	O	O	O	R
Laportea ruderalis	C	VC		C	UC		UC				C			C	UC	UC	C	O	O	R	R	R	R
•Achyranthes canescens	LC	O			O		C	O		LC			VC	VC	LC	R	O	O	R	R	R	R	R
Lepturus repens	R	R	R	R			R			R	R	C		C	C	O	R	R	R	R	R	R	R
Phymatosorus scolopendria	VC	LA,UC			UC		UC	UC						O	C	LA,UC					R	R	
Ipomoea macrantha	LC	O		UC				O								A							
Tacca leontopetaloides	+LC															LR							
Psilotum nudum	+LR															LR							
Phyllanthus amarus																LC							
Tribulus cistoides		S																					
Sida fallax																LR							
Lepidium bidentatum																S							
+Digitaria sp.																S							

Table 3. Continued.

	Central Leeward Motus											Southern Leeward Motus							
	Mannikiba	Blackfin	Matawa	Emerald	Shark	Scarlet Crab	Nautonga	Azure	Reef-flat	Bird	Fishball	Raurau	Eitei	Pisonia	Kimoa	Ana-Ana	Total	% Frequency On Each Motu[2]	Origin
TREES (7 spp.)																			
Pisonia grandis	C	VC	UC	C	A		O	R		A		A	C	A	VC	A	32	82	I
Morinda citrifolia	R		R	R	R		R			R	O	UC	R	R	R	C	30	77	I,AI?
Cocos nucifera	LR	LR		LO	LR					LR		LR		LO		LC	17	44	AI,RI
Cordia subcordata	O	UC	C	O	LO		O			UC		C	C	C	C	C	23	59	I
Pandanus tectorius			R	C	C							LR		LR		LR	9	23	I,AI?
*Hibiscus tiliaceus																	1	3	RI?
*Thespesia populnea																	1	3	RI?
SHRUBS (4 spp.)																			
Tournefortia argentea	A	A	A	A	A	R	C	C	R	A	UC	A	A	A	A	A	39	100	I
Suriana maritima			R							UC			LR	LR	LR	O	10	19	I
*Scaevola taccada																	1	3	I
*Ximenia americana	5																2	5	RI
HERBS (15 spp.)																			
Heliotropium anomalum	C	C	C	C	C	R	C	C	R	R	UC	UC	C	C	C	UC	38	98	I
Boerhavia repens	C	UC	UC	C	UC	R	R	R		UC	R	UC	UC	UC	O	C	34	88	I
Portulaca lutea	C			C	UC	R	R	R	R	UC	R	UC	C	UC	C	LC	37	95	I
Laportea ruderalis	UC	UC	O	C	UC	R	R	R		R	R	UC	VC	UC	O	C	32	82	I
*Achyranthes canescens	UC	O	R	UC	LA		R	R		UC	R			O	C	O	29	72	I
Lepturus repens	R	R		R		R				UC	R			R	R	UC	27	69	I
Phymatosorus scolopendria	O				R											UC	14	36	I
Ipomoea macrantha														O		R	7	18	I
Tacca leontopetaloides																	1	3	RI,AI?
Psilotum nudum																	1	3	I
Phyllanthus amarus																	1	3	X
Tribulus cistoides																	1	3	I
Sida fallax																	1	3	I
+Lepidium bidentatum														5			2	5	I
+Digitaria sp.																	1	3	?

[1] Species arranged according to frequency of occurrence. List excludes transient and extinct members of the flora (Table 1).
[2] No. motus having a particular species, divided by total no. motus x 100%.
*New records for Caroline.
+Not seen on 3 visits but possibly still present.

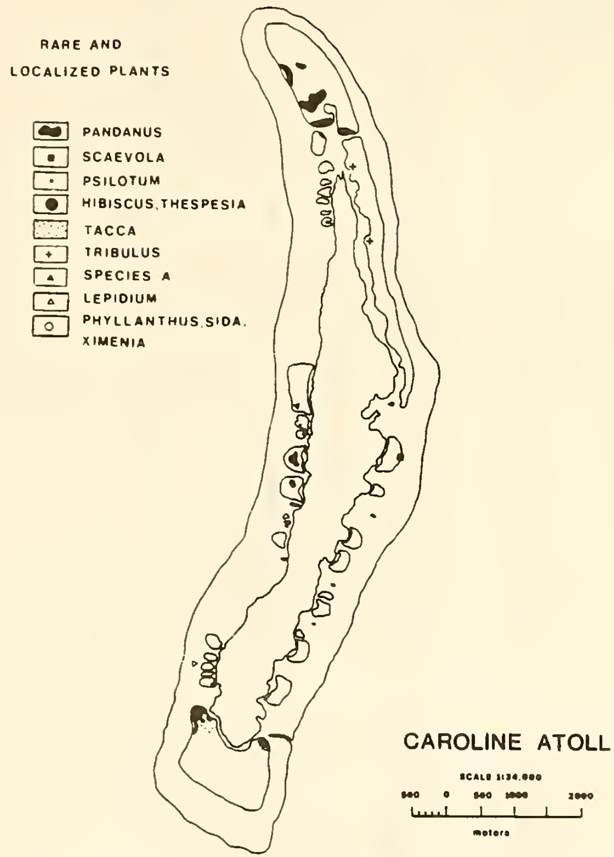


Figure 11. Entire distribution map of rare and/or localized plants on Caroline Atoll: *Hibiscus tiliaceus*, *Lepidium bidentatum*, *Pandanus tectorius*, *Phyllanthus amarus*, *Psilotum nudum*, *Scaevola taccada*, *Sida fallax*, *Tacca leontopetaloides*, *Thespesia populnea*, *Tribulus cistoides*, *Ximenia americana*, and Species A. *Psilotum* may still exist on Nake.

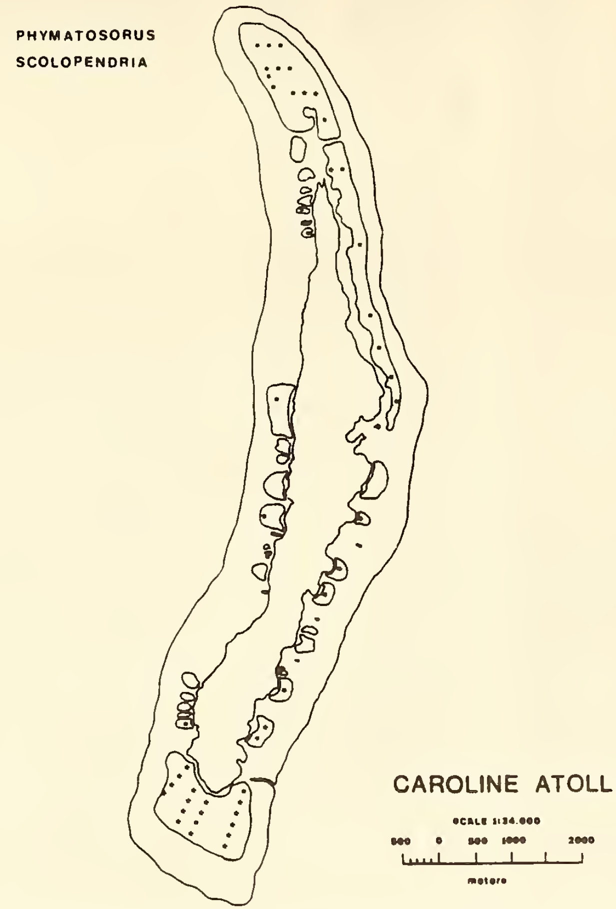


Figure 12. Transect distribution map of the fern *Phymatosorus scolopendria* on Caroline Atoll.

Present Distribution: Range extension from 3 to 11 motus. Rarely a continuous ground cover, locally rare to abundant. Commonest on Nake, 10-80% cover. Well represented on South, especially in open areas of the interior, where soils are moister. On other motus local distribution varied from less than 1 to 80%; accurate mapping is difficult. Absent from motus less than 0.6 ha in size, where habitats cannot provide appropriate cover, moisture, and substrate.

Ecology: Hardy. Leaves burn in sun but can withstand very dry conditions. Primarily in *Tournefortia* scrub, mixed forests with *Pisonia* and *Pandanus*, or *Cocos* plantations. Associated with *Cordia, Morinda, Suriana*. In open clearings within dying *Cocos* forests occurs in dense mats intermingled with *Boerhavia, Ipomoea*, and *Portulaca*. Sometimes gathers in thick bands at the interface of *Tournefortia* and *Pisonia* forests. Prefers shelter from winds, high humidity, "soil," and relative lack of wind, but absent from deeply shaded forests. Rhizomes never exposed on ground surface or epiphytic on trunks, as in wetter islands such as Hawaii or Samoa (pers. obs.) or in the moister Line Islands (Wester 1985), indicating that Caroline's habitats are suboptimal. Although most ferns are not halophytic, this species grew (rather stunted) in 1988 amongst sparse herb mats (1% cover) on older beach sands of an ancient reef channel on Long Island (Tr. C), where rainfall provides the sole fresh water, but was (temporarily ?) obliterated in February 1990. Rare to uncommon in outer beach strand, and beach scrub with *Suriana* (South, Arundel, Shark).

Substrata: Dry coral rubble, sand and gravel, rubble with sparse humus, lagoon mud, relatively fertile humus, older beach sands.

PANDANACEAE

* **? *Pandanus tectorius* Park. Fig. 11; Pls. 35-38

Formerly Known Distribution: Recorded 1840, unidentified *Pandanus*; L-3227, Pandanus Islet, seen on Nake by Long.

Present Distribution: A minor plant community (Sect. G), *Pandanus* is primarily associated with *Tournefortia* or *Pisonia* on the leeward motus. Most common on Nake. Range extension from 2 to 7 motus.

Phenology: Flowers and fruit in October, March, and May.

Substrata: Variable. Prefers lagoon mud, pure sand and rubble-humus, but survives in almost pure rubble.

GRAMINAE

* +? *Digitaria* species

Collected 1883 and recorded as ?*Panicum* (*Digitaria*) *marginata*. Examined by Long, who believes it a *Digitaria* identical to his L-3235. Not found by the authors.

* *Lepturus repens* (Forst. f.) R. Br. Fig. 13, Pl. 2

Formerly Known Distribution: Collected 1883; L-3211, 3221, 3236, 3238, 3247, 3259, 3286 from Windward, Tridacna, Nake, Long, Emerald, Crab and South Island, respectively.

Present Distribution: Many Pacific atolls. K-88-4, 5; 90-1, 2, 19 to 21, 25 from South, Tridacna, and Ana-Ana. On Caroline, range extension from 6 to 26 motus.

Ecology: Patchy, rare to locally common. Usually in exposed herb mats with *Heliotropium, Laportea, Portulaca,* and low *Tournefortia* scrub. Abundance 1-5% cover where not in thick patches. Occasionally inland under *Tournefortia, Cordia* or *Cocos*, persisting as forest undergrowth. Tufts tiny (few centimeters), dry and scrappy in exposed areas, but to 3 dm where shaded. Never in tall, upright clumps, as turf, or in the same abundance as on the drier, filled-in equatorial atolls or islands with sandier habitats (Christopherson 1927, Fosberg 1953, pers. obs.).

Substrata: Able to survive in coral rubble of varying coarseness, down to high water mark, but preferred habitat is part sand. L-3286 was from "numerous clumps under *Suriana* scrub on South Island," perhaps the low, sandy portion of the northwest point (Pl. 45), our best *Lepturus* site. Comparison of Arundel's chart (1883), recent aerial surveys, and earlier photographs indicate that several motus have altered shape since 1883. The amount of open area on South Island has also decreased markedly since 1883. The distribution of *Lepturus* parallels these changes; there is clearly much less on South Island, and more in newly-created islet fringes.

Since 1965 the lagoon shore of South Island has become overgrown by *Cocos*, so much that both *Suriana* and *Lepturus* are much less common than previously (Pls. 39, 40). However, sand and debris will always be shifting, so that *Lepturus* will move from place to place, establishing wherever conditions permit. In the second situation, a comparison of Plates 2 and 23 from 1883 and 1988, respectively, shows that a century ago the lagoon-facing shores of South Island were far more open than the dense *Cocos* plantations of today. The clumped grass in the foreground of Plate 2 is undoubtedly *Lepturus*, probably mixed with introduced grasses not seen since that time (*Eleusine indica, Eragrostis plumosa*), and the dubious *Digitaria* sp.

PALMAE

** # *Cocos nucifera* L. — Figs. 14, 36, 51; Pls. 2, 3, 17, 23, 34, 37, 44

Formerly Known Distribution: Recorded 1840, 1884; L-3285 from South Island, extensive groves on South and Nake, scattered on north portion of Long.

Present Distribution: Range extension from 3 to 15 motus. Planted groves on South, Nake, and Long; the rest derived from drift.

Phenology: Flowers and fruit year-round.

Ecology: Forms a major vegetation type (Sect. F). Primarily South and Nake, where closed canopy forests average 21 m high.

TACCACEAE

**? *Tacca leontopetaloides* (L.) O. Kuntze — Fig. 11
Tacca pinnatifida Forster

Formerly Known Distribution: Normally an aboriginal introduction on Pacific islands, but on Caroline is first mentioned as planted in 1834 (Bennett 1840); L-3213, 3219, and K-90-7, 16 from moist muck, South Island. L-3234, common under *Cocos* and numerous patches found in muck, south end, Nake.

Present Distribution: Common in northwest South. None in flower; each plant had 2-3 leaves, possibly dying back. None found on Nake, despite searching the south end. Has large underground tubers, dies back, and though cultivated, still occurs spontaneously in *Cocos* groves on many atolls. Harvested by the Falconers.

Ecology: Needs fine, moist soil and shade. Though its seeds float for months (Guppy 1906), it has not established itself on other motus in 150 years, probably due to the prevalence of rubbly substrates.

Phenology: Flowers and fruit in March and May, dies back in October.

URTICACEAE

* *Laportea ruderalis* (Forst. f.) Chew — Fig. 15
Fleurya ruderalis (Forst. f.) Gaud. ex Wedd

Formerly Known Distribution: Reported 1840, collected 1884. L-3215 common in shady areas South Island; L-3229 scattered on exposed coral and sand, west side Crescent Islet. L-3253 under shade of *Cocos* and *Pisonia* on north side of Long Island.

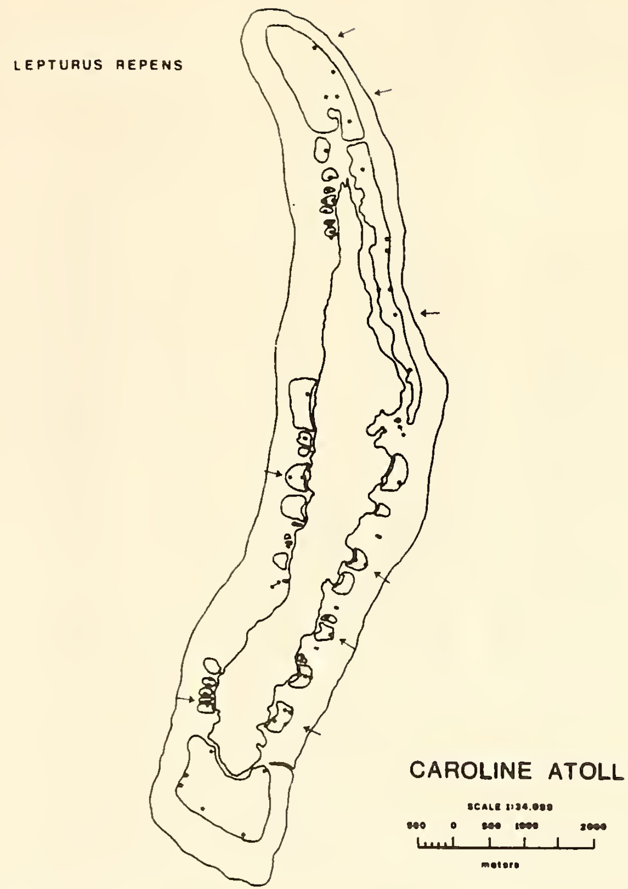


Figure 13. Transect distribution map of the grass *Lepturus repens* on Caroline Atoll. Arrows indicate areas of highest density.

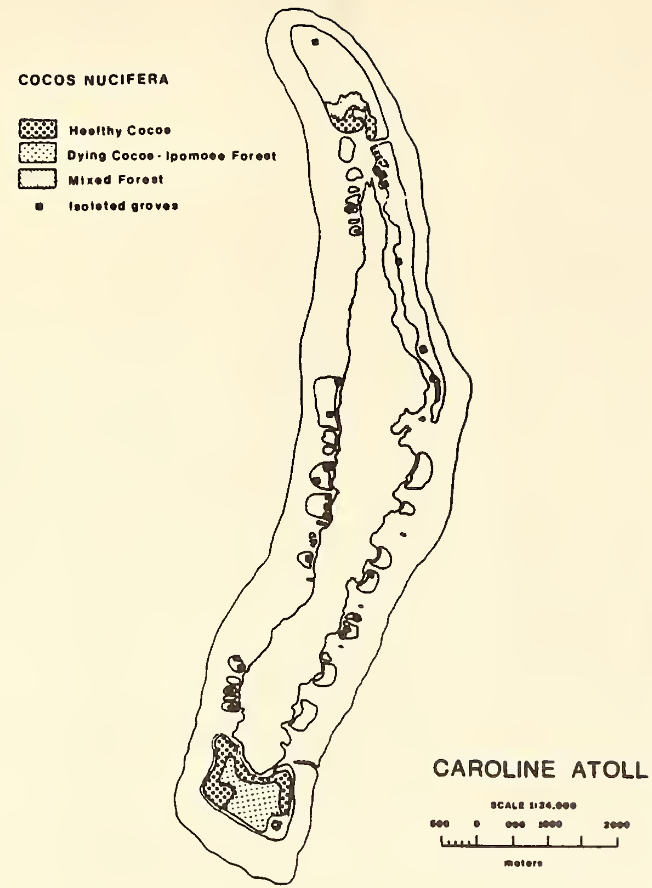


Figure 14. Entire distribution map of the coconut *Cocos nucifera* on Caroline Atoll. Note that the dying *Cocos-Ipomoea* forest covers approximately two-thirds of the original plantation.

Distribution and Abundance: K-88-3 South Island, Transect 1, elevation 0.3 m, under old *Cocos* plantation, in humus and rubble. Range extension from 3 to 32 islets (Table 3). Commonest and most widespread ground cover, patchily distributed. Rare to locally abundant, percentage cover from less than 1% in herb mats of tiny motus to 60% in tall *Pisonia* forest. Best represented on Nake, Long, Brothers, South, Pisonia, Eitei and Mannikiba, where coverage exceeded 50% in appropriate habitats. To 1.1 m tall on Kimoa.

Ecology: Largest (to 0.5 m) specimens found under *Tournefortia*, *Pisonia*, *Cocos*, or *Pandanus*. Tiny (1-2 cm) and tougher in sunny, exposed sites. Halophytic, pioneering in herb mats on islets less than 0.75 ha in size (e.g. Fishball). Optimum habitat is *Tournefortia* scrub, in sunny clearings or belts behind beach scrub. Uncommon in *Pisonia* forest. Occurs in both windward and leeward sites, but in greater density leeward. Will persist through several stages of plant succession if given adequate shade.

Phenology: Flowers and fruit in October, March, and May.

Substrata: Primarily beach gravel or coarse rubble. Also rubble-sand mixtures; not lagoon silt.

OLACACEAE

° * (#?) *Ximenia americana* L. — Fig. 11

Never previously collected. K-90-170 South Island, 50-100 m north of cistern, elevation 0.3 m, 10-20 m from coastal *Tournefortia* fringe, within *Cocos* plantation. Collected by crew of the yacht *Amanita* and posted by Anne Falconer to AKK. K-90-23 and 24, single sterile shrub 2.5 m tall, southwest Motu Mannikiba, leathery leaves, arching stems 4-5 m long. Found by John Phillips, collected by JP and AKK, identified by D. Herbst and R. Fosberg.

Distribution and Abundance: Locally abundant in one location, about 50 bushes (3-4 m high, 2-3 m wide) spread over about 100 m. Adjacent to indigenous scrub, on edge of *Cocos* plantation near old settlement.

Phenology: Flowering in July 1990.

Substrata: Moist soil (South), coarse strand rubble (Mannikiba).

AMARANTHACEAE

° * *Achyranthes canescens* R. Br. — Fig. 16, Pl. 41

Never previously collected. K-88-1 South Island, Transect 5, to 0.7 m, elevation 0.3 m, in *Tournefortia* fringe, coral rubble.

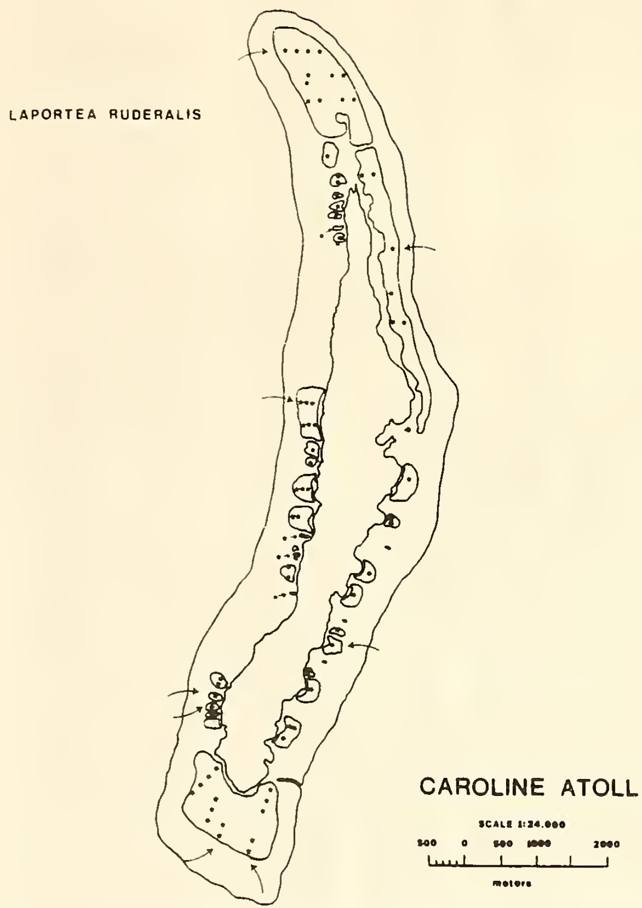


Figure 15. Transect distribution map of *Laportea ruderalis* on Caroline Atoll. Arrows indicate areas of highest density.

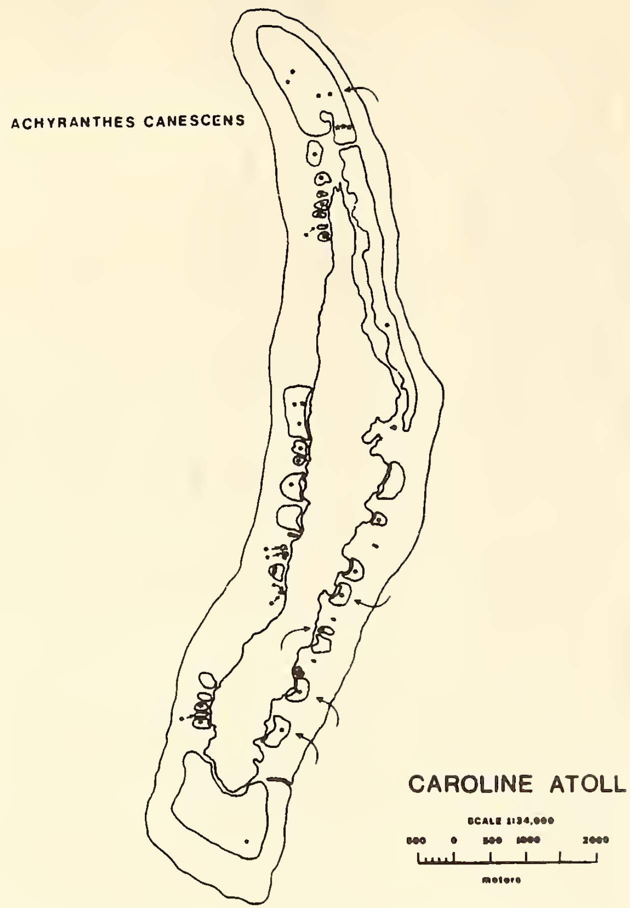


Figure 16. Transect distribution map of *Achyranthes canescens*. Arrows indicate areas of highest density.

Distribution and Abundance: Quite widespread, primarily in interior scrub and forest of 19 motus (Table 3), from tiny, barely vegetated Fishball (0.73 ha) to the largest, South (106 ha). Density variable: from less than 1% in *Tournefortia* scrub to 50% local ground cover in mixed *Pandanus* forest. Primarily associated with *Tournefortia*. May be locally abundant in clearings in *Pisonia* forests, pure or mixed. Often in a zone dividing *Tournefortia* and *Pisonia* trees, especially on Pig, Brothers, and Nake.

Ecology: Never in natural herb mats. Needs shade but requires some direct sun; rare in pure stands of *Cocos* and *Pisonia*. Prefers small, sunny openings in forest or scrub. Drought-resistent and probably partly halophytic. Dies back annually in the dry season and reappears with winter rains (Anne Falconer, pers. comm.). To 1.5 m tall. Little or no capacity for dispersal by sea. On other islands, seeds carried by birds, especially fruit pigeons (Guppy 1906), but pigeons are absent from the Line Islands. Perhaps dispersed by the Long-tailed Cuckoo (Ellis et al. 1990).

Phenology: Flowers and fruit present in October, March, and May.

Substrata: Lushest growth in humus soils of forest interiors. Often grows in pure rubble.

NYCTAGINACEAE

* *Boerhavia repens* L. Fig. 17, Pl. 34

Boerhavia diffusa L.
Boerhavia hirsuta: sensu Bennett 1840
Boerhaavia species: Dixon 1884

Formerly Known Distribution: Reported 1840, collected 1884; L-3210, 3324, 3239, 3225, 3252, 3262, 3289, 3291 from Windward, Tridacna, Nake, Long, Emerald, and South, respectively.

Present Distribution: Cosmopolitan, widespread in the Pacific. K-90-164 and 165 from Ana-Ana. Range extension on Caroline from 6 to 33 motus (Table 3).

Abundance: Present in every habitat, leeward and windward, ranging from less than 1 to 80% cover. Often in large patches. Best locations (>50% cover) on Nake, Long, Windward, Pig, Brothers, Arundel, Tridacna, South, Ana-Ana, Pisonia, and Pandanus Islets.

Ecology: Mostly found beneath *Tournefortia*, either in pure scrub or mixed with *Pisonia*, *Cordia*, *Morinda*, *Suriana*, or *Cocos*. Not in deep *Pisonia* shade; rarely in herb mats. Thick ground cover in indigenous scrub (Shark) or within clearings in old *Cocos-Ipomoea* forest (South), where it mingles with *Phymatosorus*, reaching a high density (Pl. 34) and large size (rooting at nodes, vines exceeded 1 m long).

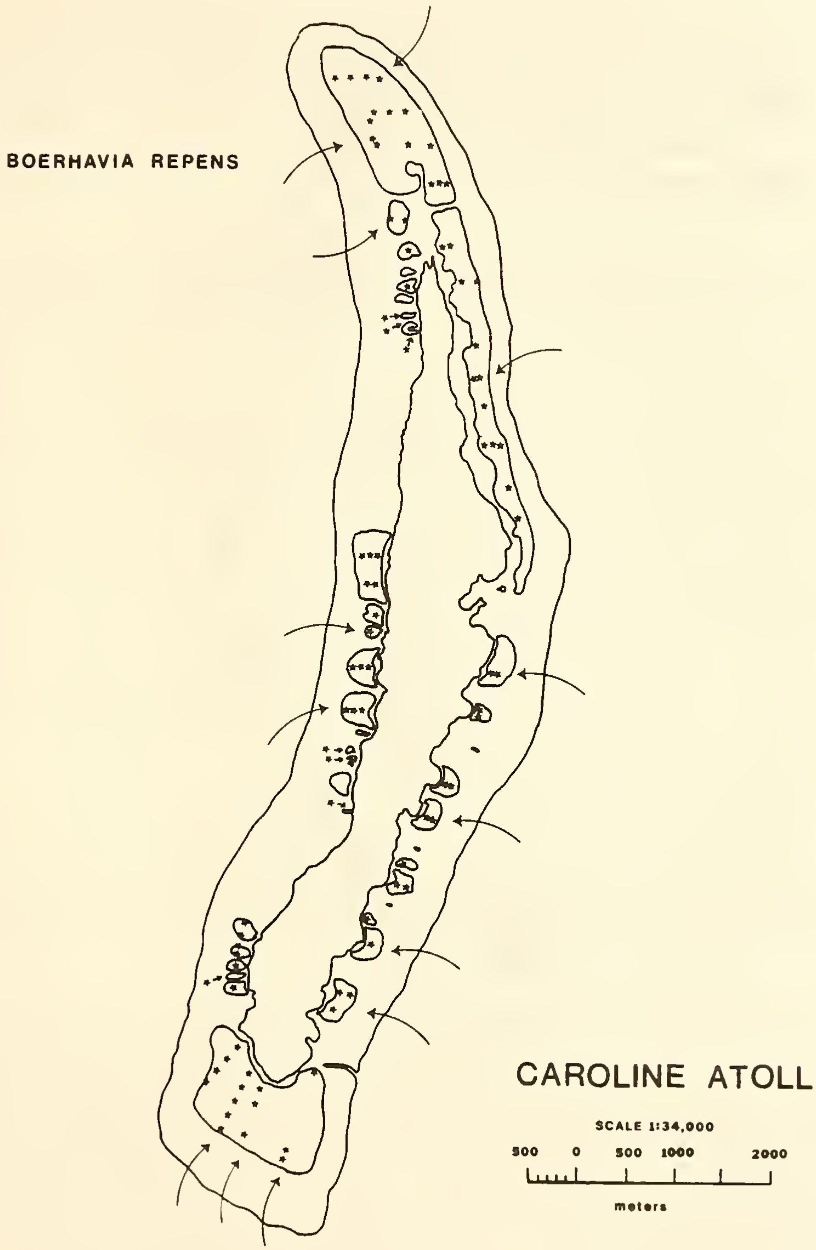


Figure 17. Transect distribution map of *Boerhavia repens*, Caroline Atoll. Arrows indicate areas of highest density.

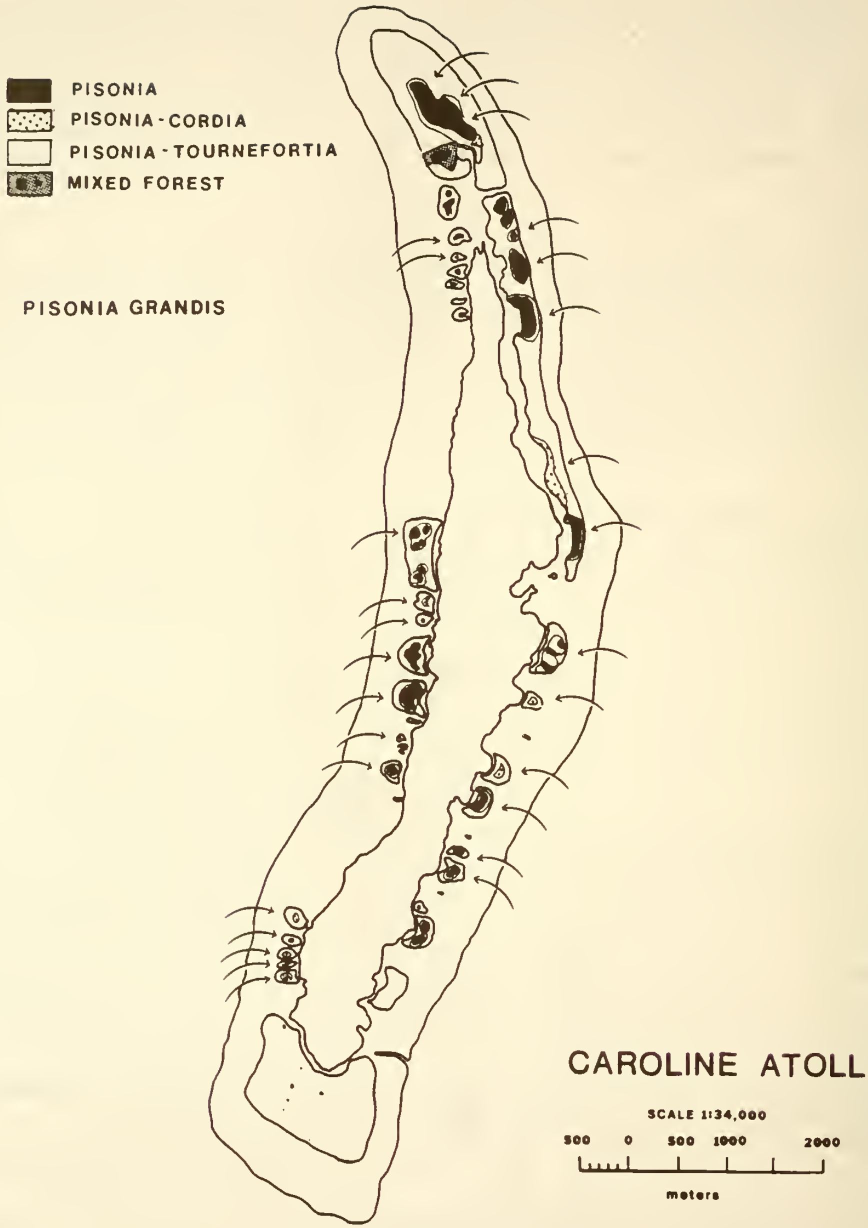


Figure 18. Entire distribution map of *Pisonia grandis*, Caroline Atoll. Arrows indicate forests from 10 to 21 m tall.

BIRDS: Bristle-thighed Curlews fed within the *Boerhavia* mat in old *Cocos* forests, South. Sticky fruits (3 mm long) found entangled in preened down and adhering to contour feathers of a juvenile Great Frigatebird (Pl. 42). Species is customarily dispersed around large oceanic areas and within atolls by tree-nesting seabirds (Guppy 1906, Ridley 1930).

Phenology: Small mauve flowers and seeds present in October, March, and May.

Substrata: Coral rubble with sand or humus, rarely pure beach rubble. Lushest growth in humus-and-guano-laden rubble clearings where *Pisonia* forest once grew.

* *Pisonia grandis* R. Br. Fig. 18, Pl. 43

Formerly Known Distribution: Collected 1884; L-3280 4 m tree, north shore, South. Small grove, north end, Long.

Present Distribution: Indo-Pacific. Caroline range extension from 2 to 29 motus (Table 3).

Abundance: A major plant community (Sect. G), of special conservation value.

Substrata: Occupies, and contributes to, best soils on atoll: mixture of rubble, humus, and guano.

PORTULACACEAE

* *Portulaca lutea* Solander ex Forster F. Fig. 19; Pls. 34, 38

Formerly Known Distribution: Reported 1840 and 1884; L-3233 and 3292, 3231, 3237, 3255, 3257, from South, Pandanus, Nake, Long, and Emerald, respectively, in open coral, rubble, gravel and exposed areas, to 1.5 dm high.

Present Distribution: Range extension from 5 to 33 islets (Table 3).

Abundance: Along with *Heliotropium anomalum* is a component of the plant community, Natural Herb Mat (Sect. G). Widespread, predictable on coast and former reef channels but local inland. Covered from one to 60% of land area on almost every transect, windward and leeward, especially facing lagoon. Best areas are Long, Transect 4 (36 m wide meadow); South, north end of Transect 6 (50 m wide); Brothers, lee, almost pure mat covering 20% ground (6 m wide); Kimoa, north side (8 m wide), 10 cm high; Eitei, north side, 5 cm high.

Ecology: Primarily occurs along edges of motus in rubble mat and open *Tournefortia* scrub, averages 12 cm high. Prominent in sparsely vegetated areas, extending seaward to high tide level. Halophytic; highly tolerant of sun. A flat mat in exposed areas but lusher inland, rising to 2 dm tall. Generally found with *Heliotropium*, *Lepturus*, *Boerhavia*, or *Laportea*, but may form pure mats. Uncommon in *Tournefortia* scrub, patchy in clearings within *Pisonia* forests up to 13 m high. Exceptionally common in old *Cocos* groves with *Boerhavia*, etc. (Pl. 34); otherwise rare or absent from closed canopy *Cocos* plantations. Pinker stems found in sunny sites. BIRDS: Provides nesting cushion for Masked Booby, Sooty Tern, Brown Noddy. On Noddy Rock, Brown Noddies nest on a thick mat of pure *Portulaca*. Feeding location for shorebirds.

Phenology: Flowers and fruit October, March, and May.

Substrata: Coral rubble and gravel, fine to very coarse. Healthier on older sands and coral-humus.

ZYGOPHYLLACEAE

* *Tribulus cistoides* L. Fig. 11

Formerly Known Distribution: Collected 1884. L-3245 in open sandy area among *Tournefortia* shrubs, Long Island. Not seen elsewhere on atoll.

Present Distribution: Not seen on our surveys, but present in 2 sites on west-central Long Island. K-90-161 (collected by Anne Falconer), probably from one of same sites as 1965 collection. Flowers in March.

SURIANACEAE

* *Suriana maritima* L. Fig. 20; Pls. 20, 39, 40, 44

Formerly Known Distribution: Collected 1884. L-3220, shrub to 1.8 m, east edge of Tridacna Islet.

Present Distribution: K-90-5, 6 from South Island. Range expansion from one to 9 motus (Table 3).

Abundance: Occasional. Forms a vegetation unit, Beach Scrub with *Suriana* (Sect. G).

Phenology: Flowers in March and May.

Substrata: Best sites in sand but also on coral rubble.

EUPHORBIACEAE

Phyllanthus amarus Schum. and Thonn. Fig. 11

Formerly Known Distribution: Collected 1884. L-3283, herb *Phyllanthus niruri* L. (Trelease 1884) to 4 dm, common on north side of South Island.

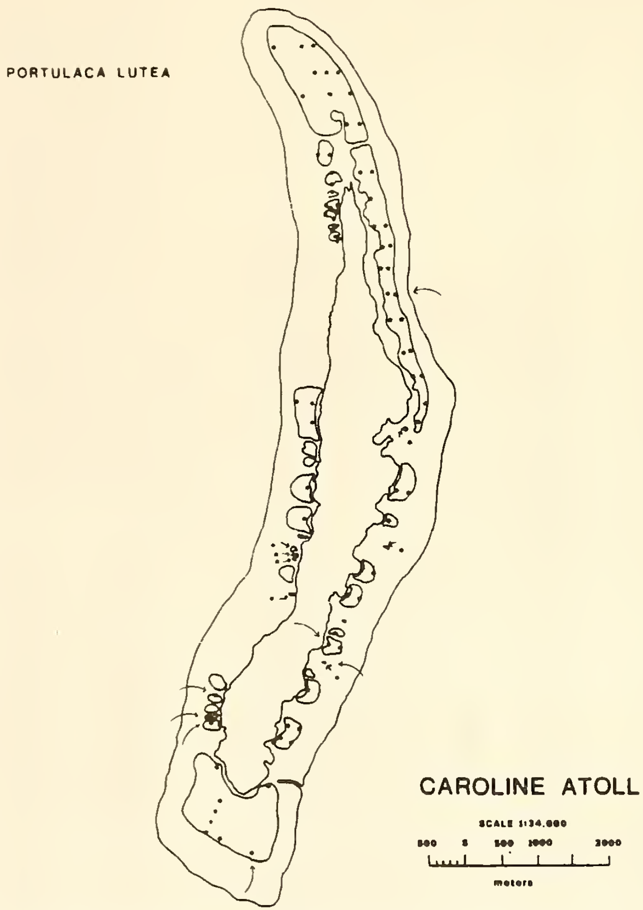


Figure 19. Transect distribution map of *Portulaca lutea*, Caroline Atoll. Arrows indicate pure *Portulaca* flats.

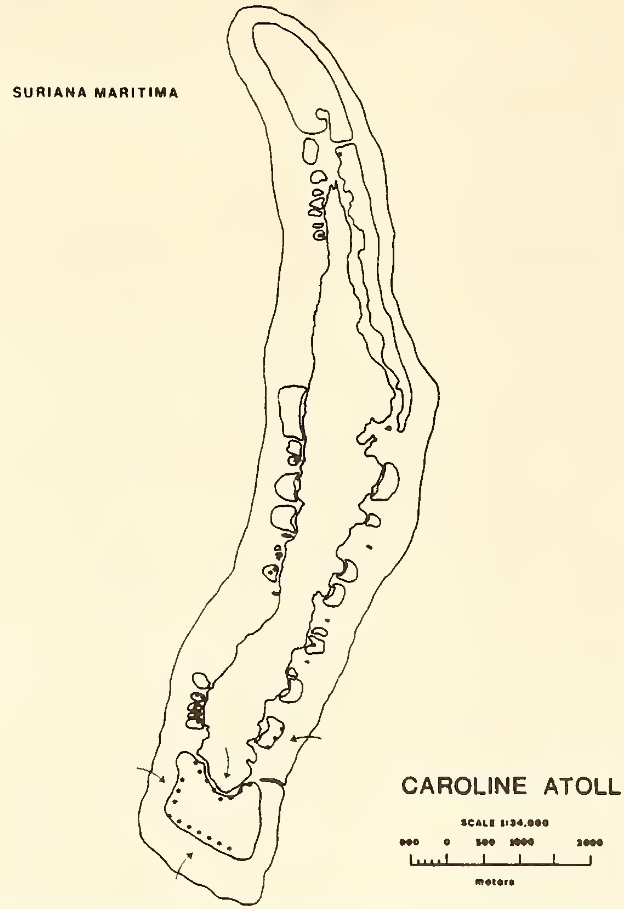


Figure 20. Transect and perimeter survey distribution map of *Suriana maritima*. Arrows indicate areas of highest density.

Present Distribution: K-90-10-13, herb, 2 small patches, South Island. Limited to a few square meters in the atoll's only weedy area, less than 10 m^2 in 2 small clearings by the recently-renovated cistern, South. A fairly common weed in the Society and Tuamotu Islands, probably arriving with 20th century copra-cutters and perhaps again within the last 2 years. Caroline's only established "weed" (excluding Polynesian introductions such as *Cocos*).

MALVACEAE

° * (**?) (#?) *Hibiscus tiliaceus* L. Fig. 11

Never previously collected. K-90-8, 9 from South Island, northwest peninsula, in *Cocos* plantation near old settlement and "landing," in coral rubble and humus, 0.6 m in elevation.

Present Distribution: Two or 3 large spreading trees in heavy *Cocos* shade, 10 m tall, with recumbent branches forming an impenetrable thicket, similar in size and form to specimens in Flint's settlement. Since Flint was evidently first settled in 1872 (i.e. no aboriginal population was present, see Kepler, in prep.), Caroline's trees, restricted to the old settlement area, are most likely recent Polynesian introductions.

° * (**?) (#?) *Thespesia populnea* (L.) Soland. ex Correa Fig. 11

Never previously collected. K-90-22, 154, 155 from South Island, in *Cocos* plantation and in lagoon strand, northwest peninsula, near "landing."

Present Distribution: Two trees (10 m tall), one near the cistern, the other in a fringe of native vegetation bordering the lagoon. The history of this species is probably the same as *Hibiscus tiliaceus*.

* *Sida fallax* Walp. Fig. 11

Formerly Known Distribution: Collected by Dixon, 1884, who found one specimen.

Present Distribution: Not seen for 106 years. K-90-156, 157, 158 from South Island, at edge of cistern, north side. One clump located in a sunny clearing, recently enlarged by the Falconers.

CONVOLVULACEAE

* *Ipomoea macrantha* R & S Fig. 21; Pls. 34, 37
Ipomoea tuba (Schlecht.) G. Don

Formerly Known Distribution: L-3228 and 3293, 3242, 3251 on South, Nake, and Long, respectively. Trailing vines, white flowers, stems to 25 m long climbing over *Tournefortia*, *Morinda*, and *Cocos*.

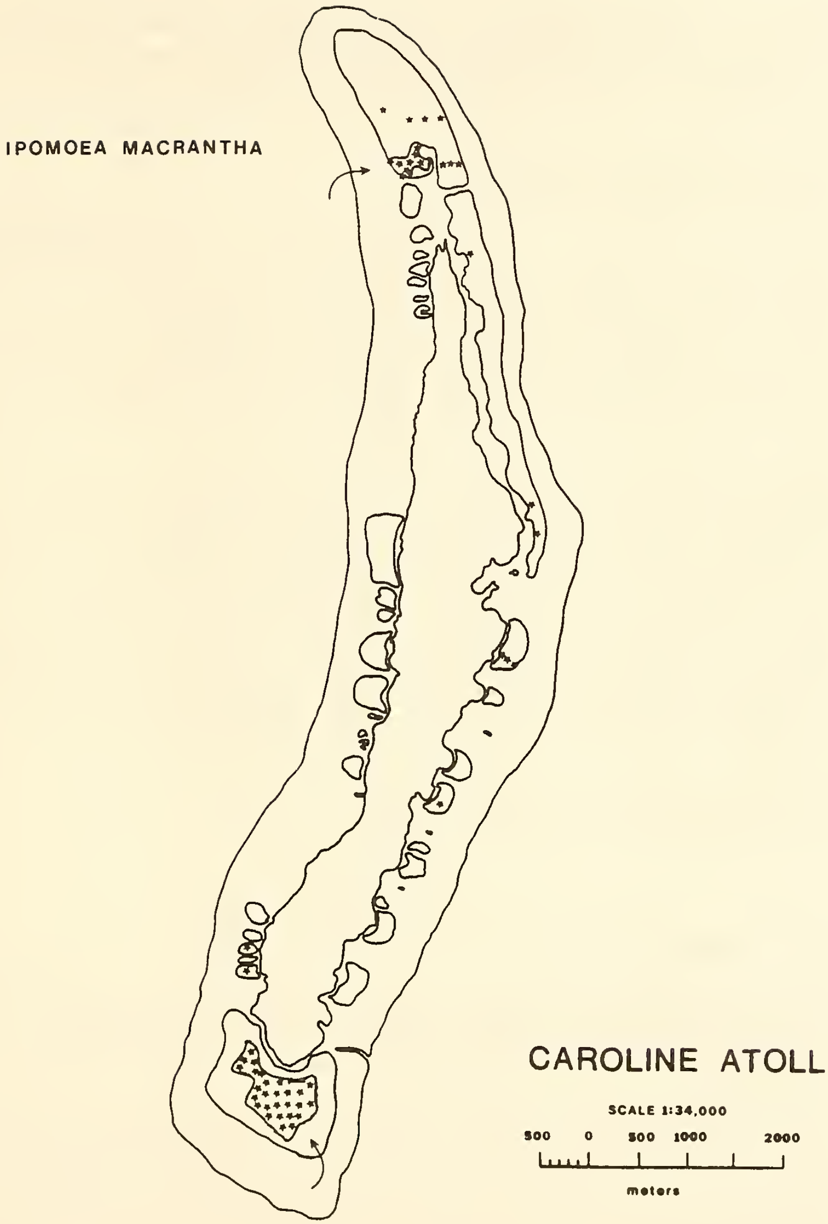


Figure 21. Transect distribution map of *Ipomoea macrantha*. Entire distribution is shown for South Island. Arrows indicate areas having significant amounts of this vine.

History: Not collected last century, though plantation records indicate that it was a major reason for the abandonments of the coconut plantations: "The Pohue Vine[2], which is the worst pest on the island, was reported in 1921 to be under control" (Young ca. 1922). Today it strangles about 54 ha, two-thirds of South Island's plantation.

Present Distribution: Range extension from 3 to 7 motus, 5 Windward and 2 Southern Leeward Islets (Table 3).

Abundance: Forms part of a vegetation subunit, Dying *Cocos-Ipomoea* Forest (Pl. 34, Sect. F). An indigenous, nonparasitic vine, abundant in disturbed areas. Rampant growth over most of the interior of South Island, where it forms dense tangles up to 25 m high. Less dense thickets on southern Nake drape *Pandanus*, *Tournefortia*, *Morinda*, and *Cocos* to 10 m. Coverage 2-5% elsewhere, except in 2 *Pisonia* sites, where its coverage was 20% (Long Island, Tr. B; Windward Islet, Tr. 1).

Ecology: Lush in dying *Cocos* forests and mixed forest with *Pandanus*, aided by relatively fertile soils, moisture, humidity, and partly sunny clearings. Strangles all but the tallest *Pisonia* and *Cordia*. Typically sea-dispersed to atolls (seeds germinate after floating up to 1 year in seawater), crawls inland, progressively dropping seeds, to attain full size in interior forests (Guppy 1906, Ridley 1930). Seeds of *I. pes-caprae* are known to be ingested by White Terns in the Marshall Islands, perhaps as gizzard stones (Fosberg 1953). Possibly these same terns, abundant at Caroline, once aided the seed dispersal of *I. macrantha*. Also characteristic of *Cocos* plantations elsewhere in the Pacific (Lamberson 1987, Stoddart & Sachet 1969, Fosberg 1965).

Substrata: Prefers humus-laden rubble, but can grow in coarse rubble and sand, especially in leeward areas.

BORAGINACEAE

* *Cordia subcordata* Lam. Fig. 22, Pl. 26

Formerly Known Distribution: Collected in 1884. L-3213 and 3261a, 3228, 3246, and 3261b on South, Pandanus, Long, and Emerald, respectively; flowering trees to 4.5 m high in leeward coral rubble or along lagoon.

Present Distribution: Africa to Polynesia. K-90-3 from South Island, lagoon edge. Range expansion on Caroline from 5 to 23 motus (Table 3).

Phenology: Peak flowering November through April, fruits collected in March and May.

---

[2] misidentified as *Tuumfetta* [= *Triumfetta*] *procumbens*.

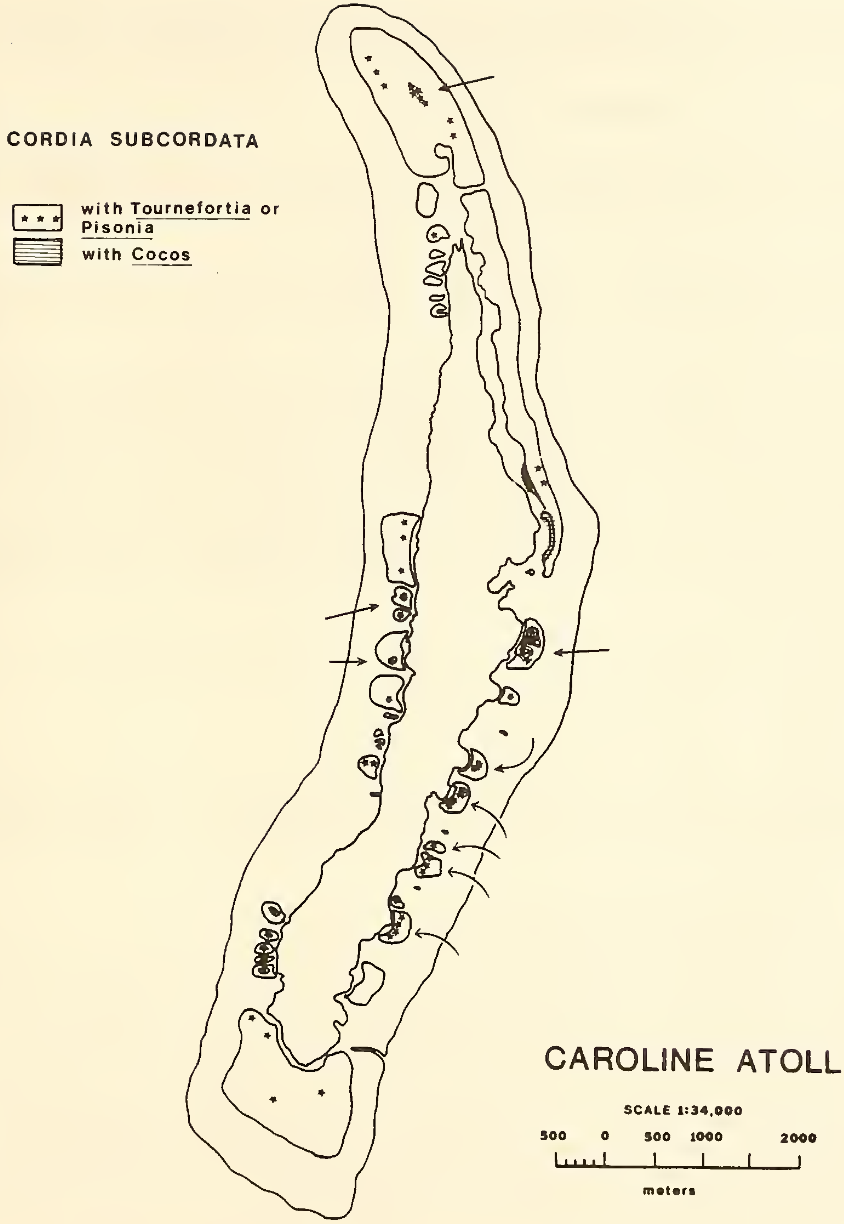


Figure 22. Entire distribution map of *Cordia subcordata*. Arrows indicate small, but monotypic, stands.

Abundance: A separate, though minor, plant community (Sect. F). Although groves are small and mixed with other emergents, individual trees attain 13 m tall. *Cordia* has special conservation value.

* *Heliotropium anomalum* H. & A. Fig. 23; Pls. 16, 32, 45-47

Formerly Known Distribution: Recorded (mistakenly as *H. curassavicum*) in 1840, collected in 1884. L-3222 and 3288, 3240, 3248, 3256, 3288 on South, Danger, Long, and Emerald, respectively.

Present Distribution: Central and Eastern Pacific. K-90-17 from Ana-Ana. In coral gravel, leeward and windward shores. Range extension on Caroline from 4 to 34 motus (Table 3).

Abundance: Forms part of a major vegetation unit, Natural Herb Mat (Sect. G), often associated with *Laportea*, *Lepturus*, or *Boerhavia*. Area coverage ranges from less than 1% to 50%. Widespread, predictable on wind- and salt-blown, low flats where vegetation does not overhang edge of motu. Also in ancient reef channels and newly evolving land connecting islets. Covers major areas of islets, that is those less than 1.0 ha (e.g. Fishball, Skull, and Bo'sun Bird). Best developed on Skull, Tridacna, South, Emerald, and Mannikiba (50% coverage, western seaward rim).

Ecology: Halophytic pioneer. Heights to 22 cm, averaging 7 cm. Thrives in heat and exposure.

Phenology: Flowers and fruits year-round.

Substrata: Primarily coral rubble and rubbly sand. Marginal habitats extend down to high tide line in areas of coarse coral chunks, where it is tiny and leathery.

* *Tournefortia argentea* L. Fig. 24; Pls. 9, 37, 47, 48
Messerschmidia argentea (L.f.) Johnston

Formerly Known Distribution: Collected 1884. L-3216, 3226, 3241, 3249, 3258 from South, Tridacna, Nake, Long, and Emerald Isle; shrub to 3 m high, edge of lagoon and above high tide, with white flowers.

Present Distribution: Range extension from 5 to 38 motus (Table 3). Widespread in the Pacific, especially on small islets, but rarely inland. Reaches Ducie Atoll, the most southeasterly island in Polynesia. Caroline's large tracts are excellent examples of relatively undisturbed, pure *Tournefortia* scrub and forest.

Abundance: Dominates the atoll woodlands, forming the major vegetation type (Sect. G). On almost every motu ranging from a spattering of exposed shrubs within herb mats, through scrublands and taller forests to 14 m high.

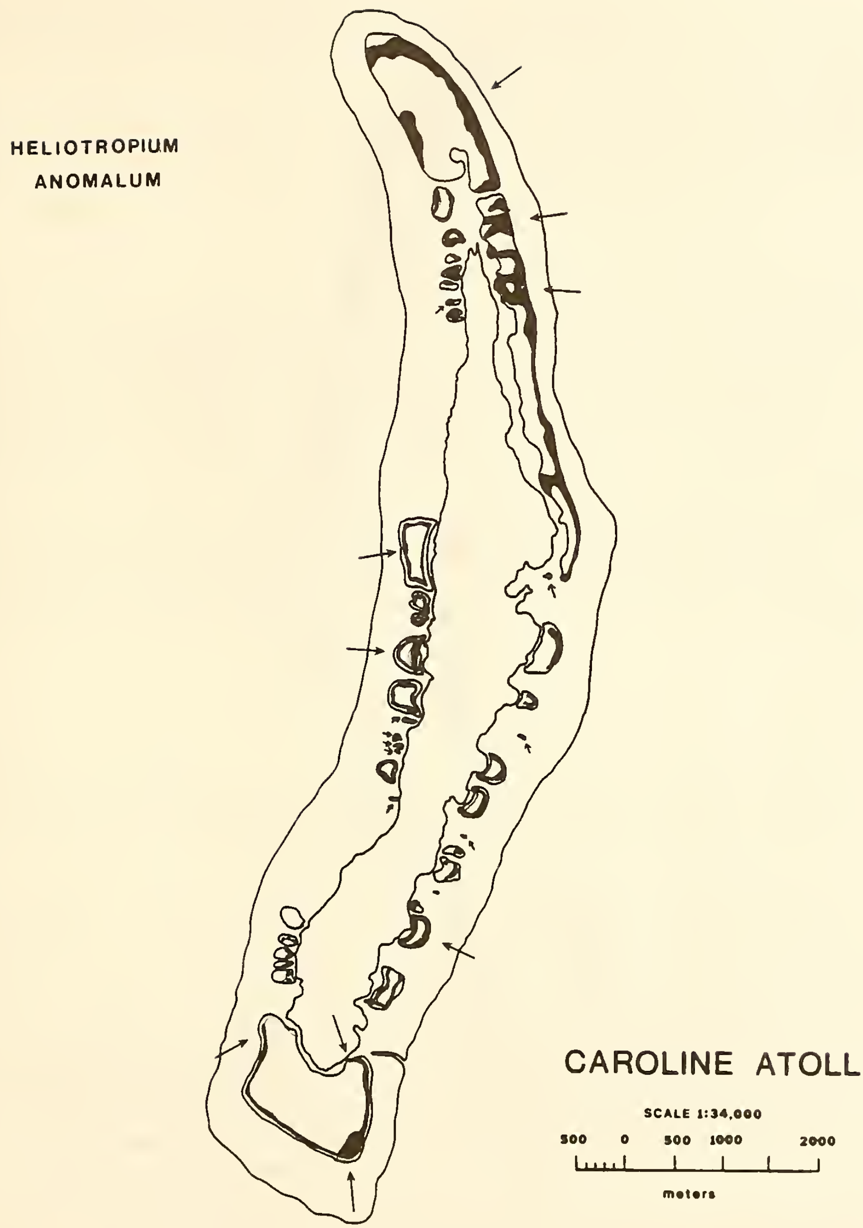


Figure 23. Entire distribution map of *Heliotropium anomalum*. Arrows indicate areas of highest density.

Figure 24. Entire distribution map of *Tournefortia argentea*. Because this shrub dominates Caroline's woodlands, there are no individual arrows to indicate areas of high density.

Ecology: Supports 7 species of breeding seabirds; provides feeding habitats for Reef Herons (*Egretta sacra*), shorebirds, land crabs, and rats.

Phenology: Flowers and fruits year-round.

Substrata: Pure coral clinker; mixtures of rubble, gravel, sand, and humus.

BRASSICACEAE

* *Lepidium bidentatum* Montin — Fig. 11

Formerly Known Distribution: Reported in 1825: "a boat load of pepper-grass and pursley" (Paulding 1831) and in 1835, "a *Lepidium* of luxuriant growth" (Bennett 1840). Collected by Dixon as *L. piscidium* Forst in 1883.

Present Distribution: Widely distributed throughout the North and South Pacific. K-90-169 and 171 (collected by Alexandre Falconer), on Tridacna and Pisonia, most probably in coastal *Tournefortia* scrub. Entire and serrated leaf forms present, which have also been collected on Flint (St. John & Fosberg 1937).

RUBIACEAE

* *Morinda citrifolia* L. — Fig. 25, Pl. 48

Formerly Known Distribution: Reported 1840, collected 1884. L-3214, 3217 and 3282; 3232; 3254 on South, Nake, and Long, respectively.

Present Distribution: K-90-4, 18 from South's lagoon edge and Ana-Ana, respectively. Range extension on Caroline from 3 to 30 motus (Table 3).

Abundance: Coverage 2% to 50%. Basically an inland species, widespread and predictable in scrub and forest understory. Rarely a canopy component, except on Raurau, where 12 m tall in a 13 m *Pisonia* forest. Associated with established *Tournefortia* woodlands on motus greater than one hectare in size. Quite common on South despite major disturbance, occurring within beach strand, *Cocos*, and dying *Cocos-Ipomoea* interior. Best locations (40-60% coverage): Nake, Transect 3; Tridacna, both transects; Long, Transect 8; Raurau and Ana-Ana.

Ecology: Appears early in plant succession: in *Tournefortia* scrub as an early pioneer (Stage I), then from Stages II to IV, progressively becoming more common and robust. Not in pure *Pisonia* forest (Stage V). Much less common in *Pandanus* stands. Thrives in light to heavy shade, preferably growing in moist substrata.

Biogeographical Note: *Morinda* is generally considered a naturalized aboriginal introduction in the Pacific. Although possibly introduced to

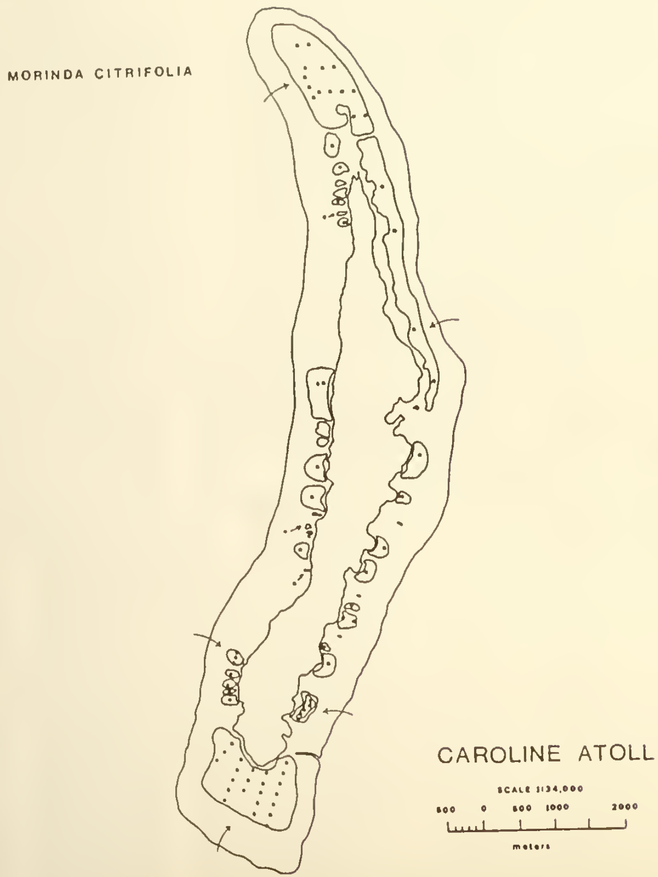


Fig. 25. Transect distribution map of *Morindo citrifolia*. The outlined area on Tridacna Islet (northeast of South Island) encloses *Tournefortia-Morinda* forest. Arrows indicate areas of highest density.

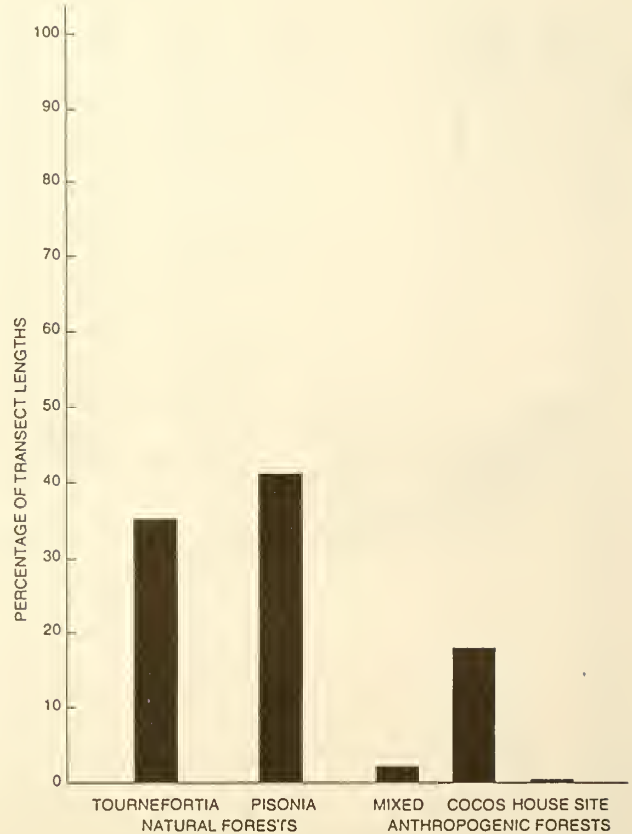


Fig. 26. Evidence for the indigenous status of *Morindo citrifolio* on Caroline Atoll: percentage cover on transects within natural and anthropogenic forests. *Morinda* occurs on 30 (77%) motus, never in a "planted" situation.

Caroline by early Tuamotuan settlers, its present distribution strongly suggests that it is indigenous, as theorized for the northern Line Islands (Wester 1985). *Throughout the atoll* Morinda *occurs in the greatest densities on motus with no anthropogenic forests or in areas distant from historical settlements* (Fig. 26). Furthermore, it is present on (30) 77% of the motus, virtually all those larger than 0.4 ha in size, and many of which are presumed virgin. On Nake, *Morinda* occurs frequently--in places abundantly--within the interior indigenous forests, yet its coverage is only 5-10% in the mixed *Cocos* forests of the southern sector. It also appears to be part of natural biological succession (Table 6). However, on nearby Flint, which was probably never settled in prehistoric times and where our 1990 surveys found *Morinda* in all habitats (mixed woodland, native coastal scrub, *Cocos* plantations, and abandoned settlement), the largest tree and highest abundance was close to the old settlement (Kepler, in prep.).

Originating in southeast Asia, *Morinda* has been widely dispersed by man, but has spread, unaided by man "widely by sea in the Malayan and Polynesian Islands" (Ridley 1930). Fosberg (1974) notes that it is always difficult to determine its true status. Its air-filled, buoyant pyrenes can float for at least 53 days and "its seeds are almost certainly disseminated by birds and bats" (Guppy 1906). It could also be disseminated by *Coenobita* crabs and rats within and between motus, as has been found elsewhere by Ridley.

Phenology: Flowers and fruits year-round.

Substrata: Coral rubble, gravel, sand, and humus. Rarely found in coarse clinker. On larger motus, prefers moist soils under tall forests.

GOODENIACEAE

° * *Scaevola taccada* var. *sericea* (Vahl) St. John — Fig. 11
Scaevola sericea var. *sericea* Vahl

Never previously collected. K-88-2, Windward Islet, central-windward side, elevation 0.3 m.

Distribution and Abundance: One wind- and salt-sheared "hedge," found by K. Teeb'aki on Windward Islet, was growing on a coarse rubble beach. "The saltbush..., being recorded for the first time too from the island...covered approximately 3% of the islet's land area,[3] occupying the mid-windward side. The patch grew very low--only up to 2' high with its foliage forming an extended raised mat canopy all along the area it occupied" (Teeb'aki 1988). We have been unable to return to this spot to observe and photograph it directly.

---

[3] This probably translates as "3% of the area covered at that location on the transect," as we understood from Teeb'aki's description that it was small.

Because *Scaevola* is hardy, halophytic, and widespread in the Pacific, it is surprising that it is so rare on Caroline. However, none occur on Vostok, and only one clump is known from Flint (St. John & Fosberg 1937). Fosberg (1953) noted that *Scaevola* seeds are transported by Bristle-thighed Curlews (*Numenius taitensis*) in the Marshall Islands: curlews are common on Caroline (Pt. II) and could have brought seeds from elsewhere.

Substrata: Coarse rubble, windward beach.

° * *Scaevola taccada tuamotensis* St. John Fig. 11
Scaevola sericea var. *tuamotensis* (St. John) Fosb.

Never previously collected. K-90-168 (collected by Alexandre Falconer), northeast peninsula, South Island, in coral rubble.

Present Distribution: One individual, of unknown size, with *Suriana* and *Heliotropium*, northeast peninsula, South Island, facing the inner side of the "blind passage."

Floristics and Ecology of the Motus

Size of the Flora

Atoll floras characteristically lack diversity. Numbers of species range from 1 (Ducie Atoll) to around 150 in the Pacific and 284 in the Indian Ocean. Tiny gravel banks such as Kingman Reef (Line Islands) and Motu-One (Marquesas) have no vascular flora at all (Fosberg 1974). The flora of the Southern Line Islands is particularly impoverished because of 1) their easterly location (far from the major source areas of Australasia), 2) low profiles (most only rise a few meters above sea level), 3) lack of topographic diversity (most have a very limited range of habitats), 4) low to medium rainfall (approximately 1,500 mm p.a.), and 5) edaphic factors such as salinity, highly calcareous soils, etc. Long-distance dispersal and hardiness are important factors in establishing a flora, especially since the closest high island, Tahiti, is 830 km away, and the ultimate source of its flora, the Malayan-Melanesian region, is over 8,000 km away. South America, the closest continent, is approximately 9,000 km distant. The motus of Aitutaki, for example, at a similar latitude but further west and wetter, are considered depleted with 45 species. Fanning, at a similar longitude but wetter, has 123 species. Tarawa, 3,900 km to the northwest, receives a similar rainfall but supports 109 species.

Where an atoll's potential flora is larger, the increased shade and greater protection from wind, salt spray, and storms result in a greater number of natural plant species on its larger motus. However, such atolls are generally inhabited and alterations by both aboriginal and modern man have modified their original flora. Caroline's isolation, variety of motu areas, and minimal human disturbance all contribute to its excellence for the study of atoll evolution.

The number of species presently established on Caroline's 39 motus is 26 (Tbs. 2, 3). The previous expedition in 1965 (Clapp & Sibley 1971a) collected 20 species, of which 4 were new to the atoll. Their total of 35 species, however, incorporating reports and collections from the 1800s, is misleading. Our total, 5 of which were new records, would have brought the atoll total to 43 (plus about 15 more unestablished, mostly garden, plants). However, following recent custom (see Sect. E), we have listed transient or extinct members of the flora separately (Table 1).

The 1883 drawings of the South Island settlement, inhabited when most of Caroline's species were catalogued, shows that the island was vastly different then (compare Pls. 2, 3 and 23). A century ago homes were set amidst large grassy clearings; now the site is completely obliterated beneath shady 21-m-tall coconut palms. Nine exotic species have not been seen for over a century (Table 1). Evidently most ornamentals and domestic vegetables perished during uninhabited periods. The Falconers struggled to keep garden plants alive because of poor soils, irregular rainfall, and foraging land crabs. This situation has been noted for other atolls (Fosberg 1949). A few native species might also have been eliminated during the guano and copra-harvesting years.

Numbers of Indigenous Plants

A comparison of the percentage of indigenous species between different island groups (Table 4) shows that Caroline, with 85% (N = 23)[4] indigenous, is unusually high. Only 12 of 45 Pacific islands reviewed have more than 75% of their species indigenous. Of these, 9 (including Caroline) are remote and lack permanent human occupation. Vostok, Caroline's nearest neighbor (243 km west), is one of only 2 islands in the world which have less than 4 species (Fosberg, pers. comm.).

The Tuamotu Islands (149° to 134°W) lie east and south of Caroline, yet they harbor considerably larger floras. Rainfall is similar. Three of them average 121 species (Table 4), averaging 42 indigenous species. When the variables rainfall and distance from a colonization source to the west are considered, the proximity of the Tuamotus to the diverse high islands of the Societies seems to play a major part in determining their indigenous flora. A similar situation exists in the southern Cook Islands. Caroline and other remote Line and Phoenix Islands are sufficiently isolated from high volcanic and raised reef (*makatea*) islands that they exhibit a much simpler flora. Tahiti, the closest high island (830 km south), is in the wrong direction for prevailing currents, winds, or vagrant birds to bring seeds to Caroline.

---

[4] Perhaps as high as 92%; the *Digitaria* sp., if still extant, is of unknown identity and origin.

Table 4. Sizes of Pacific atoll floras, with emphasis on the percentages of indigenous plants.[1] Islands in bold have more than 75% of plant species indigenous.

Island Group	Atoll	Total[2] No. Species	No. Species Indigenous	% Indigenous	Source
Caroline Is. (Fed. States of Micronesia)	Kapingamarangi	98	38	39	Niering 1962
Cook Is. (New Zealand)	Aitutaki (motus)	45		50	Stoddart & Gibbs 1975
	Rarotonga (motus)	49		≈60	Stoddart & Fosberg 1972
Gilbert Is. (Rep. of Kiribati)	**Onotoa**	60	50	83	Moul 1957
	Tarawa	109	28	26	Catala 1957
Northwest Hawaiian Is. (U.S.A.)	Kure	42	23	55	Lamoureux 1961, Clay 1961
	Laysan	38	27	71	Ely & Clapp 1973
Line Is. (Kiribati)	**Caroline**	26	23(24?)	89(92?)	This paper
	Christmas (Kiritimati)	69	19	28	Garnett 1983
	Fanning	123	23	19	Wester 1985
	Flint	43	18	42	Kepler (in prep.)
	Malden	9	9	100	Garnett 1983
	Palmyra	58	21	36	Wester 1985
	Starbuck	7	4	57	Garnett 1983 (incomplete, little known)
	Vostok	3	3	100	Kepler 1990c
	Washington	91	25	27	Wester 1985
Marshall Is. (Fed. States of Micronesia)	Ailuk	56	26	46	Fosberg 1955
	Arno	125	40	32	Hatheway 1953
	Enewetak	128	55	43	Lamberson 1987
	Jaluit	288	55	21	Fosberg & Sachet n.d.
	Jemo	34	17	50	Fosberg 1955
	Kwajalein	89	25	28	Fosberg 1955, 1959
	Lae	61	35	57	"
	Likiep	91	31	34	"

Table 4. Continued.

Island Group	Atoll	Total[2] No. Species	No. Species Indigenous	% Indigenous	Source
Marshall Is. (cont.)	Taka	23	18	78	Fosberg 1955
	Ujae	61	32	52	Fosberg 1955, 1959
	Ujelang	50	29	58	"
	Utirik	55	26	47	"
	Wotho	40	28	70	"
Phoenix Is. (Kiribati)	Kanton (Abariringa)	164	14	9	Degener & Gillaspy 1955,
		129	18	14	Garnett 1983
	Birnie	3	3	100	Fosberg & Sachet (n.d.)
	Enderbury	23	18	78	"
	Nikumaroro	35	17	49	"
	Orona	≈29	19	≈66	"
	McKean	7	7	100	"
	Phoenix	6	6	100	"
	Manra	≈18	14	≈77	"
Society Is.	Tetiaroa	95	47	49	Sachet & Fosberg 1983
Solomon Is.	Ontong Java	150	58	39	Bayliss-Smith 1973
Tokelau Is. (N.Z.)	Nukunono	55	35	64	Parham 1971
Tuamotu Is. (France)	Rangiroa	121	39	32	Stoddart & Sachet 1969
	Raroia	135	54	40	Doty 1954
	Takapoto	106	33	31	Sachet 1983
Outlyers	Clipperton (U.K.)	31	14	45	Sachet 1962
	Ducie	1	1	100	Rehder & Randall 1975
	Oeno	17	14	82	St. John & Philipson 1960
	Wake	94	20	21	Fosberg & Sachet 1969

[1]An updated version of Table 11, p. 105, Stoddart and Gibbs (1975).
[2]Number of species of those indigenous are not always comparable. Ferns are usually included, but certain ornamentals may not be. *Artocarpus*, *Morinda*, and *Pandanus* may be indigenous, aboriginal introductions, or both. Without its full scientific name, a species has an unknown biogeographical status.

Composition of the Flora (Tbs. 2, 3)

Caroline's botanical affinities lie with other Southern Line Islands and the Tuamotus. Although the strand and inland floras consist of pan-Pacific or pan-tropical species, there are several widespread species and communities that are notably absent (see below). Those that survive have withstood the atoll tests of time--poor soils, scarcity of fresh water, periodic inundation by salt water, intermittent cyclonic storms and hurricanes, harsh climate, high seedling mortality, and human impacts. Caroline provides an excellent ecological laboratory in which floristic correlations with variations in habitat, motu size, vegetational zonation, and leeward/windward aspect may be studied. Fosberg (1985) and Sachet (1967) have noted the importance of such details in understanding the biogeography and taxonomy of Pacific plants.

Caroline's present established flora includes very few introduced species: ancient Polynesian introductions (*Cocos*, possibly *Pandanus* and *Morinda*), recent Polynesian introductions (*Hibiscus tiliaceus*, *Thespesia populnea*, *Tacca leontopetaloides*, *Ximenia americana*), and 20th century exotics (*Phyllanthus amarus*). This latter is restricted to one tiny patch <2 sq m in area.

The number of indigenous plants is complicated by the fact that 3 species most likely introduced by recent Polynesians (*Hibiscus*, *Thespesia*, *Ximenia*) could also be indigenous, as is the case with *Pandanus* and *Morinda*. In Table 4 we have counted these 5 as indigenous until later research proves otherwise. The unknown *Digitaria* sp. accounts for the query in Table 4.

<u>Trees</u>: Seven species present. Only 3--Pacific-wide natives--are widespread: *Pisonia grandis*, *Morinda citrifolia*, and *Cordia subcordata*. *Cocos nucifera* and *Pandanus tectorius* are locally abundant, while *Thespesia populnea* and *Hibiscus tiliaceus* are rare and limited to the old settlement site. The absence of typical Pacific species such as *Calophyllum inophyllum* and *Guettarda speciosa* is notable, as they are both present on nearby Flint (with a similar plantation history to Caroline) and occur naturally on more easterly atolls such as Rangiroa (Stoddart & Sachet 1969).

<u>Shrubs</u>: Four species present, at least 4 indigenous. Only *Tournefortia argentea* is abundant; its most abundant size class is under 4 m. *Scaevola* and *Suriana*, tough and widespread elsewhere, are poorly represented on Caroline. It is noteworthy that 2 varieties of *Scaevola taccada* are present. *Ximenia americana* is represented by a single, large patch and one individual on South and Mannikiba, respectively. *Pemphis acidula*, though common on atolls of similar latitude and climate, is typically absent from most of the Line and Phoenix Groups (Stoddart & Gibbs 1975, Fosberg & Sachet n.d.). This may be due to the paucity of its preferred habitats: low rocky substrates (reef or conglomerate rock) and sand-gravel ridges.

<u>Herbs</u>: Fifteen species present, at least 12 indigenous. Of these only 7 are common: *Heliotropium anomalum, Boerhavia repens, Portulaca lutea, Laportea ruderalis, Achyranthes canescens, Lepturus repens*, and *Phymatosorus scolopendria. Ipomoea macrantha* and *Tacca leontopetaloides* are locally abundant, while *Phyllanthus amarus, Tribulus cistoides, Lepidium bidentatum*, and *Psilotum nudum* are rare and localized. *Digitaria* sp. may be extinct. The fact that *Sida fallax* has only been recorded twice in 106 years is curious.

F. ECOLOGICAL SUCCESSION

We have attempted to trace the development of Caroline's flora from the smallest to largest motus, using field data and aerial photos, which reveal past geological processes of unknown dates or duration. The general processes involved in motu formation are treated in Stoddart & Steers (1977, p. 95).

Three tables provide our analysis of ecological succession: Table 5 presents Caroline's motus in order of ascending size, together with the numbers of plant species and major plant communities. Since the atoll's total land area is small, our data provides relatively complete floristic lists for each islet and detailed maps of their plant communities (Figs. 37-57). The number of species varied from 3 growing on 4 tiny islets (0.02 ha each) to 23 on South (104.41 ha). Because the total number of species for the entire atoll (27) is also small, the addition of one or 2 rare species contributes significantly to the total flora. Such additions must be kept in perspective when evaluating plant succession.

Table 3 provides a summary of plant species distribution by islet, and Table 6 is a summary of plant species distribution and relative abundance with respect to islet area and the primary mode of seed dispersal.

<u>Basic Seral Stages</u>

Islets appear, grow, mature ecologically or vanish in violent storms. Many interacting factors, including geographical (islet area, atoll shape, distance from high islands and continents), geological (changes in sea level, reef growth and destruction), chemical (nitrates from bird droppings, leaf fall, etc.), climatological (wind, droughts, storms, microclimates), and biological (seabirds, rats, land crabs, reef bioerosion, and man, both aboriginal and modern) constantly interact to change conditions. The relative influence of some of these factors is evident when comparing the floras on motus of different sizes.

Seed-dispersal mechanisms (Table 6) and the presence of underground fresh water are also vital. Unfortunately, the relationships between groundwater salinity, species distribution, and vegetation patterns on atolls are poorly understood (Fosberg 1985). The presence and relative salinity of permanent water depends on

Table 5. The distribution of plant subcommunities, together with the numbers of plant species on the motus of Caroline Atoll. Motus are arranged according to increasing area, illustrating seral stages in plant succession.

Motu	Area Category / ha	Motu Area / ha	Number of Plant Species[1]				Natural Plant Subcommunities								Anthropogenic Plant Subcommunities		
							Coastal				Inland						
			Trees	Shrubs	Herbs	Total	Natural Herb Mat	Beach Scrub With Suriana	Pandanus Forest	Tournefortia Scrub <5 m tall	Tournefortia Forest >5 m tall	Cordia Forest	Tournefortia/ Pisonia Forest	Pisonia Forest	Cocos Plantation	Dying Cocos/ Ipomoea Forest	Mixed Forest With Cocos
Noddy Rock	<0.2	0.02	0	1	2	3	X										
Skull Islet		0.02	0	1	2	3	X										
Motu Atibu		0.02	0	1	2	3	X										
Reef-flat Islet		0.09	0	1	2	3	X										
Azure Isle	0.2 - 0.7	0.20	1	1	5	7	X			X							
Motu Nautonga		0.34	3	1	5	9	X			X	X						
Scarlet Crab		0.46	0	1	5	6	X			X							
Fishball Islet		0.57	1	1	6	8	X			X							
Motu Kota		0.64	3	1	7	11	X			X	X						
Booby Islet	0.8 - 25.0	0.84	2	1	6	9	X			X	X		X	X			
Bo'sun Bird Islet		0.86	0	1	3	4	X			X							
North Arundel Islet		0.91	4	1	6	I1	X			X	X		X	X			
Motu Mouakena		1.00	1	I	6	8	X			X	X		X				
Motu Eitei		1.41	3	1	5	9	X	X	X	X	X	X	X	X			
Coral Islet		1.70	2	1	6	9	X			X	X		X				
Motu Matawa		1.71	4	2	4	10	X			X	X	X	X	X			
North Brothers Islet		1.71	3	I	5	I0	X			X	X		X	X			
Motu Kimoa		1.80	3	2	6	11	X	X		X	X	X	X	X			
Lone Palm Islet		1.99	3	1	7	11	X			X	X		X				
Motu Ana-Ana		2.16	5	2	8	15	X		X	X	X	X	X	X			
Pisonia Islet		2.45	5	2	8	15	X	X	X	X	X	X	X	X			
Blackfin Islet		2.62	3	1	5	9	X			X	X	X	X	X			
Danger Islet		2.71	2	1	7	10	X		X	X	X	X	X	X			
Crescent Islet		3.10	3	1	6	10	X			X	X	X	X	X			
Motu Raurau		3.48	5	1	4	I0	X		X	X	X	X	X	X			
Bird Islet		4.05	4	2	6	12	X			X	X		X	X			
Brothers Islet		4.31	3	2	5	10	X			X	X		X	X			
North Pig Islet		5.44	3	1	7	11	X			X	X	X	X	X			
Pandanus Islet		7.20	3	1	6	10	X		X	X	X		X	X			
Pig Islet		7.25	4	1	6	11	X			X	X	X	X	X			
Arundel Islet		7.34	3	1	7	11	X			X	X		X	X			
Shark Islet		7.98	5	1	6	12	X		X	X	X	X	X	X			
Emerald Isle		8.34	5	1	6	12	X		X	X	X	X	X	X			
Tridacna Islet		9.08	2	2	9	13	X	X		X	X						
Windward Islet		11.42	3	1	7	11	X			X	X	X	X	X			
Motu Mannikiba		21.49	4	2	7	13	X			X	X		X	X			
Long Island	>25.0	75.98	4	2	9	15	X	X		X	X	X	X	X	X		
South Island		104.41	7	3	13	23	X	X	X	X	X	felled			X	X	
Nake Island		107.46	5	1	10	16	X		X	X	X	X	X	X	X		X

[1]Excludes transient and extinct species.

Table 6. Distribution and abundance of plant species in relation to motu size.[1] Species are arranged according to their dispersal mechanisms: sea, bird, wind, man (aboriginal and "recent"[2]). Within these categories, species are further subdivided in order of decreasing frequency on the motus.

	Size of Motu (ha)																						
	< 0.2		0.2 - 0.7					0.8 - 25.0													> 25.0		
	0.02 (3)*	0.09 (1)	0.2 (1)	0.3 (1)	0.4 (1)	0.5 (1)	0.6 (1)	0.8 (2)	0.9 (1)	1.0 (1)	1.1-2.0 (6)	2.1-3.0 (4)	3.1-4.0 (2)	4.1-5.0 (2)	5.1-6.0 (1)	7.0-8.0 (4)	8.1-9.0 (1)	9.1-10.0 (1)	11.0-12.0 (1)	21.0-22.0 (1)	75.0-76.0 (1)	104.0-105.0 (1)	107.0-108.0 (1)
INDIGENOUS SPECIES																							
SEA-DISPERSED																							
Tournefortia argentea	R-O		C	C	R	UC	C	VC-A	A	A	A	A	A	A	A	A	A	A	A	A	A	C	A
Heliotropium anomalum	R	R	C	C	R	UC	UC	UC	UC	R	O-C	R-C	UC	R-C	UC	UC-C	C	C	C	C	VC	C	C
Portulaca lutea	UC-A	R	R	R		R	O	O-C	C	R	O-A	R-UC	C	A	UC	UC-C	C	C	C	C	C	C	C
Laportea ruderalis			R	R	R	R	R	O	UC	R	R-VC	O-UC	UC	R-C	UC	UC-C	C	C	C	UC	VC	UC	C
Achyranthes canescens				R		R	R	R	UC	R	R-C	O		UC	C	O-LA	UC	LC	O	UC	O	R	LC
Lepturus repens	R-C					R	R	R	R	R	R	R		R	R	R-C	R	C	R	R	R	O	R
Cordia subcordata				R-O							O-C	UC-LA	LA	VC	UC	UC	O		C	O	UC	R	UC
Suriana maritima											RL	O		O							LR	LC	
Pandanus tectorius[3]												LR	LR			LR-LC	C					LO	LA
Ipomoea macrantha												LR-O				O			O		O	A	LC
Scaevola taccada																					R,S		
Morinda citrifolia[3]				R		O	R	R	R		R	R-UC	UC-O	R-O	R	R-UC	R	VC	UC	R	UC	C	UC
Hibiscus tiliaceus[3]																						LR	
Thespesia populnea[3]																						LR	
Sida fallax																							R
Lepidium bidentatum[4]												S					S						
Ximenia americana[4]																				R,S			LA
+*Digitaria* sp.[4]																						+LR	
BIRD-DISPERSED																							
Boerhavia repens			R	R		R	R	O	O		R-UC	O-UC	UC-C	UC-C	C	UC-C	C	C	C	C	LC	VC	C
Pisonia grandis			R	O			R	VC	VC		R-A	VC-A	A	A	A	VC-A	C	R	A	C	VC	R	A
Tribulus cistoides																					LR		
WIND-DISPERSED																							
Phymatosorus scolopendria							R		R		R	UC	UC		UC	R-UC		C		O	LA	LA	VC
Psilotum nudum																						LR	+LR
INTRODUCED SPECIES																							
MAN-DISPERSED																							
Aboriginal Introductions																							
Cocos nucifera				LR			LR				LR	LR-LC	LR	LR		LR	LR			LR	LA	A	LA
"Recent" Introductions																							
Tacca leontopetaloides																						LR	+LC
Phyllanthus amarus																						LC	

[1] List excludes transient and extinct members of the flora (Table 1).
[2] "Recent" covers the time period 1834 to an unknown date in the 20th century.
[3] Possibly also an aboriginal introduction.
[4] Dispersal method unknown.
*Number in parentheses refers to the number of motus in this area category.
+Not seen but possibly still present.

Ghyben-Herzberg lenses of varying thickness on different islets, and this in turn depends upon island dimensions (especially width), soil porosity, rainfall, tidal fluctuation, and other hydrological factors. Though groundwater supplies have been studied on many atolls (Wiens 1962, Maude 1953), each island group is so unique that it is unwise to extrapolate information from one to the other.

Caroline's 39 motus fall naturally into 4 size classes: motus with areas of: a) <0.2 ha, b) 0.2 to 0.7 ha, c) 0.8 to 25.0 ha, and d) >25.0 ha. These size groupings harbor all 5 of the seral stages identified on Enewetak Atoll (Lamberson 1987), tailored to reflect Caroline's particular geography, geology, and impoverished flora. Each stage may be the sole example of ecological succession on an islet or may occur as one of several stages. Typically the early stages cover the peripheral rubble and scrubby outer zones, while the later ones appear as a series of roughly concentric bands progressing inland.

Stage I — Early pioneers on sandbars, spits or small rubbly islets subject to storm damage and washover. Harsh conditions, intense sun, drying winds, salt spray. High salt concentration in the substrate. Lack of fresh water and nutrients. Plant genera present include *Heliotropium*, *Portulaca*, *Lepturus*, *Boerhavia*, and seedling or open *Tournefortia* scrub. No *Cocos*. This stage covers many small motus (Noddy Rock, Fishball) and former interislet channels (e.g. Long Island) or occurs peripherally on larger motus.

Stage II — Thick scrub of mixed genera, often impenetrable. Its protective barrier allows for the development of vegetation on the larger islets. Seabirds begin to contribute to the soil (guano, eggs, regurgitated fish, decaying nesting material). Plant genera include *Tournefortia*, *Suriana*, *Cordia*, and *Laportea*. If *Cocos* present, accompanied by coconut crabs. Very common around the periphery of most motus just inland of the natural herb mats or flanking sheltered shores adjacent to the lagoon (South, Kota).

Stage III — Trees larger, seabirds add further to soil fertility. Open grassland may develop in sunny clearings (Tridacna Islet). Added plant communities are *Cordia-Tournefortia*, *Tournefortia-Morinda*, and *Pisonia-Tournefortia* forests. Occurs in the next inner concentric zone of vegetation to Stage II on larger motus (Nake, Long) or, more commonly, the entire interior of smaller ones (Pandanus, Southern Leeward Islets).

Stage IV — *Pisonia* dominates the older mixed forest. *Morinda* and *Tournefortia* mature. Forests are more open. Undergrowth mostly a ground cover of *Laportea*, *Boerhavia*, *Lepturus* and *Portulaca*. Covers the main portion of larger islets. If *Cocos* and *Pandanus* present, forms a mixed forest with vines (southern Nake, Shark). Coconut crabs common. A widespread stage in the center of most motus (Central Leeward, Windward Islets).

Stage V *Pisonia* takes over. Other trees are confined to the forest edges. Always in the deep interior of the larger islets. Little or no ground cover. Abundant nesting Black Noddies (*Anous minutus*). A more restricted stage (Brothers, Raurau, central Nake, Pig).

Ecological Succession on Motus of Different Size Classes

To assist discussions of succession on Caroline's motus, see individual vegetation maps and graphs (Figs. 27-57) and photographs (Pls. 13-70). Figures 27-30 summarize the amounts of each islet's surface covered by each major plant community and provide the numbers and percentages of indigenous species for each islet.

1) Motus with Areas <0.2 ha — Figs. 27, 31; Pl. 49; Tbs. 5, 6

Caroline has 4 motus in this category, 3 windward and one leeward, whose combined area totals 0.15 ha. There are also 3 incipient islets which, because of their temporary character, have not been counted in Caroline's overall total (Fig. 2, Pl. 15). With the exception of Noddy Rock, a jagged, upraised limestone plateau, all consist predominantly of coarse coral rubble (75-98% coverage). These tiny motus are the simplest ecosystems on the atoll, representing early Stage I in plant succession. The number of plant species per motu averages 3, all hardy, sea-dispersed and salt-tolerant pioneers (*Heliotropium*, *Portulaca*, *Lepturus*, *Tournefortia*). The sole plant community is a natural herb mat of varying thickness and extent. *Tournefortia*, though stunted and scattered, is not sufficiently common to form a separate scrub habitat. Indigenous vegetation covers 2 to 25% of the islet areas. Seabirds, especially Brown Noddies and Red-tailed Tropicbirds, may attempt to nest.

2) Motus with Areas 0.2 to 0.7 ha — Figs. 28, 31; Tbs. 5, 6

There are 5 leeward motus in this category, whose combined areas total 2.21 ha. Their vegetative cover is more extensive and diverse than in size class a, with herb mats and *Tournefortia* scrub and forest, but open rubble is still abundant (30-55% cover). Plant succession corresponds to late Stage I and Stage II. The average number of species is 8.2 (range 6-11), one-third of Caroline's total. All vegetation is indigenous except for a few *Cocos* palms. Seeds are dispersed by sea, wind and birds.

With the appearance of shrubs, the number of species increases markedly, and woodlands, primarily of *Tournefortia*, form and expand to create dense thickets averaging 5 m tall and covering 25% of the land area. Canopies of 10 m occur on Motus Nautonga and Kota. Seabird colonies of up to 6 species (Brown and Red-footed Boobies, Great Frigatebirds, Black and Brown Noddies, White Terns) are present.

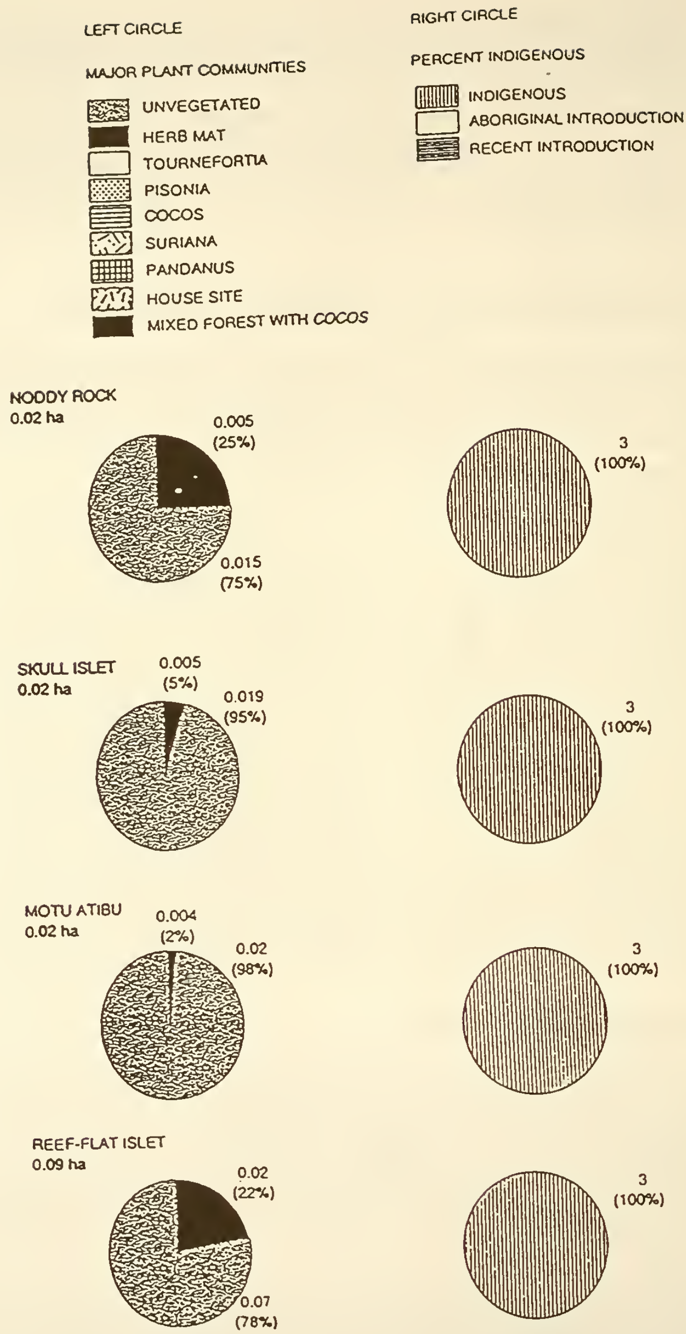


Fig. 27. Plant communities and amount of indigenous vegetation on motus less than 0.1 ha, Caroline Atoll. The left "pie" depicts the relative amount of a motu's total surface area covered by each plant community; numbers indicate actual area in hectares. The right "pie" depicts the numbers and percentages of indigenous and anthropogenic species per motu. Data is based on the vegetation maps for each motu (Figs. 37-57) and Tables 2 and 9.

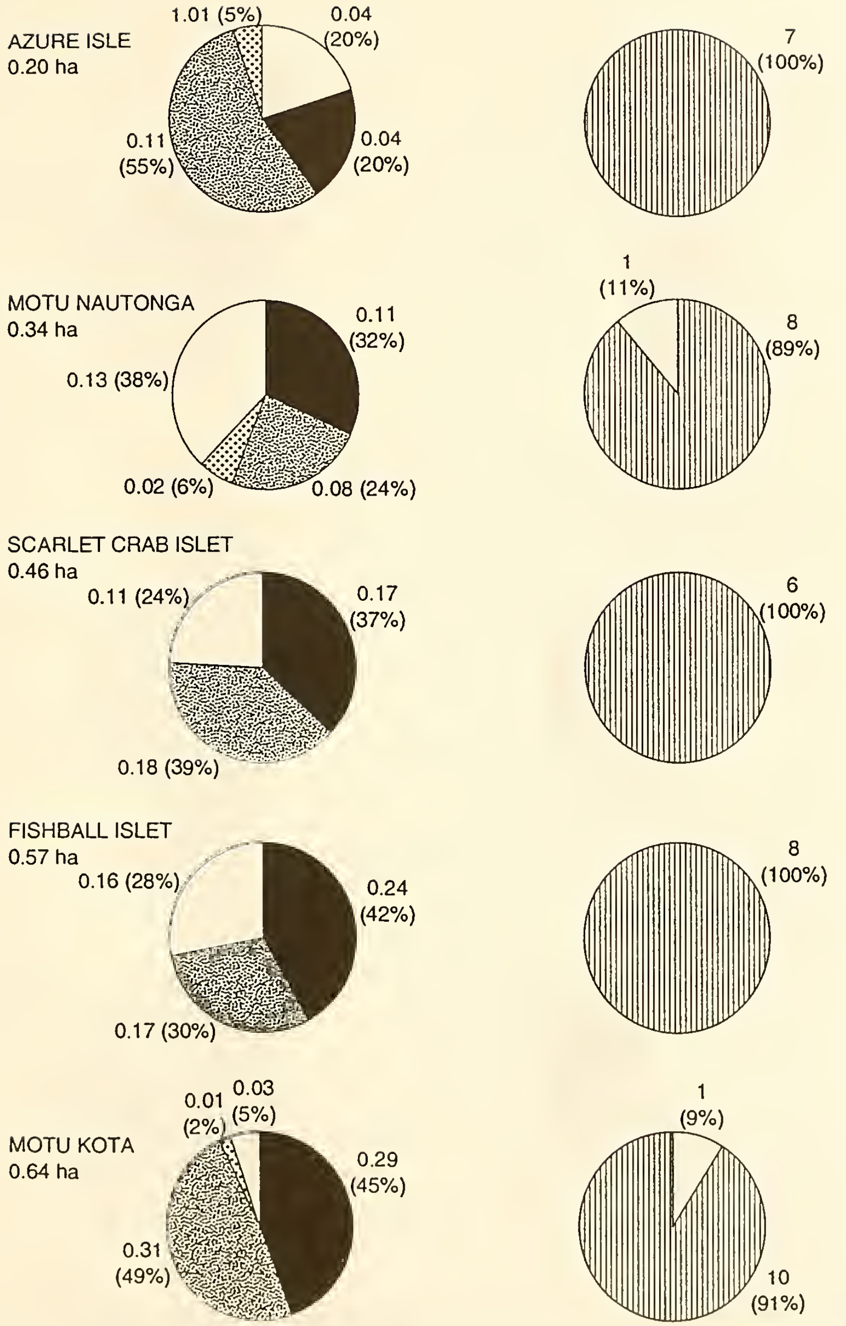


Fig. 28. Plant communities and amount of indigenous vegetation on motus 0.2 to 0.7 ha, Caroline Atoll. See Fig. 27 for explanation of the figure.

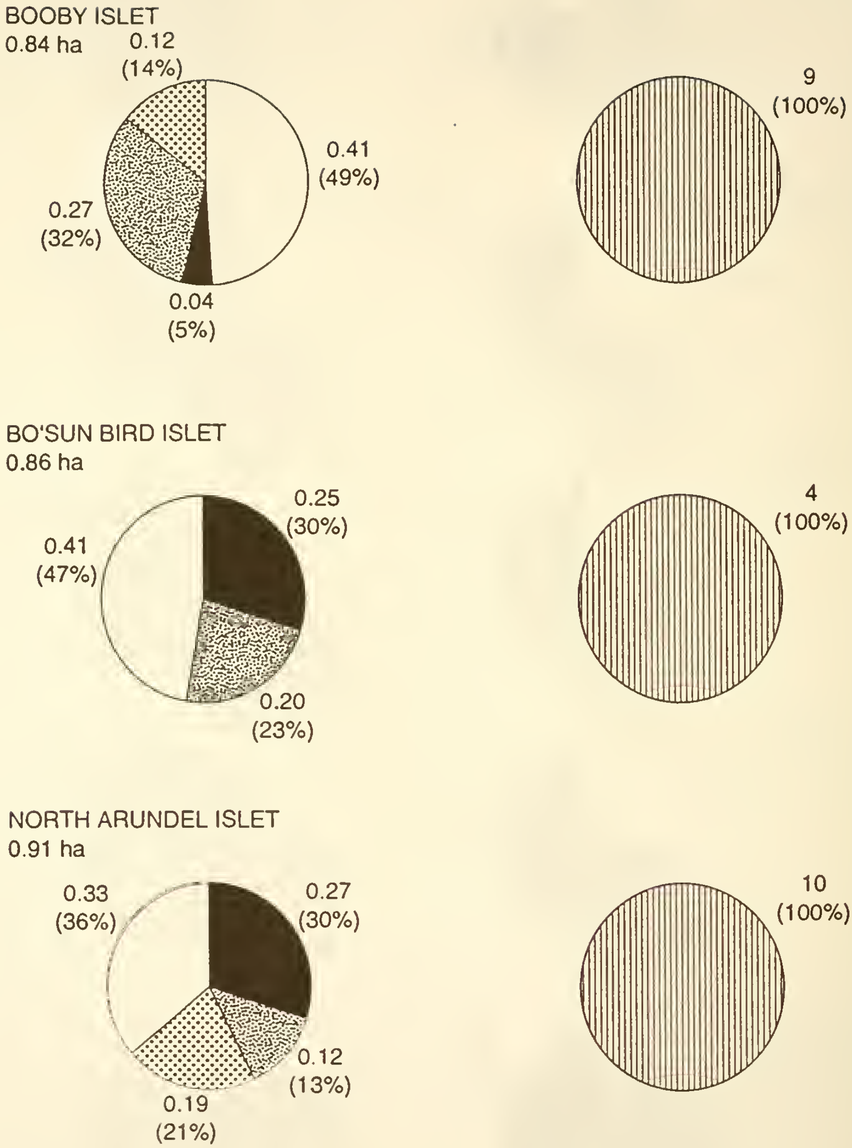


Fig. 29a. Plant communities and amount of indigenous vegetation on motus 0.8 to 25.0 ha, Caroline Atoll. See Fig. 27 for explanation of the figure.

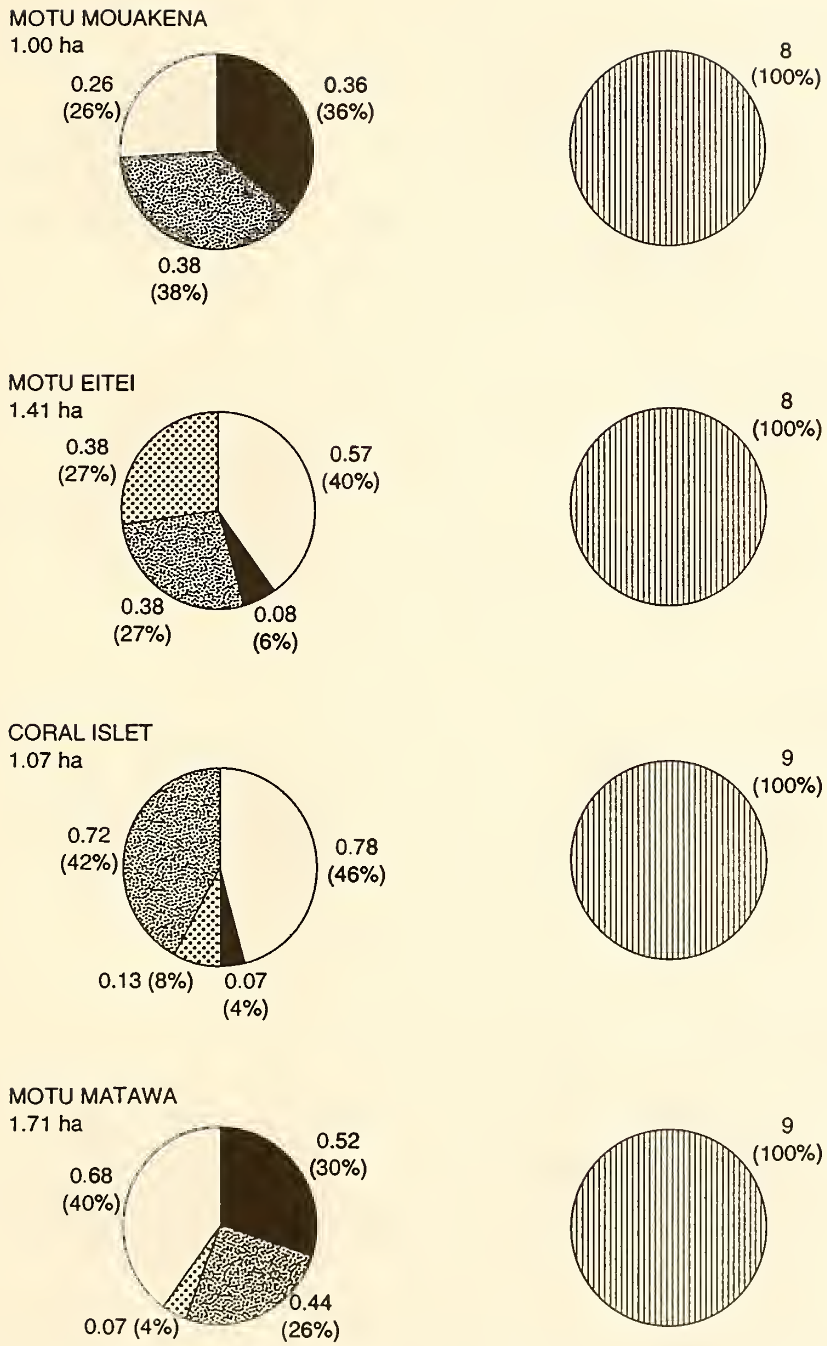
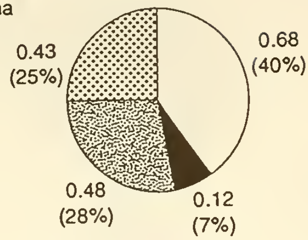
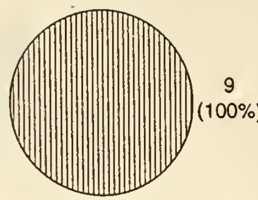


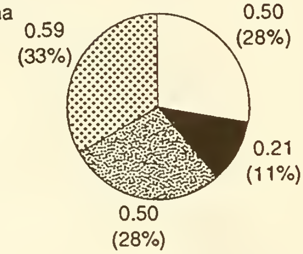
Fig. 29b. Plant communities and amount of indigenous vegetation on motus 0.8 to 25.0 ha, Caroline Atoll. See Fig. 27 for explanation of the figure.

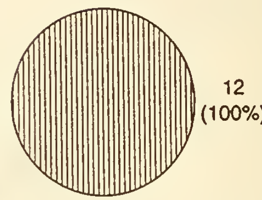
NORTH BROTHERS ISLET
1.71 ha



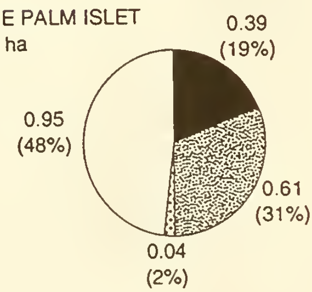


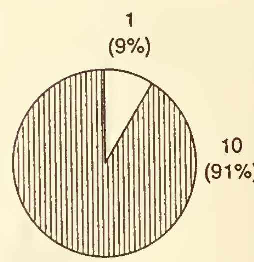
MOTU KIMOA
1.80 ha



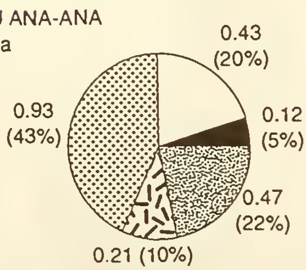


LONE PALM ISLET
1.99 ha





MOTU ANA-ANA
2.16 ha



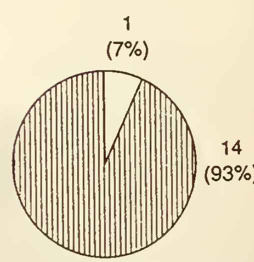


Fig. 29c. Plant communities and amount of indigenous vegetation on motus 0.8 to 25.0 ha, Caroline Atoll. See Fig. 27 for explanation of the figure.

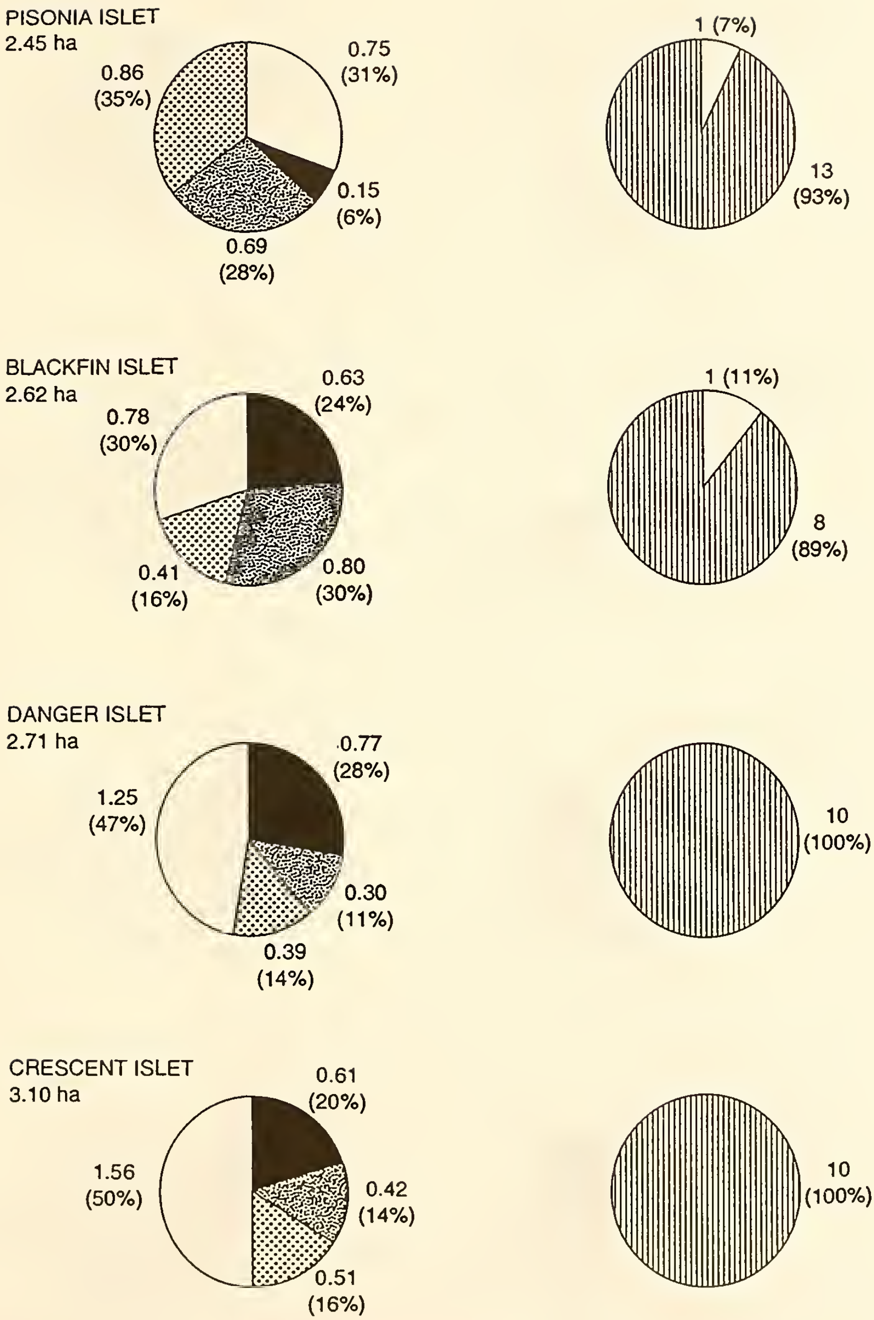


Fig. 29d. Plant communities and amount of indigenous vegetation on motus 0.8 to 25.0 ha, Caroline Atoll. See Fig. 27 for explanation of the figure.

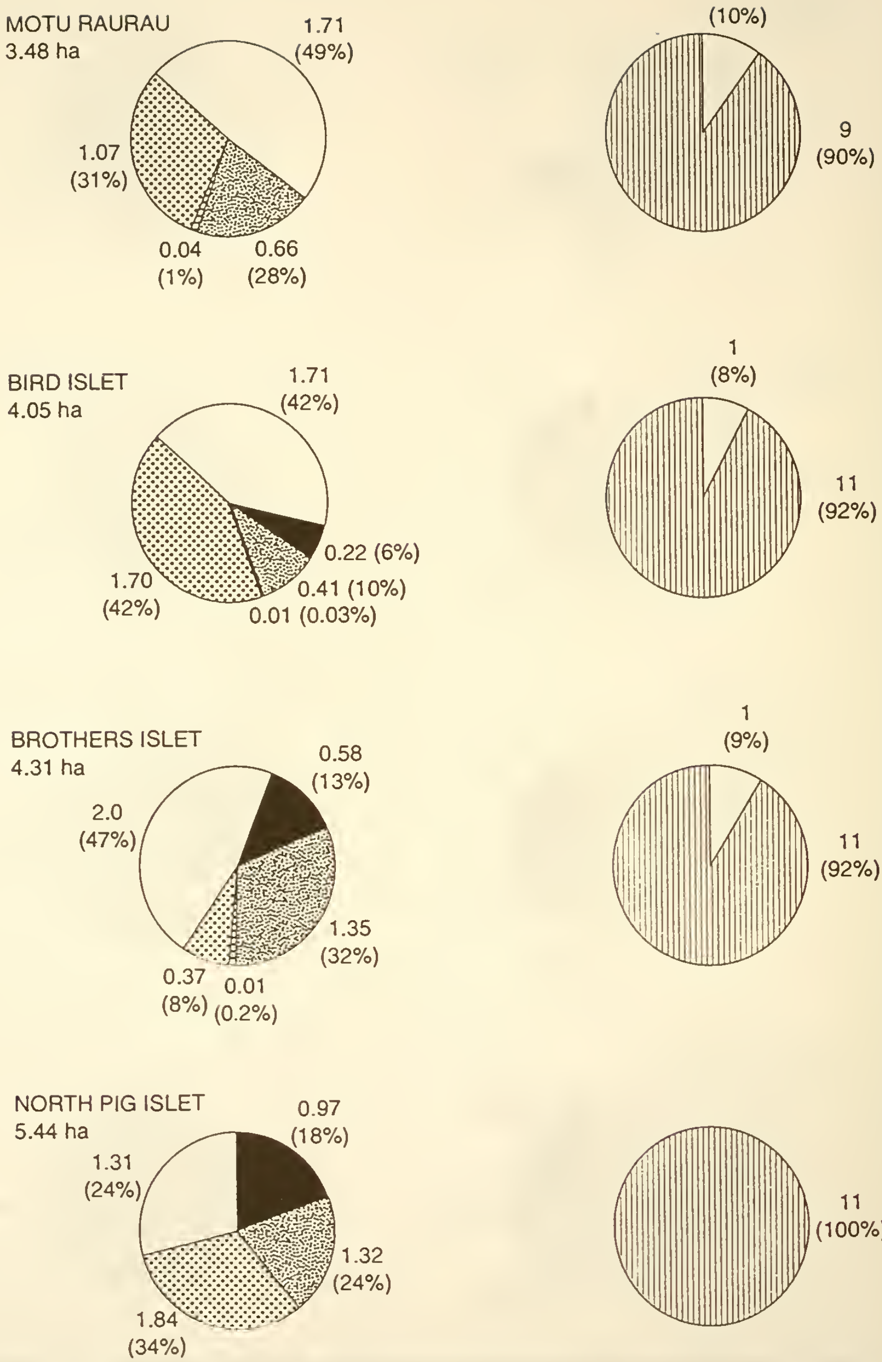


Fig. 29e. Plant communities and amount of indigenous vegetation on motus 0.8 to 25.0 ha, Caroline Atoll. See Fig. 27 for explanation of the figure.

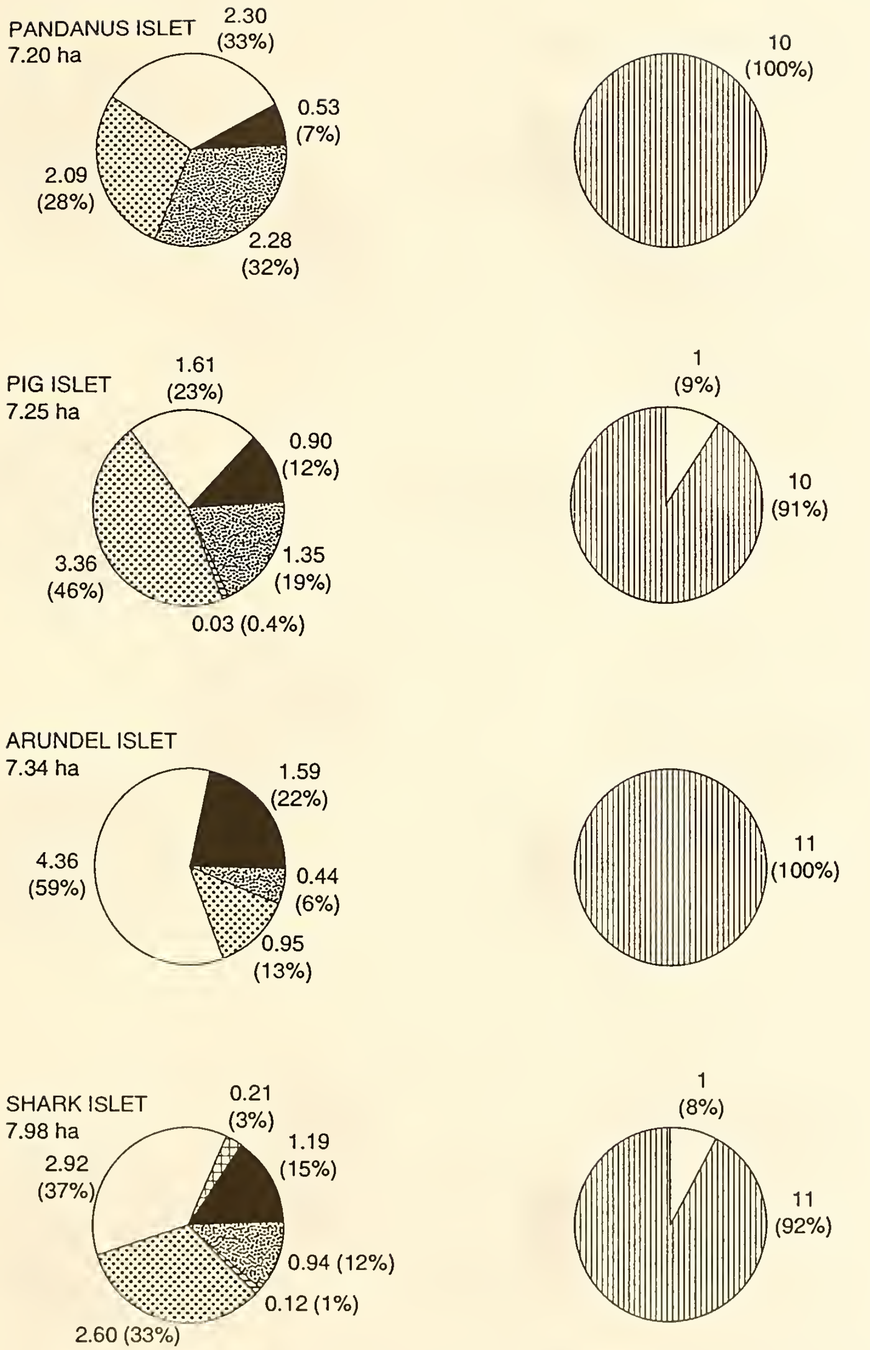


Fig. 29f. Plant communities and amount of indigenous vegetation on motus 0.8 to 25.0 ha, Caroline Atoll. See Fig. 27 for explanation of the figure.

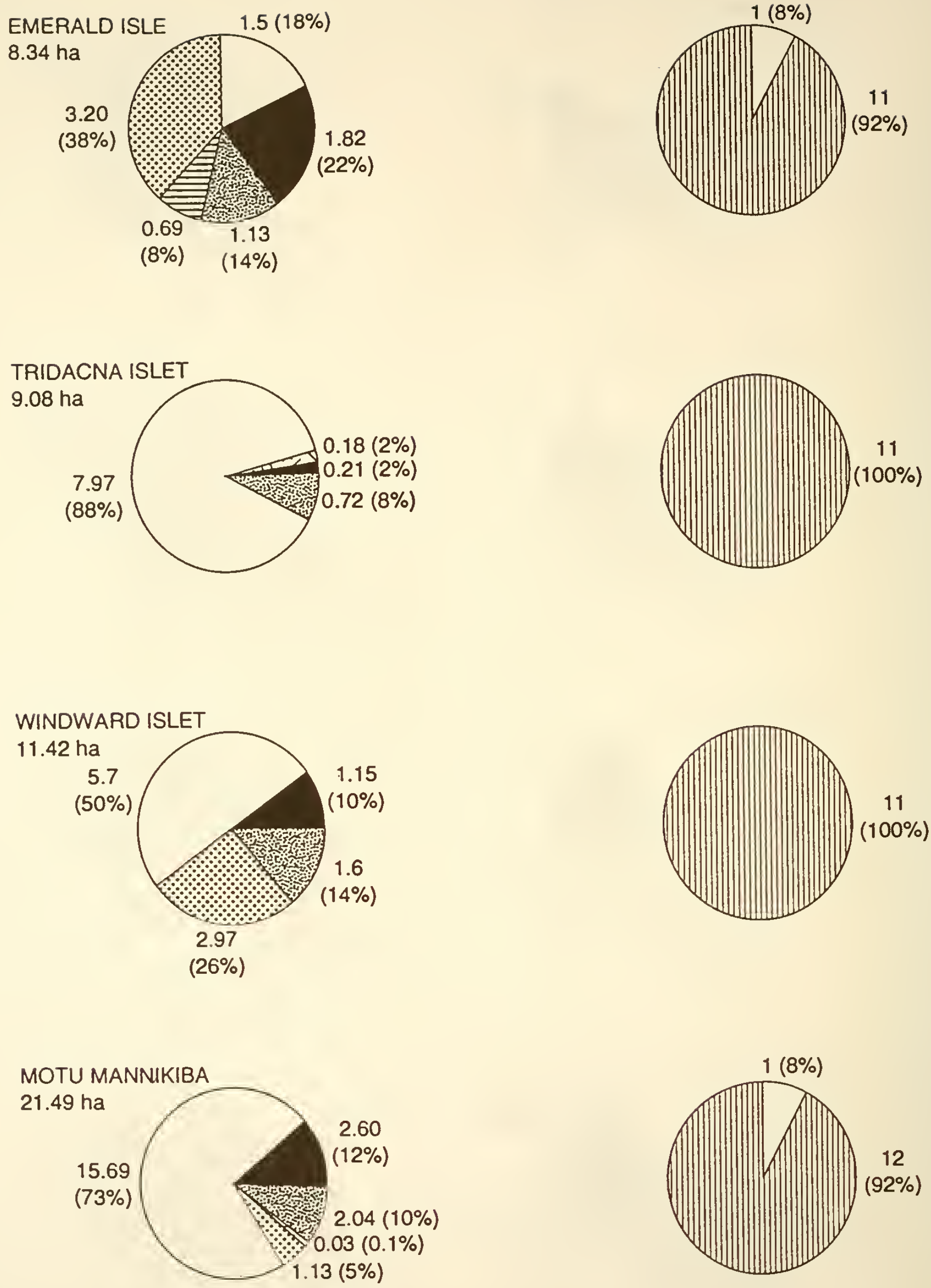


Fig. 29g. Plant communities and amount of indigenous vegetation on motus 0.8 to 25.0 ha, Caroline Atoll. See Fig. 27 for explanation of the figure.

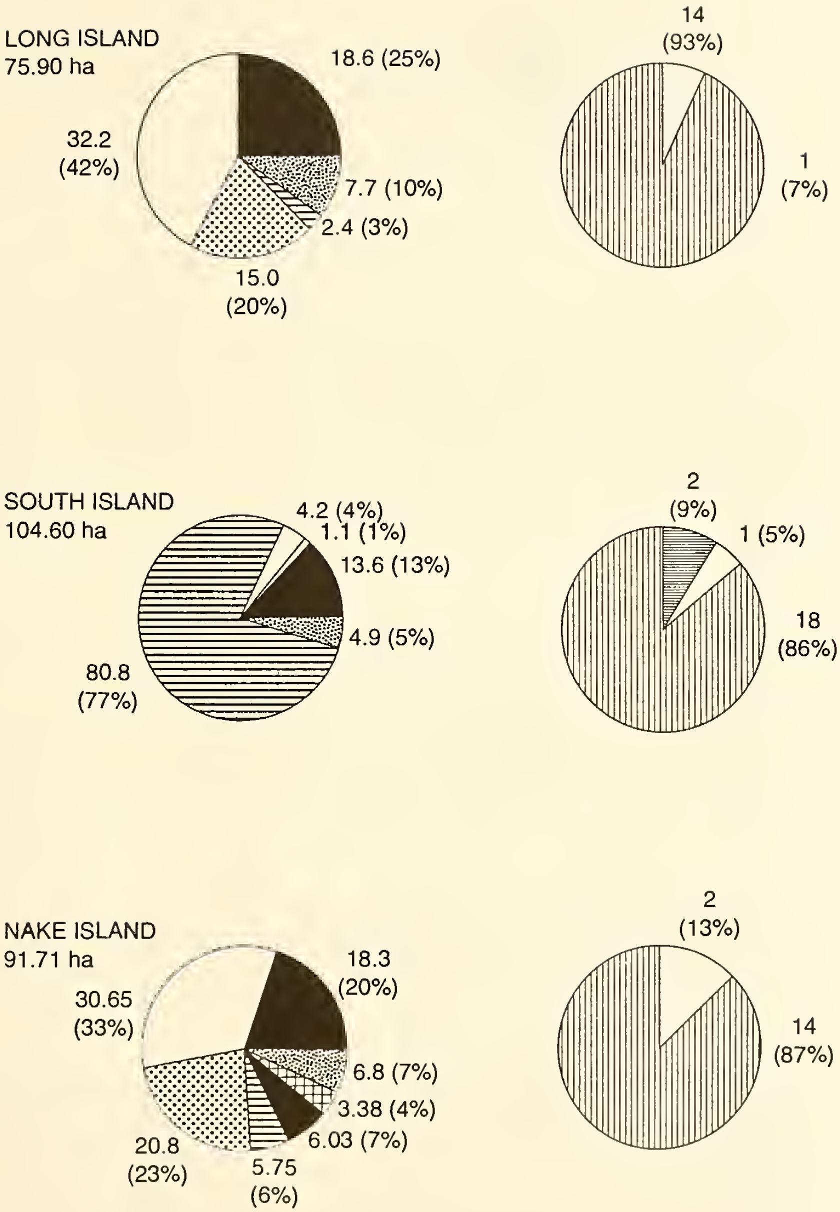


Fig. 30. Plant communities and amount of indigenous vegetation on motus over 25.0 ha. See Fig. 27 for explanation of the figure.

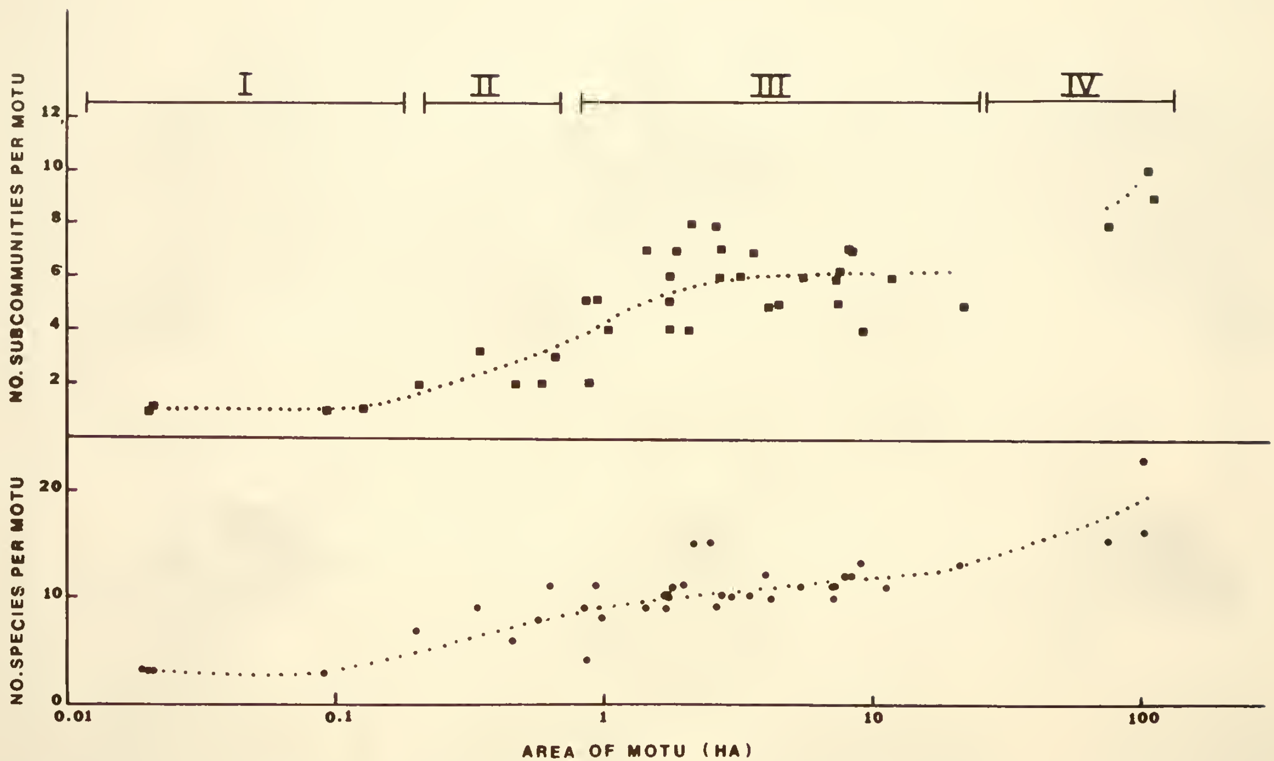


Figure 31. Total numbers of plant communities (upper graph) and species (lower graph) in relation to motu area, demonstrating plant succession on the different sized motus encircling Caroline's lagoon. Roman numerals refer to size classes of the motus: I = < 0.2 ha, II = 0.2 to 0.7 ha, III = 0.8 to 25.0 ha, IV = > 25.0 ha. The break between II and III marks a substantial increase in the diversity, area coverage, and height of the forest ecosystems. Data is based on Table 5.

A low herb mat, dominated by *Heliotropium*, *Portulaca*, *Boerhavia*, and, more rarely, *Lepturus*, develops first, after which *Tournefortia* quickly becomes established. Shade, producing locally humid conditions, and better "soils" derived from guano, decomposing leaves, and the activities of land crabs and rats, provides appropriate habitat for *Laportea* and occasional *Phymatosorus* and *Achyranthes*. The major tree species--*Pisonia*, *Morinda*, *Cordia*, and *Cocos*--subsequently appear, but are relatively rare. *Pisonia*, typically an inland species assumed to need underground water (Spicer & Newbery 1979, Wiens 1962), could well be salt tolerant as it occurs on motus as small as 0.2 ha (Tbs. 5, 6). In this size class *Pisonia* occupies only 2-6% of the total islet areas.

3) <u>Motus with Areas from 0.8 to 25.0 ha</u> Figs. 29, 31; Tbs. 5, 6

All 27 motus in this category share a similar complement of species and plant communities (Tbs. 5, 6). Their combined area totals 124.35 ha. They are well-wooded (Fig. 29), although the leeward motus have a higher proportion of rubble and herb mats, and forests are higher to windward. Unvegetated rubble covers less land area (21%) than in size classes a and b (87% and 39%, respectively). Within the woodlands of these motus, substrates mature from basic rubble to primitive "soils" with small, but significant, structural development. Their flora shows increasing diversity with size, and almost the full complement of seabirds may nest.

All natural ecosystems are firmly established; canopy heights range from 4 to 21 m. On small Booby Islet (0.84 ha), *Pisonia* is very common, and the *Pisonia* forests on North Brothers (1.71 ha) and Pig (7.25 ha), at 21 m, are the tallest on Caroline. As rich guano and dead foliage accumulate, a layer of phosphate-rich humus enables those species already present but poorly represented on the small motus (*Pisonia*, *Morinda*, *Boerhavia*, *Laportea*, *Achyranthes*) to increase in abundance and stature (Table 6). Additional species are *Suriana*, *Pandanus*, *Ipomoea*, *Lepidium*, and *Ximenia*.

Plant succession, ranging from Stage III to Stage V in the interior, primarily involves forest maturity rather than the addition of large numbers of species. On the larger islets, the number of plant species increases by relatively small increments, filling out the sub-canopy layers and, in the cases of *Cordia* and *Pandanus*, adding variety to the canopy.

The average number of plant species is 11.0, ranging from 4 to 15. If we divide the motus into smaller size classes, we find that their species numbers show a slight overall increase with increasing size: 8.0 species for areas 0.8-1.0 ha, 9.8 species for areas 1.1-2.0 ha, 11.5 species for areas 2.1-4.0 ha, 11.3 species for areas 4.1-10.0 ha, and 12.0 for areas 10.1-22 ha. An increase in herbs (range 3-9) is primarily responsible for these higher averages (Table 5).

Despite the large range of motu sizes in this category, plant communities are essentially natural (Table 5). Their overall species composition is 96% indigenous. Seventeen of the motus lack *Cocos*, the only introduced species in this area category, which is represented by small, isolated clumps or individual palms.

On the larger motus, and within the taller forests, more species of birds, especially Red-footed Boobies, Great Frigatebirds, White Terns, and Black Noddies, nest in increasingly large colonies, furnishing more minerals to the developing soils, especially where *Pisonia* covers large areas.

In summary, by the time a motu on Caroline has reached 0.8 ha in size, all the natural plant communities, most species of trees, shrubs and herbs, and most species of seabirds are present, assuming no major intervening disturbances (for example, hurricanes) have occurred. In Caroline's depauperate flora there are few species left to increase floral diversity on the larger islets, regardless of their size. This is very different from the inhabited atolls such as Kapingamarangi (see next section).

Although we do not know when true freshwater lenses develop, they may occur in motus of this size class. If we assume that *Pisonia* is not specially salt-tolerant, limited fresh water must be available on motus as small as 0.2 ha, and actual freshwater lenses may begin forming at ca. 0.7 ha, as indicated by the sudden proliferation of *Pisonia* forest (Tbs. 5, 6). However, the Falconers were unsuccessful in locating underground fresh water on Motu Ana-Ana (2.16 ha), which suggests that *Pisonia* may be somewhat salt-tolerant.

4) <u>Motus with Areas >25.0 ha</u> Figs. 30, 31; Tbs. 5, 6

On Caroline no motus fall between 22 and 75 ha in size. Thus the 3 motus in this category (Nake, South, Long) cover a limited range: 75.98 to 107.50 ha. They average 18.0 plant species. The floral components and forest heights of these larger motus (Figs. 33, 34; Table 5) are essentially the same as for class c. There are no additional natural ecosystems (mangrove swamps, salt flats, grasslands, etc.) or understory layers. One additional plant community (3 subcommunities) exists, dominated by the introduced coconut palm. Ten species, all rare or uncommon, are present only on the larger motus (Table 3): *Scaevola, Tribulus, Hibiscus, Thespesia, Ximenia*, *Psilotum*, *Tacca* (introduced in 1834), *Phyllanthus, Sida*, and the dubious *Digitaria*. Four, possibly as many as 8, are indigenous. In 1965, one vine of the indigenous *Ipomoea pes-caprae* was also found, but 3 subsequent surveys failed to locate it.

Species-Area Relationships

The relationship between the numbers of plant species and island size has long attracted interest (Fosberg 1949, Wiens 1962, MacArthur & Wilson 1967, Whitehead & Jones 1969), yet data from uninhabited islands is scant. The studies from Kapingamarangi (Niering 1956, Wiens 1956) and Aitutaki (Stoddart & Gibbs 1975) treat atolls with long histories of human occupancy. Some of the villages on Kapingamarangi's 23 motus date to 1200 A.D. Aitutaki's 16 uninhabited motus lie adjacent to a westernized volcanic island in an "almost-atoll." People on both these atolls have profoundly influenced their flora.

Caroline provides an opportunity to compare the numbers of species on motus of different sizes in an uninhabited atoll, then to compare the results with Kapingamarangi, Aitutaki, and uninhabited islands in the Line and Phoenix Groups that have no introduced species and have experienced minimal human contact (Table 8). Comparison of Caroline with remote, uninhabited Oeno and Ducie Islands, also having entirely indigenous flora (Fosberg et al. 1989) would also be beneficial (T. Spencer, pers. comm.).

Comparisons of Species-Area Relationships with Other Atolls

Studies of Kapingamarangi (Niering 1956) contributed greatly to theories of island biogeography (MacArthur & Wilson 1967). Because its motus cover the same range of sizes as Caroline, the 2 atolls might be expected to exhibit similar patterns. However, their species-area relationships are completely different. On Kapingamarangi, islets less than 1.4 ha showed a constant, small number of species, after which islets up to 100 ha showed a direct correlation of area with numbers of species. On Caroline, a motu of 1.4 ha supports almost two-thirds of the total number of species, and plant diversity on islets up to 107 ha shows only a slight, but not necessarily steady, increase (Table 5).

Species-area relationships on the motus of Aitutaki (Stoddart & Gibbs 1975, Figs. 33 and 34 of that paper) conformed to the Caroline model: the number of species increased only slightly on motus from 4 to 71 ha. Unfortunately, Aitutaki had only one motu less than 1.4 ha, so comparisons for smaller islets cannot be made. The floras of all 3 atolls have been impacted by man, but Caroline far less so than the others. Much of the floral diversity on larger islets at Kapingamarangi is derived from plants introduced by man and cannot be considered natural.

Six islands in the Line and Phoenix Groups (Malden, Starbuck, McKean, Phoenix, Vostok, Birnie) are uninhabited, *with entirely native flora*. All are Caroline's "neighbors" in an oceanic sense, and all except Vostok are dry, receiving about 750 mm (30") of rain p.a. They are old, essentially filled-in atolls, containing hypersaline central lagoons or no lagoon at all. Although the largest island (Malden) has the greatest diversity, there is only a very small linear increase in plant species with increasing area (Table 7). Plant diversity is more a function of climate (hot and dry) and distance from source areas, than size, similar to the situation on Caroline.

The Question of Fresh Water

The Kapingamarangi data were analyzed with availability of fresh water in mind (Wiens 1962, Whitehead & Jones 1969). These authors

Table 7. Species-area relationships of six Pacific islands with entirely indigenous flora.

Island	Area	No. Species
Malden	39.3 sq km	9
Starbuck	16.2 sq km	6
McKean	57 ha	7
Phoenix	49 ha	6
Vostok	24 ha	3
Birnie	20 ha	4

Islands are arranged according to decreasing area. Data is from Garnett (1983), Fosberg and Sachet (n.d.), Clapp and Sibley (1971b), and pers. obs.

suggested that 1.4 ha is the threshhold at which a freshwater lens can develop. Below this size only halophytes can survive. They argue that as there are only a limited number of salt-tolerant species, the floral composition on islets below 1.4 ha is relatively constant. On larger islets, species numbers increase in direct proportion to land area, because permanent groundwater promotes the survival of an increasing variety of nonhalophytic plants.

The groundwater vs. plant model does not apply to depauperate Caroline for a number of reasons: first, the number of plant species is not constant on islets below 1.4 ha: in fact, species are added *faster* on motus from 0.02 to 1.4 ha than between any other size range.

Second, on Kapingamarangi, the number of species increased in direct relation to islet size from 1.4 ha to 100 ha. On Caroline, species numbers increased only slightly from 1.4 to 22 ha and exhibited another minor increase from 70 to 108 ha (see Fig. 31; Tbs. 5, 6; and Sect. F, Ecological Succession). Thus, Caroline's data do not support the area-diversity theory.

Third, Whitehead and Jones (1969) argue that the flora on "small" motus lacking a freshwater lens (i.e. <1.4 ha) consists *only* of salt-tolerant strand species. This is not true on Caroline (Table 6). In addition to harboring the usual strand species (*Tournefortia*, *Portulaca*, *Laportea*, *Heliotropium*, *Boerhavia*, *Lepturus*), Caroline's "small" motus also support inland species that are generally considered non-halophytic (*Pisonia*, *Morinda*, *Achyranthes*, *Cordia*, *Phymatosorus*). Either these latter 5 species are moderately salt tolerant, or on Caroline the minimum islet size with a freshwater lens is much less than 1.4 ha, or both.

Fourth, Whitehead and Jones (1969) postulate that the non-halophytic species are those that control overall species-area associations. This may be a good generalization for less remote islands, but does not hold up for atolls with depauperate floras (Table 6). For example, on Caroline the halophytic *Ipomoea macrantha*, *I. pes-caprae*, *Scaevola taccada*, *Sida fallax*, *Lepidium bidentatum*, *Hibiscus tiliaceus*, *Thespesia populnea*, and *Tribulus cistoides*, which theoretically should only occur as strand species on the smaller islets, occur *only* on larger islets.

Fifth, the authors do not mention bird-dispersal of seeds, which is probably a factor that needs to be taken into account on remote islands: at Caroline, *Pisonia* and *Boerhavia* occur on islets from 0.2 ha to 108 ha. In addition, the numbers and diversity of seabirds and migrant shorebirds are much greater on unoccupied islets/atolls than on inhabited ones, strongly affecting the distribution of certain plant species.

Sixth, Caroline does not have an assemblage of nonstrand plants that *only* occur on larger motus; the only naturally occurring, nonstrand plant is *Psilotum*.

Seventh, the greatest factor complicating our understanding of Kapingamarangi's natural evolutionary processes is the presence of numerous exotics: of its 98 vascular plants, only 38 (39%) are indigenous. Its exotics include numerous weedy herbs and food plants which occupy gardens, abandoned house sites, taro patches, and plantations (*Cocos*, *Pandanus*, *Artocarpus*). These man-made habitats are particularly prevalent on larger islands. Such an abundance of exotics, both in species and area covered, renders a discussion of natural processes on Kapingamarangi almost impossible. Relatively undisturbed habitats such as those on most of Caroline's motus, and on other uninhabited Pacific islands such as Ducie and Oeno, whose quota of indigenous plants exceeds 75%, provide far better data on species-area relationships.

Motu Size in Relation to the Distribution of Trees, Shrubs and Herbs

As one progresses from small to large islets (Table 5), the number of tree species rises from zero to 7, the number of shrubs from one to 4, and the number of herbs from 2 to 12. Caroline's trends are similar to those at Aitutaki (Stoddart & Gibbs 1975), where the numbers of trees and shrubs are relatively constant over a wide range of motu sizes (3.8-71 ha), while the number of herbs shows a slight increase. There are too many recent exotics on Kapingamarangi for comparisons to be valid. We believe that if Niering's data were reanalyzed, using *only* indigenous species, similar generalizations would be found, viz: most species on atolls establish rapidly on small motus, after which a few additions occur on motus of increasing size until the maximum number of potentially available species is reached. Cursory examination of Niering's Figure 31, detailing the breakdown of total species numbers into indigenous and non-indigenous components, bears out this hypothesis.

G. PLANT COMMUNITIES

General Account

The total area covered by vegetation on Caroline is 357.55 ha, 90% of the combined areas of all the motus. Of this, two-thirds (289.82 ha) is woodland. Substantial areas of Caroline's native woodlands and herb mats are relatively pristine, and 89% (possibly 92%) of its plant species are indigenous. Twenty-three (60%) of its 39 motus harbor wholly indigenous vegetation (Figs. 27-30). Atolls supporting substantial areas of native forest are typically remote and uninhabited. Where people are present, native vegetation is usually confined to the smallest motus or the extremities of larger ones--areas with marginal human usefulness.

Overall vegetation patterns strongly support the theory that the original vegetation of many atolls is arranged in concentric or parallel belts according to salinity and ground water gradients, drainage, and exposure to salt spray (Fosberg 1976). Because of its impoverished flora, Caroline has no mixed broadleaf forest *per se* but is rich in pure stands or simple combinations of 2 or 3 species (Figs. 17, 21, 23, 26-29). Monotypic stands of shrubs and trees are common on atolls, but unusual for the continental tropics, where species diversity is considerably larger.

The present vascular flora of Caroline, 26 species, is organized into 7 plant communities (11 subcommunities) defined principally by dominant species (Fosberg 1953, 1976), whose areas are given in Table 8. Eight subcommunities are natural, 3 are anthropogenic (Table 5). The subcommunities include a mix of dominant species, which are discussed in the major community sections below.

NATURAL COMMUNITIES:
Natural Herb Mat
Beach Scrub with *Suriana*
Pandanus Forest
Tournefortia Scrub and Forest
Cordia Forest
Pisonia Forest

ANTHROPOGENIC COMMUNITY:
Coconut Woodlands

<u>Natural Herb Mat</u> (67.73 ha) — Figs. 19, 23; Pls. 19, 32, 34, 45, 46, 47

Widespread and predictable on wind- and salt-blown coastal coral rubble and incipient motus, these mats are composed primarily of *Heliotropium* and *Portulaca*. They are pioneers on newly emergent motus, cover most of the ground area of small motus, extend inland along ancient reef channels, and typify newly evolving land which connects or augments established islets. Natural herb mats may persist through all

Table 8. Areas of plant communities on the islets of Caroline Atoll.

	Area (ha)	% of Total Land Area	Total Area (ha)	%
Unvegetated Habitats			41.39	10.37
Coral Rubble and Sand	41.39	10.37		
Natural Plant Communities			261.41	65.53
Natural Herb Mats	67.73	16.98		
Beach Scrub with *Suriana*	1.49	0.37		
Pandanus Forest[1]	3.38	0.85		
Tournefortia Scrub and Forest	25.25	31.40		
Cordia Forest[2]	1.39	0.35		
Pisonia Forest	62.17	15.58		
Anthropogenic Community			96.14	24.10
Coconut Woodlands	96.14	24.10		
Total Area Above High Water			398.94	

[1]Pure *Pandanus* only. Also mixed with *Pisonia*, *Tournefortia*, and *Cocos*.
[2]*Cordia*, where mixed with *Pisonia* and *Tournefortia*, is included in totals for those forest communities.

5 stages of plant succession as long as sunny openings occur. Caroline's motus illustrate 2 general principles: 1) the smaller the area the more extreme is the strand character of its vegetation, and its corollary, 2) as areas enlarge, strand flora becomes less important (Fosberg 1949).

The following species are present (see Table 2 for abundance indices):

Trees: *Morinda citrifolia* (1 drift seedling on 1 motu);

Shrubs: *Tournefortia argentea*, *Suriana maritima*, *Scaevola taccada*; and

Herbs: *Heliotropium anomalum*, *Portulaca lutea*, *Boerhavia repens*, *Lepturus repens*, *Laportea ruderalis*, *Lepidium bidentatum*, *Ipomoea macrantha*.

Near the high water mark, the herbs are recumbent, leathery, and somewhat desiccated. As environmental conditions improve further inland, they spread more laterally and average up to 7 cm tall. Their rubbly habitat, often sprinkled with *Tournefortia*, resembles a low savannah. Although these prostrate herbs can tolerate intense sunlight, they grow optimally in slight shade, sandy soils, and higher relative humidity, when they may reach 22 cm tall, forming a fairly thick mat (Pl. 45). With too much shade the mats disappear or their species proportions and abundance changes according to the presence or absence of sunny clearings. Thus, natural herb mats may be found in patchy clearings within forests up to 13 m tall. They are common in the abandoned *Cocos* plantations of South Island, where *Boerhavia* proliferates into thick mats which completely cover the substrate, vying with *Phymatosorus* and *Ipomoea* for "lebensraum" (Pl. 34). A thick, exposed mat of succulent herbs, primarily *Portulaca*, is found on Noddy Rock.

Herb mats occurred on almost every transect, windward and leeward, ranging from 1% to 60% coverage (Figs. 19, 23), predominating in sparsely vegetated areas. The most extensive areas (coverage 35-50%) were on Skull, Tridacna, interior South, Emerald, and Mannikiba. Their widths varied according to the age, shape, exposure, and geographic position of the motu but were widest on seaward-facing shores. Wide bands of herb mats may encircle an entire motu; to windward they average 36 m (Table 9), while, bordering the relatively placid and intermittently shaded lagoon, they shrink to a mere 0.9 m. On leeward motus, the corresponding figures are 18.5 m and 4.2 m.

Table 9. Widths of natural herb mats on seaward- and lagoon-facing shores, Caroline Atoll.

	Average Width of Herb Mat (m)	
	Seaward	Lagoonward
Leeward Motus	18.5 (3-81)	4.2 (0-28)
Windward Motus	36.0 (24-69)	0.9 (0-3)

Although reef flats widen where islets turn sharply, it is not unexpected that these perimeter bands are the most extensive on the extremely exposed shores of northern Nake (Pl. 16) and southern South Island. On the latter, they are up to 59 m wide. Similarly, on small exposed motus (e.g. Skull, Noddy Rock), they carpet most of the area (Fig. 27). Under such conditions, *Portulaca* and *Boerhavia* develop much redder stems, possibly due to the presence of a chemical "sunscreen" or introgression with *P. oleracea* (Fosberg, pers. comm.).

Seabird Use

Whether bordering the edges of established islands or composing the entire ground cover of tiny motus and ancient reef channels, herb mats are nesting sites for Red-tailed Tropicbirds, Masked and Brown Boobies, Sooty Terns, and Brown Noddies. They provide sites for the development of phosphatic hardpan (Sect. D, Substrata). Herb mats also provide foraging grounds for shorebirds.

Beach Scrub with *Suriana* (1.49 ha) Fig. 20; Pls. 23, 39, 44

Uncommon on Caroline, Beach Scrub with *Suriana* is typically found on sand or sandy rubble bordering *Tournefortia* or *Cocos*. On Caroline, it is evidently limited by the paucity of low-lying sand and gravel sheets, with which it is normally associated elsewhere (Fosberg 1953, Wiens 1962, Stoddart & Gibbs 1975).

The following species are present (see Table 2 for abundance indices):

Shrubs: *Tournefortia argentea, Suriana maritima*; and

Herbs: *Heliotropium anomalum, Boerhavia repens, Portulaca lutea, Laportea ruderalis, Phymatosorus scolopendria, Lepturus repens.*

This plant community was found on 9 motus (Fig. 20), either in thick bands or as scattered shrubs. *Suriana* is most robust on sandy substrates, especially fringing the lower lagoon on South Island (Fig. 36; Pls. 23, 39) and on windward Tridacna. The fringe, repeatedly interrupted by other species, grows to 12 m wide and 1.8 m high. Here the shrubs are closely appressed and slightly entangled, forming dense shade which supports a sparse understory. On South, where its roots are submerged at high tide, it is being shaded out by overhanging *Cocos* (compare Pls. 39 and 40), having retreated since 1965. *Suriana* also occurs as scattered individuals or in open bands in coarse rubble. Beach strand up to 60 m wide, containing herb mats, *Tournefortia*, and scattered *Suriana*, were found on South (Tr. 1, Pl. 20), Long (Tr. C), Brothers, Matawa, Long, and the Southern Leeward Islets.

Pandanus Forest (3.38 ha[5]) Fig. 11; Pls. 17, 35-38

Although several species of *Pandanus* are native to the Line Islands, and their seeds are common components of Pacific sea-drift (Ridley 1930, Stone 1968), it is possible that the groves of *P. tectorius* on Caroline represent both natural forests and cultivars transported by early Polynesians. However, we have no data to verify

[5]This figure is pure *Pandanus* forest. Mixed forests containing *Pandanus* account for a further 14.96 ha.

this, except that its present and past distribution on Flint Island suggests that it is indigenous there (Kepler, in prep.). Its largest acreages are on 2 islands that contained historical settlements (Nake, South). However, its presence within the interior forests of a few motus lead us to conclude that it may have experienced a dual introduction. On Emerald, 3.20 ha (38% of the islet) supports a mixed forest of *Tournefortia*, *Pisonia*, and *Pandanus*. Similarly, Shark's interior woodlands of *Tournefortia*, *Pisonia*, and *Cordia* (5.52 ha, 70% of the islet's area) also contain a substantial amount of *Pandanus*, but there was possibly a hut on Shark last century. The occurrence of *Pandanus* groves or lone trees on other islets (Fig. 11) is easily attributable to drift seedlings. Dried *Pandanus* phalanges are the most conspicuous litter along Caroline's lagoon beaches (Pl. 38); its seeds last for months in seawater (Guppy 1906) and are probably distributed locally by rats and land crabs, as noted elsewhere (Ridley 1930). Phalanges from Nake's southern mixed woodlands undoubtedly established the grove on Pandanus Islet.

The mixed forest with *Pandanus* on south Nake (with *Cocos*, *Cordia*, *Pisonia*, and *Tournefortia*) contains up to 50% *Pandanus* attaining heights of 12 m (Fig. 37).

Many *Pandanus* trees were felled on South Island during the coconut planting era (ca. 1873-1925), as we know that they were "somewhat numerous" in 1834 (Bennett 1840), but only "one or more of the screw pines were found growing in various parts of the island" in 1883 (Trelease 1884). A drawing in this latter paper depicts a grove from South, where today *Pandanus* is uncommon in the beach scrub bordering the *Cocos* plantation.

Trees were fruiting abundantly in September 1988. The green phalanges, 17.5-20 cm in diameter, ripen to yellow and orange when they fall, to be eaten by hermit crabs, *Coenobita perlatus* (Pl. 38).

Tournefortia Scrub and Forest (125.25 ha) — Figs. 24, 32; Pls. 7, 9, 19, 29, 47

General Distribution

Characteristic of many Pacific islands, *Tournefortia*, a broadleafed evergreen, dominates the wooded motus of Caroline, forming 40% of its vegetative cover and 31% of the total land area (Fig. 24, Table 8). Its pale foliage and hemispherical canopies (to 14 m tall) typically surround the taller, darker canopies of *Pisonia* and *Cordia*.

A hardy halophyte, *Tournefortia* occurs on every motu and in every habitat except pure *Pisonia* forest. It is tallest, widest and lushest on the windward motus, particularly on those where *Pisonia* is also best developed. Without direct sun though, as under dense *Pisonia* or *Cocos*, it withers (Pl. 23).

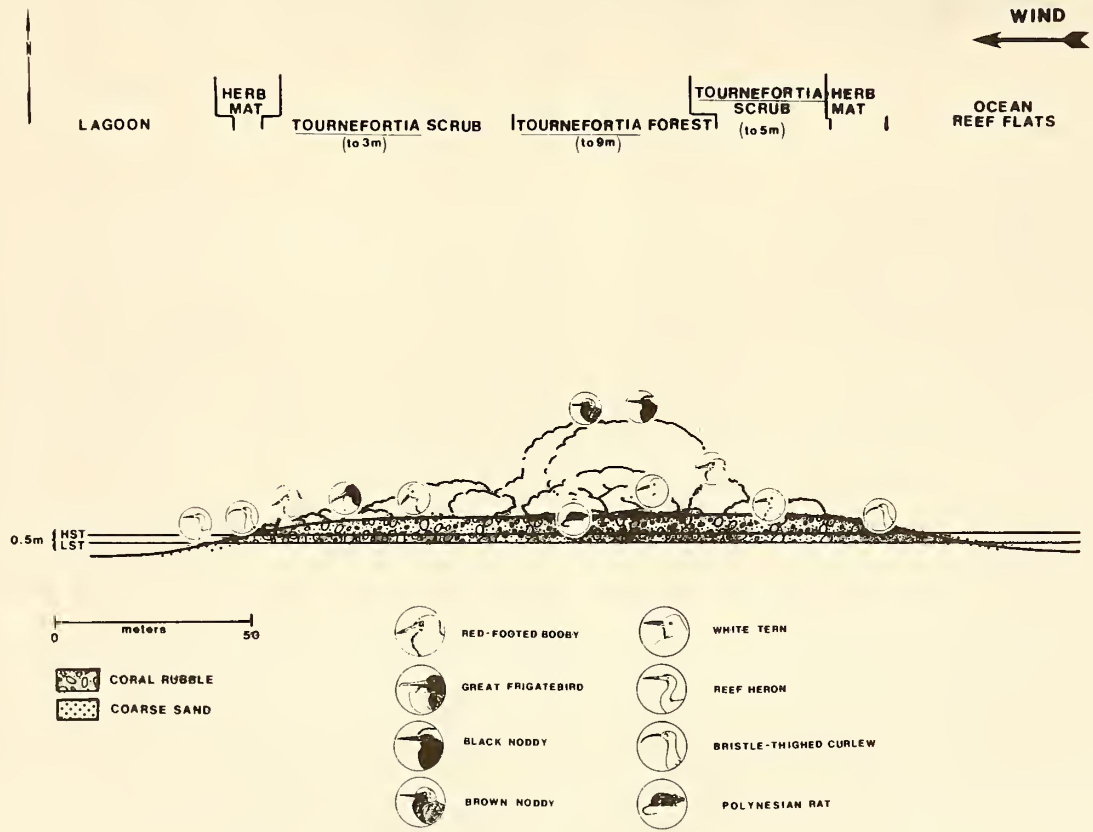


Figure 32. Schematic profile through Arundel Islet, recovering from disturbance over 60 years ago, showing natural herb mats, *Tournefortia* scrub and forest, and 5 species of breeding seabirds. Vertical height is exaggerated.

On other atolls *Tournefortia* forms a narrow or interrupted belt inland of the beach, or is a component of mixed scrub (Fosberg 1953). However, given the floristic poverty on Caroline, especially of shrubs and trees, *Tournefortia* not only has expanded into niches which might elsewhere be occupied by combinations of *Scaevola*, *Pemphis*, *Suriana*, *Terminalia*, *Hernandia*, *Thespesia*, *Hibiscus*, etc., but frequently occurs in pure stands (113.03 ha) that extend well inland. It thus occupies a much higher percentage of the islet areas on Caroline than on atolls with greater biodiversity. For example, Nake, the largest islet, has the greatest amount of *Tournefortia* (79.68 ha): 28.9 ha of pure scrub and forest, 18.28 ha of "savannah," 17.48 ha with *Cordia*, 8.99 ha with *Pisonia*, and 6.03 ha mixed with *Cocos*, *Pandanus*, and *Pisonia*.

Overall, we classify *Tournefortia* as a shrub (Stoddart & Gibbs 1975). However, following Mueller-Dombois et al. (1981, p. 58), we also distinguish between its shrub (scrub) and tree communities. Because they intergrade, we may lump them together (vegetation maps and schematic profiles of the motus), or treat them separately (Tbs. 2, 5, 10 and ecological discussions):

1) *Tournefortia* Scrub: ≤5 m high ($\bar{x}$ = 2 m), <60% canopy coverage (Pls. 19, 29, 32, 47). This open scrub growth is typically confined to islet perimeters or emergent reef channels and covers much of the vegetated rubble on smaller islets. Its species composition is similar to that of the taller forest, except that herbs are more prominent.

2) *Tournefortia* Forest: >5 m high ($\bar{x}$ = 8 m), >60% canopy coverage (Pl. 48). This taller, closed forest, with maximum height 15 m, develops as a second belt of woody vegetation approaching the interior of the larger islets. Figure 32 depicts a schematic profile through pure *Tournefortia* scrub and forest, while Figure 35 diagrams a profile of a larger islet where *Tournefortia* is represented only on its periphery.

Species Diversity in *Tournefortia* Woodlands

The following species occur in both scrub and forest. Those marked "*" occur primarily in the scrubland (Table 2).

Trees: *Pisonia grandis*, *Morinda citrifolia*, *Pandanus tectorius*, *Cocos nucifera*, *Cordia subcordata*;

Shrubs: *Suriana maritima*, *Tournefortia argentea*, *Scaevola taccada*, *Ximenia americana*; and

Herbs: **Heliotropium anomalum*, *Boerhavia repens*, *Portulaca lutea*, *Lepturus repens*, *Laportea ruderalis*, *Achyranthes canescens*, *Phymatosorus scolopendria*, *Ipomoea macrantha*.

Caroline's tallest *Tournefortia* stands (12-15 m) occur on Nake. On all other windward motus, the *Tournefortia* canopies vary between 6 and 9 m tall, shorter than expected if their forests were virgin. This has historical significance: we do not know the extent of forest felling (if any) on the Windward Islets (Crescent through Tridacna) during the guano era, but we do know that 4,587 coconut palms were planted during 1919-20, and that "misses" (dead seedlings) were fastidiously replaced over the following 2 years (Young ca. 1922). Thus, their forests, though weed-free today, comprise secondary growth around 60 years old. It is not surprising that *Achyranthes canescens* and *Lepturus repens*, both weedy (though indigenous), are particularly common inland on some windward motus (Figs. 13, 16). *Tournefortia*'s rapid recovery illustrates that ecosystems in the pioneer stage generally recover their original condition rapidly when left alone (Fosberg 1983).

Stature and Area Coverage

Forming an umbrella-like canopy, a typical *Tournefortia* forest is very simple. Its twisted branches and gnarled trunks stretch untidily over an open understory. The lower branches die off as the trees increase in stature. Sometimes a scant herbaceous cover develops in localized pockets of better soil, such as a clearing where a dead tree fell or a semishaded spot beneath a colony of seabirds.

Tournefortia is abundant throughout the atoll. Areas with 90%-100% canopy cover were found on Nake (Tr. 4), Long (Trs. B, C, 4, 6, 10, 12), North Pig, Pig, North Brothers, Brothers, Crescent, Arundel (Fig. 32), Tridacna (Trs. 1, 2), South (Trs. 1, 4), all 5 Southern Leeward Islets, all Central Leewards over 0.5 ha, and Pandanus Islet. *Tournefortia* is present across the entire width of some small motus, e.g. Fishball (144 m wide). Even on larger motus such as Mannikiba (280 m wide), *Tournefortia* blankets nearly all the land (Pl. 63). Long (75.98 ha) is a composite motu: long, narrow, and derived from the coalescence of at least 5 former islets. Because *Tournefortia* encircled the perimeters of these ancient islets, it is now present in 5 sets of concentric circles, connected by herb mats, down the length of the island (Fig. 39).

In the herb mats, *Tournefortia* is small ($\bar{x}$ = 1.4 m) and widely scattered (Table 10). It may be of typical hemispherical shape or irregularly windshorn (Pls. 13, 45). On windward coasts they typically form a tight wind barrier, one or 2 trees thick. Moving inshore from the seaward fringe, the trees become progressively taller ($\bar{x}$ = 6 m) with a more open understory. *Cordia* often mixes with *Tournefortia*, either as scattered individuals in the understory or canopy, or as small groves. On the Southern Leeward Islets such belts border the seaward scrublands.

Although still widespread in the Pacific, *Tournefortia* is far less abundant than formerly. On inhabited islands it exists primarily in relict patches or as edging around anthropogenic forests. It rarely covers most of the land area of islets; exceptions are Taongi and Bikini (Marshall Islands), Gaferut (Caroline Islands), and Ducie Atoll (Pitcairn Islands) (Fosberg 1956, Wiens 1962). The finest quality

Table 10. Stature and percentage cover of Tournefortia in the major habitats of Caroline Atoll.

	Av. Hgt. (m)	Av. Width (m)	% Tournefortia Cover	No. Motus	No. Transects
Natural Herb Mat	1.4 (0.3 - 1.8)	49 (3 - 198)	25 (5 - 95)	14	20
Tournefortia Scrub & Forest	6 (0.3 - 15)	55 (2 - 287)	81 (5 - 100)	38	71
Tournefortia-Pisonia Forest	9.5 (5 - 15)	98 (8 - 284)	47 (5 - 90)	18	27

Tournefortia on Caroline (15 m tall, 80% cover) occupy central and northern Nake (Fig. 37), but even this islet was completely felled for *Cocos* (Table 13). These 15-m *Tournefortia* compare favorably with 18 m specimens found at Jemo Island by Fosberg (1956). Perhaps Jemo's trees are at the upper size limit for the species, as *Tournefortia* is generally recorded as 3 to 6 m tall (Wiens 1962).

Ecology

Tournefortia is an integral part of the atoll's evolution and ecology. Bearing seeds capable of floating for at least 4 months in the sea (Guppy 1906), it is the first woody plant to establish on Caroline's tiny motus (<0.1 ha), appearing immediately after the native herbs have begun to germinate in the coarse coral rubble. It is the only plant species on tiny Ducie Atoll (Fosberg et al., 1989). Requiring little or no soil and adequate rainfall, it can grow up to 2 m a year (Fosberg 1959). *Tournefortia*'s leaves contribute to soil development, paving the way for plant succession from Stages I through IV, for it only persists in soils that are conducive to the growth of its mesophytic competitors (Fosberg 1953). The most mature trees ($\bar{x}$ = 9.5 m) occur at the *Tournefortia-Pisonia* interface, but die off as *Pisonia* expands. When *Tournefortia* has reached its maximum height, most of its lower branches have fallen, leafage is reduced, and flowers and fruits are few. *Tournefortia* usually drops out after one generation. Seedlings are rarely seen in heavy shade, and fallen trees are fairly common on the edge of the interior forests where *Pisonia* replaces it.

An example of complete replacement of *Tournefortia* by *Pisonia* is illustrated by nearby Vostok. It has heretofore been assumed that Vostok's sole tree species was *Pisonia grandis* (Fosberg 1936, Bryan

1942, Clapp & Sibley 1971b, Garnett 1983). However, Young (ca. 1922) stated that when Capt. J. Larsen, of the schooner *Papeete*, planted 100 coconuts there on 31 May 1922, he found "*Pukatea* and *Tauhinu* trees, etc. 60 to 80 feet high," that is, *Pisonia grandis* and *Tournefortia argentea*, but no "Tou" trees (*Cordia subcordata*). By 1935 only *Pisonia* remained (Fosberg 1936); hence, the last *Tournefortia* must have been eliminated naturally by *Pisonia*.

Along some coasts (Long, Nake, South), *Tournefortia* overhangs the water, its roots immersed at high tide. We found floated debris up to 20 m inland within dense *Tournefortia* forest, indicating that this hardy shrub can withstand periodic storms and high tides. If a rosette of *Tournefortia* leaves is placed in fresh water, it droops within an hour, indicating that its tissues require a high salt concentration in order to maintain turgidity (pers. obs.). Perhaps decreased salinity in the ground water, coupled with reduced light intensity in advanced seral stages, contribute to the eventual disappearance of *Tournefortia* in the center of coral islands.

Seabird Use

Tournefortia is a favored roosting and breeding site for most of Caroline's seabirds. The taller the trees, the greater the bird diversity they harbor: scrub contained 4 species (36%) and forest, 9 (82%). Sooty Terns nest in tight colonies in its shade, its canopies support large populations of Red-footed Boobies and Great Frigatebirds (Pt. II), and its branches are favored by White Terns (Figs. 32, 35, 36). *Tournefortia* leaves provide nesting material for noddies.

Cordia Forest (1.39 ha) — Fig. 22, Pl. 26

General Distribution

Cordia does not form "the main native woodland" on Caroline Atoll, as implied by Clapp & Sibley (1971a) and stated by Stoddart & Gibbs (1975, p. 104). It occupies far less area than *Tournefortia* or *Pisonia* (Table 9). *Cordia* is generally mixed with other emergents: monotypic *Cordia* forest covers only 1.39 ha, while *Tournefortia* or *Pisonia* containing substantial amounts of *Cordia* total 25.89 ha. *En toto*, this is less than 10% of Caroline's woodlands, and *Cordia* is usually subdominant. These "mixed" forests of *Cordia* mixed with *Pisonia* or *Tournefortia* (rarely all 3), occasionally with a *Morinda* understory, are the closest equivalent to Mixed Broadleaf Forests of other coral islands. This widespread Pacific plant community (Fosberg 1953, 1976; Wiens 1962) is conspicuous by its absence on Caroline. We treat *Cordia* forest as a separate plant community because of its increasing rarity on Pacific atolls, which makes Caroline's groves an increasingly important resource in need of conservation. *Cordia* forest occurs primarily on Nake, Windward, Crescent, North Pig, Pig, Danger, Shark, and the Southern Leeward Islets.

History

Bennett (1840) recorded "two species of *Tournefortia*" on Caroline, possibly referring to *Tournefortia* and *Cordia*. There are no other 19th-century records. From *Cordia*'s present distribution we can infer that it was formerly more extensive on South and Nake. Scattered trees within and bordering the *Cocos* plantations suggest that its history is similar to the species on Flint, which was "in 1872...covered with a forest of 'Tou' trees *Cordia subcordata*)" (Maude ca. 1942). Both Flint and Caroline were worked simultaneously by the same companies for guano (1872-1890) and copra (into the 1930s). *Pisonia* and *Cordia* forests were felled to make room for coconuts. From Flint, several hundred *Cordia* logs were exported to San Francisco for furniture and panelling. The last logs were exported in 1896, 6 years after the guano supplies were depleted, but coconuts were still being planted (Young ca. 1922), and some large *Cordia* trees were still present in the southern 20% of the island still covered with virgin forest (E. Campbell 1908, Kepler, in prep.). Today, Flint's recovering forests contain much *Cordia* (A. Kepler 1990b), unlike Caroline, where *Cordia* is rare in similar habitats. Some of Flint's present windward *Cordia* trees may be those "few tiny, struggling...trees...recently planted" (St. John & Fosberg 1937).

Abundance and Distribution

Cordia seeds are dispersed by ocean currents and can germinate after 40 days in sea water (Guppy 1906). On Caroline this species develops both as an understory shrub and forest emergent (to 15 m high). It typically occupies the woodland periphery, occurring in small circular or linear groves, or mixing with *Tournefortia* and/or *Pisonia* (Table 5). *Cordia* may form tall, straight-trunked trees (Pl. 26) or sprawl like *Hibiscus tiliaceus*. In dry rubble sites it may become chlorotic or semideciduous. The tallest groves are on Pig (Pl. 26), where 6 trees averaged 12.6 m tall, 116 cm circumference at 1.5 m (cbh), and 99.8 cm base circumference. Lush *Cordia* groves occur in sheltered parts of the upper lagoon on Long Island (Tr. 10).

Flowering times are unpredictable. Two flowers were seen in September 1988. In November 1989, flowers were abundant, extending through March, yet in November 1990 not one flower was observed (pers. obs., Anne Falconer and AKK).

Seabird Use

Black and Brown Noddies, frigatebirds, and White Terns nest in *Cordia* wherever it is a forest component. Great Frigatebirds and Red-footed Boobies favor roosting in the lush, lagoonside forest of *Cordia* and *Pisonia* near the south end of Long Island.

***Pisonia* Forest** (62.17 ha) — Figs. 18, 33, 34, 35, 39, 41; Pls. 43, 50, 51; Tbs. 11-14

General Distribution

Although *Pisonia grandis* was previously recorded as "present" (Trelease 1884, Clapp & Sibley 1971a), the quality and extent of its forests has not been recognized. Some stands are prime representatives of a major ecosystem that was formerly far more widespread in the Pacific.

Common throughout the atoll, *Pisonia* occurs on 29 motus, covering 22% of the woodlands. Well developed groves, 10-21 m tall and up to 359 cm circumference at 1.5 m, are present on 23 of these (Table 11). Although present on motus less than one hectare in size (Table 5), it typically occupies interior forests (schematic profile, Fig. 35), with individual trees or groves contributing from 5% to 100% of the canopy. In general, Caroline's windward motus support the lushest forests: the maximum height of windward *Pisonia* forests is 21 m, of leeward forests, 15 m.

Mature *Pisonia* forests are monocultures of grandeur. The trees bear one to several stout boles of irregular shape, whose rotting cavities often harbor large coconut crabs or miniponds alive with mosquito larvae. Their scraggly branches occasionally bend over and reroot. It is dark and humid, but open except for exposed roots and scattered broken branches. Few seedlings occur. Polynesian rats scurry underfoot.

In September 1988 we saw no flowers or fruit. Anne Falconer reported flowers on Motu Ana-Ana in August 1990. *Pisonia* was beginning to bloom on Vostok in March 1990 (A. Kepler, in prep.).

An Historical Perspective

Some of Caroline's most mature *Pisonia* groves (to 21 m tall, 660 cm circumference at 1.5 m, multiple trunks) appear to be virgin, (Pl. 43) but are most likely only 60-70 years old. Overall dimensions of the trees, the low species diversity, and general character of the plant community compare favorably to virgin groves on Vostok (Table 12; A. Kepler 1990c, d).

Despite the maturity of many groves, especially those to windward, planting records from 1916-22 indicate that *Cocos* was planted throughout not only South, but also on Nake, Long, and all the major Windward Islets (Young ca. 1922). Given the standard planting density of 73 m^2/palm (Young ca. 1922), we calculated the approximate area on each islet given over to *Cocos* plantations, based on the number of coconuts planted times the area required for each tree. We then compared this to the usable areas based on today's forest cover (Table 13). On the 9 Windward Islets, collectively, 36.36 ha were planted in *Cocos*, fully 92%

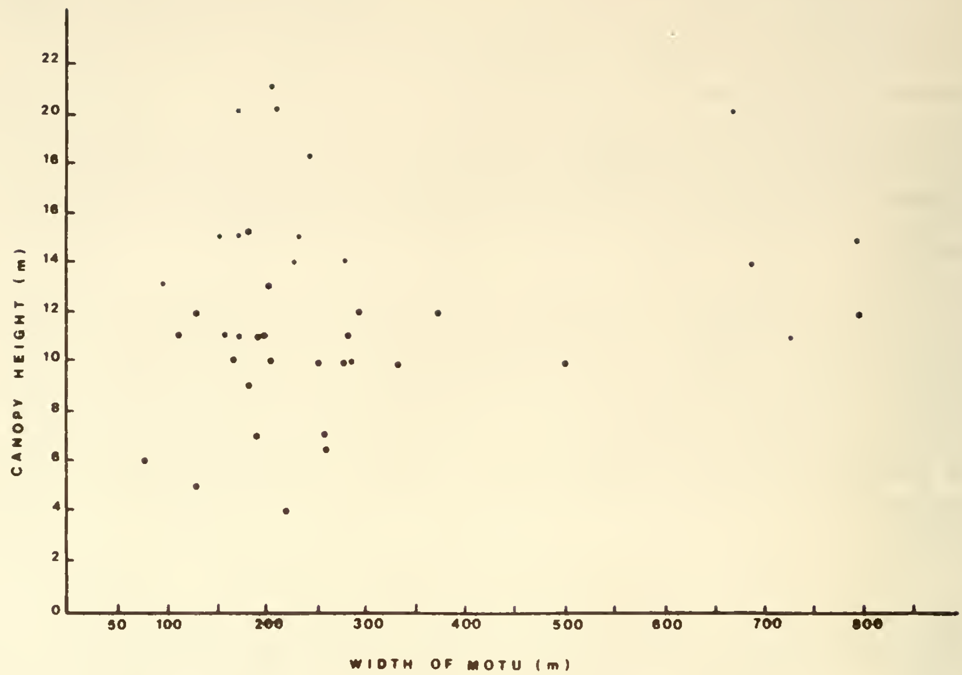


Figure 33. Maximum heights of *Pisonia* forests in relation to width of the motus. Stars represent forests with 90-100% canopy cover; dots represent forest or scrub with less than 90% cover.

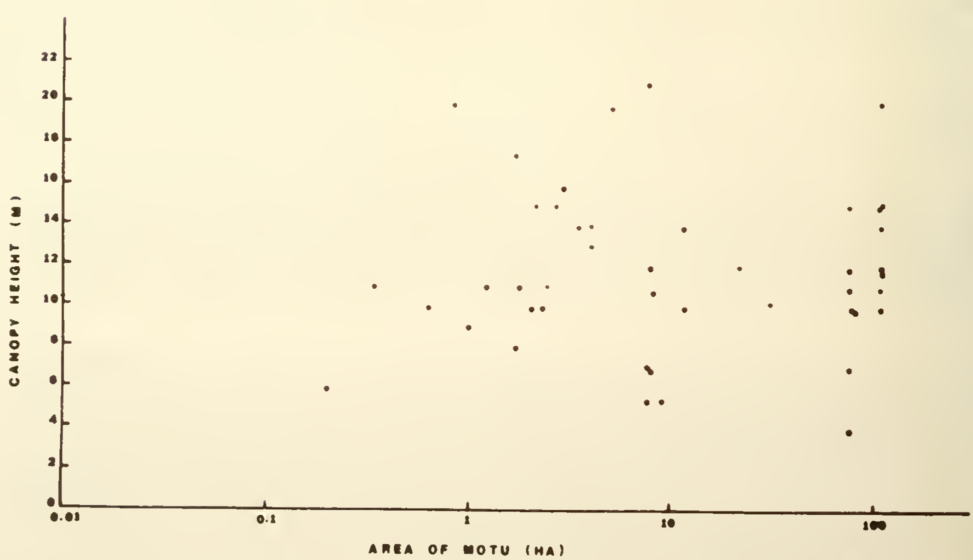


Figure 34. Maximum canopy heights of *Pisonia* forests in relation to motu area. Stars represent forests with 90-100% canopy cover; dots represent forest or scrub with less than 90% cover.

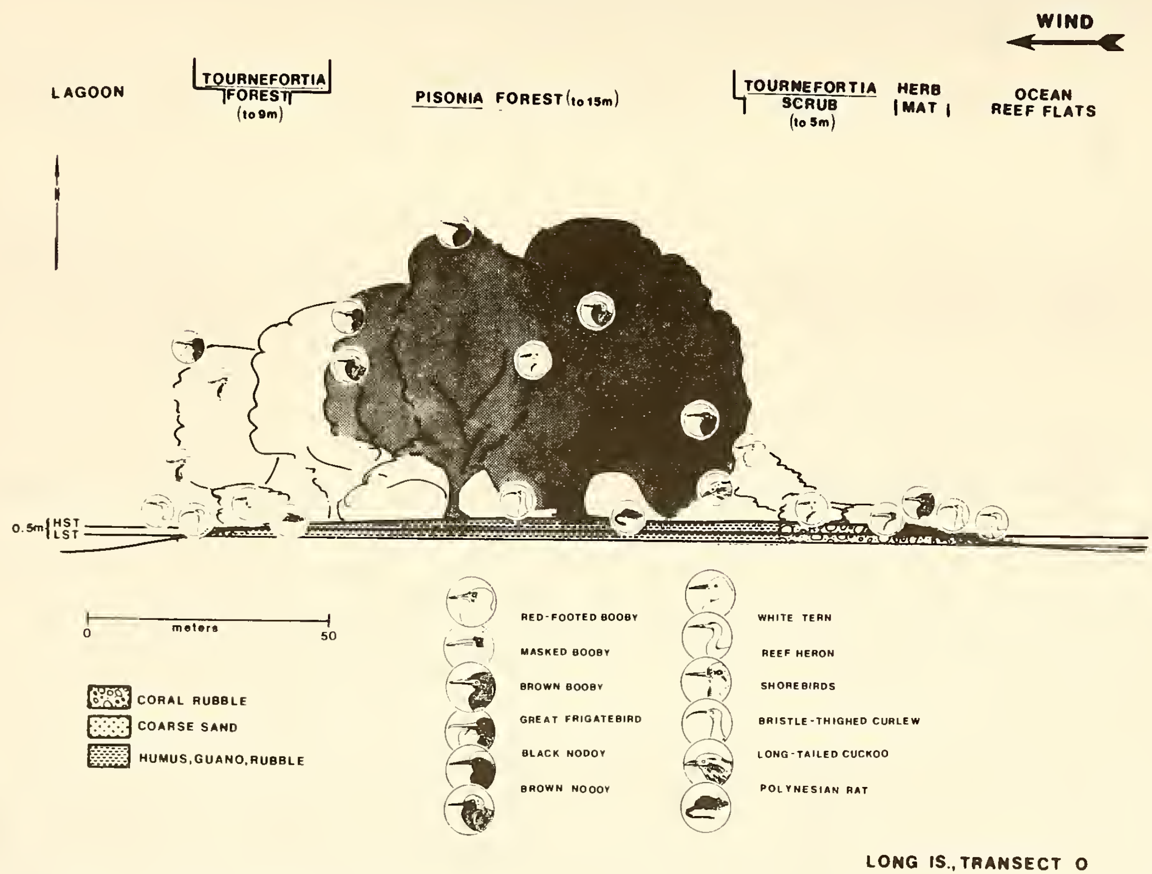


Figure 35. Schematic profile through Long Island, Transect O. Although Long Island has been formed in the recent past by a merger of 5 smaller islets, this section of the islet is very mature, containing natural herb mats, *Tournefortia* scrub and forest, and tall *Pisonia* forest. Seven species of seabirds breed. Vertical height is exaggerated.

Table 11. Distribution of well-developed (≥10 m height) Pisonia forests on the motus of Caroline Atoll.[1] Motus and transects are arranged according to the decreasing height of their Pisonia groves. Capitals indicate those motus whose forests were felled for Cocos plantations from 1916-20.

Motu & Transect	Pisonia Height (m)	Area of Pisonia (ha)	Motu Area (ha)
PIG	21*	3.36	7.21
NAKE, Transect 4	20*	20.79	107.46
Booby	20*	0.12	0.84
NORTH PIG	20*	1.83	5.44
NORTH BROTHERS	18*	0.43	1.71
NAKE, Transect 3 (central)	15*	20.79	107.46
LONG, Transect 0	15*	15.00	75.98
BROTHERS	15*	0.37	4.31
Ana-Ana	15*	0.93	2.16
Danger	15*	0.39	2.71
NAKE, Transect 2	14*	20.79	107.46
Bird	14*	1.70	4.05
WINDWARD, Transect 2	14°	2.97	11.42
Raurau	14*	1.07	3.48
CRESCENT	13°	0.51	3.10
Mannikiba, Transect 1	12*	1.13	21.49
Shark	12°	2.60	7.98
NAKE, Transect 3 (west)	12°	20.79	107.46
LONG, Transect 12	12°	15.00	75.98
Pisonia	11*	0.86	2.45
Matawa	11	0.07	1.71
Nautonga	11°	0.02	0.34
NAKE, Transect 3 (southwest)	11°	20.79	107.46
Kimoa	11°	0.59	1.80
Emerald	11°	3.20	8.34
Eitei	11°	0.38	1.42
LONG, Transect B	10°	15.00	75.98
LONG, Transect 8	10	15.00	75.98
NAKE, Transect 1	10°	20.79	107.46
WINDWARD, Transect 1	10	2.97	11.42
Blackfin	10°	0.41	2.62
NORTH ARUNDEL	10°	0.18	0.91

[1]Tournefortia or Cordia may be present, but sub-dominant to Pisonia.
*90-100% canopy cover.
°50-80% canopy cover.

Table 12. Area and Dimensions of *Pisonia grandis* on Vostok, Flint, and 5 islets of Caroline Atoll. Comparative data are from A. Kepler (1990b,c,d).

Island/Islet	Area of *Pisonia* (ha)	No. trees or main trunks	Mean Height (m)	Range of Heights (m)	Mean cbh[1] (m)	Range of cbh (m)	Mean base[2] (m)	Range of base circumferences (m)
CAROLINE	62.17							
North Pig	1.83	25	19	11-21	221	110-359	261	205-470
Brothers	0.37	10	15	15	140	50-219	243	154-340
Pig	3.36	5	16	12-17	338	290-660	282	230-333
North Brothers	0.43	3	18	18			314	293-332
Long	15.00	3	15	15			414	282-500
Total for above islets at Caroline	20.99	46	18	11-21	213	50-660	293	154-500
VOSTOK	13.5	58	18	10-25	218	67-510		
FLINT	approx. 4 (fragmented)	20	17	8-30	160	60-200	598	100-1000

[1]cbh = circumference at 1.5 m.
[2]base = base circumference at 0.3 m.

Table 13. Number of trees and areas planted in Cocos on Caroline's islets during the major planting era (1916-1920), also showing remnant Cocos data for 1990. Note the remarkable recovery of indigenous forests on all islets except South.

		Area Forest or Scrub Usable for Cocos in 1990[1] (ha)					1916-20			
Islet	Islet Area (ha)	Tournefortia	Pisonia	Other	Cocos	Total	No. Cocos Planted	Approx. Area Cocos[2] (ha)	% Cocos 1990	Approx. % 1990 Forest Planted in Cocos 70 Yrs Ago
South	104.41	4.20	0	1.1	80.00	86.10	13,006	94.94	77	100%
Nake	107.46	30.65	20.8	9.41	5.75	66.61	10,544	76.97	6	100%
Long	75.98	32.20	15.0	-	2.40	49.60	1,343	9.80	3	20%
Tridacna (A1)[3]	9.08	7.97	0	0.18		8.15	910	6.64	0	82%
Arundel	7.34	4.36	0.95	-	0	5.31	646	4.71	0	89%
N. Arundel (A2)	0.91	0.33	0.19	-	few trees	0.52	69	0.50	0	100%
Brothers	4.31	2.00	0.37	-	0.01	2.38	315	2.30	0.2	97%
N. Brothers (A3)	1.71	0.68	0.43	-	few trees	1.11	180	1.31	0	100%
Pig	7.25	1.61	3.36	-	0.03	5.00	538	3.93	0.4	79%
N. Pig (A4)	5.44	1.31	1.84	-	0	3.15	402	2.93	0	93%
Crescent (A5)	3.10	1.56	0.51	-	0	2.07	228	1.66	0	80%
Windward (A6)	11.42	5.70	2.97	-	0	8.67	1,299	9.48	0	100%
						238.49		215.10		

[1] "Usable area" does not include unvegetated rubble or natural herb mats.
[2] Based on Caroline's planting densities of 28 x 28 sq ft (Young ca. 1922).
[3] The "A" series of islet names are from Young (ca. 1922).

of all usable ground; in several cases the amount calculated for *Cocos* by Young exceeded our estimates of potentially usable ground. Thus, *Cocos* was planted so intensively on the Windward Islets that virtually all *Pisonia* and most *Tournefortia* woodlands were felled.

Two remarkable points emerge from Table 13: 1) scarcely any *Cocos* remains today on the 9 Windward Islets; not one palm exists on 7 motus (Figs. 43, 44, 47, 48), and 2) the recovery of indigenous plant communities, Stages I through V (Sect. F) on the windward side has been rapid and, at least on Brothers Islet (Fig. 46), reasonably complete with regard to ecological succession and species diversity of plants and seabirds. Today the Windward Islets have the lushest and tallest plant communities, with a higher species diversity than the leeward islets (Table 3), which have evidently experienced far less human disturbance.

This differential disturbance on the windward and leeward sides of the atoll explains enigmas such as 20 m tall *Pisonia* forest on the leeward Booby Islet (0.84 ha), taller than most of the windward forests; the absence of *Pisonia* on windward Tridacna Islet (9.08 ha), which, being close to South Island, probably supported *Cocos* which was managed longer than the more distant windward islets; and the patchy distribution of *Pisonia* in the interior of several islets (e.g. Windward, Arundel). This last point also applies to Mannikiba (21.49 ha), the largest leeward islet. According to Young (ca. 1922), 6,000 seed sets were brought from Flint to Caroline in 1920 and kept on Mannikiba. This "nursery stock" was used to replant "misses" on other islets, due mostly to destruction by coconut crabs and poor planting. Today, Mannikiba's total acreage of *Pisonia* (Fig. 53) is very small and fragmented relative to the islet's size: 1.13 ha, 5% of the total land area. Compare this with Bird Islet (Fig. 55) which, as far as we know, has never been disturbed: 1.70 ha *Pisonia*, 42% of the islet's land area.

On both Caroline and Flint there is much variation in the quality of the regenerated *Pisonia* forests (Table 12). Some trees bear enormous, partly rotting boles, black algae smothering the bark, multiple trunks, and few or no understory herbs. Other trees are tall, straight-trunked, with characteristic whitish bark, and bear no rotting holes in their bases. These observations suggest that when their indigenous forests were felled, only minimal cutting was done, and many *Pisonia*s were able to regenerate quickly by sprouting from rooted stumps and fallen branches. This speculation is supported by the fact that some of Vostok's *Pisonia* trees regenerated similarly. Maude (1953, p. 96) states that "there is room for 8,000 palms on Vostok, but only 100 have been planted and most of these have been choked in the luxuriant 'buka' (*Pisonia grandis*) forest: no attempt having been made to exploit the island since the initial planting."

Pisonia, a soft, pulpy wood, has a well-known ability to sprout or send up suckers from dismembered branches or fallen trunks (Fosberg 1953), and it has been noted that older trees are virtually indestructible, fire being the only effective means of clearing forests

(Wiens 1962, p. 397). The senior author has photographed leaf sprouts from partly burned twigs as small as 1 m long and 5 to 6 cm in diameter.

Since the existing *Cocos* plantations on South and southwest Nake contain few *Pisonia*s, it seems that forest clearing was more thorough on the atoll's larger islets than on the smaller ones, which today manifest scant traces of their former history. Fortunately for Caroline, its coconut plantations were plagued by a number of problems, which resulted in their double abandonment: coconut crabs, seabirds, rats, *Ipomoea* vines, and an unknown disease (see under Coconut Woodlands, this section).

A footnote in Young (ca. 1922, p. 15) states that "the larger portion of the 30,000 trees planted were either badly planted or smitten with some disease as in 1927 it was reported by Mr. Bunckley that most of them had perished." In 1929 only 13,215 trees were left, and more were being planted. Considering the distribution of both palms and natural forests today, it appears that plantations continued on South and Nake and were abandoned on the smaller islets, allowing for a better recovery than might be expected had the *Cocos* grown to maturity. Tridacna (close to South) and Mannikiba (a nursery) were likely the most intensely managed of the smaller islets, as their *Pisonia* today is meagre compared to their overall areas.

Once a *Cocos* plantation has been well established and subsequently abandoned, *Pisonia* regrowth is more difficult. This is characteristic of many tropical islands. For example, on Cousin Island (Seychelles Islands, Indian Ocean), an ICBP wildlife perserve since 1968, *Pisonia* is currently reestablishing within a deteriorating *Cocos* plantation. Phillips & Phillips (1990, p. 37) envisioned "centuries rather than decades before something like a natural ecosystem develops." We predict a similar time frame for Caroline's South Island, sooner for Flint. Forest recovery on islands elsewhere has evidently not been studied in detail (Fosberg, pers. comm.).

Annual Growth Rates

Data on *Pisonia grandis* growth rates is very limited. A 7-year study on Kabelle Island, Rongelap Atoll, Marshall Islands, disclosed mean diameter growth rates of 1.32 and 0.39 cm/yr at 2 sites (Gessel & Walker 1992). On Cousin Island, vegetation changes, including *Pisonia* and *Cocos*, have been monitored since 1974, but no growth rates are yet available (Phillips 1984, Phillips & Phillips 1990).

Because of this paucity of data on *Pisonia*, and because its forests have diminished significantly this century, we present the following data in the hopes that it might inspire more research.

One point is clear: on all 3 of the Southern Line Islands *Pisonia grandis* has recovered fast from disturbance (except for total forest elimination), reaching close to its maximum height and ecological maturity in 70 years or less. Mature *Pisonia*, under optimal conditions of soil, temperature and rainfall, may attain 35 m, as on Fanning and Washington (Garnett 1983 and pers. comm.). However, in the Southern Line Islands, canopies of similarly virgin *Pisonia* on Vostok rarely exceed 25-30 m tall (A. Kepler 1990c), and only 16-18 m on the Great Barrier Reef (Walker 1991).

Caroline's prime groves, 21 m tall, with circumferences to 660 cm, and bearing multiple trunks and root suckers, we now know date back only to the 1920s. The largest trees, 21 m high and 660 cm cbh, appear to have averaged annual growth rates of 0.32 m in height and 3.4 cm in diameter.

Further evidence of fast growth rates is provided from Flint. In 1934 only one small *Pisonia* and a few tiny, struggling *Cordia*, recently planted, were recorded (St. John & Fosberg 1937). Virtually the entire island (324 ha) was a *Cocos* plantation. In 1990 *Pisonia*, quite common on the windward side, attained maximum heights of 30 m, with base circumferences and at 1.5 m (cbh) of 1,000 cm and 200 cm, respectively (Table 12). These compare favorably with 2 trees of similar heights and cbh to 510 cm on Vostok and a large *Pisonia*, presumably virgin, measured on Atafu Island (Tokelaus) by the U.S. Exploring Expedition in 1840, which was more than 600 cm in base circumference and about 12 m tall (Wilkes 1845, Vol. V, p. 9). Furthermore, pure indigenous mixed broadleaf forests (*Pisonia*, *Cordia*, *Guettarda*), to 25 m tall, covered 57 ha, 23% of Flint's vegetated area (Kepler, in prep.), with a further 65 ha (26% of the woodlands) in mixed forests containing less than 50% *Cocos*. Thus, *Pisonia*s have established themselves since the plantation was abandoned in the late 1930s. The largest trees, 30 m high and 200 cm cbh, now indicate a mean annual increment of 0.6 m height and 1.32 cm diameter over the past 50 years. A faster growth in height than on Caroline is likely due to Flint's higher rainfall and greater relative humidity due to the presence of a more successful coconut plantation inland: Caroline's annual output of copra was 15 tons, compared to 230 tons for Flint (Young ca. 1922, Maude 1953).

Species Diversity in *Pisonia* Forests

Caroline's motus harbor every stage in the development of a *Pisonia* forest, from stately monotypic groves to a single tree. The plant communities between these extremes harbor the greatest species diversity and most luxuriant growth on the atoll. The following species are present (Table 2):

Trees: *Morinda citrifolia*, *Cordia subcordata*, *Cocos nucifera*, *Pandanus tectorius*, *Pisonia grandis*;

Shrubs: *Tournefortia argentea*; and

Herbs: *Boerhavia repens*, *Portulaca lutea*, *Laportea ruderalis*, *Lepturus repens*, *Achyranthes canescens*, *Phymatosorus scolopendria*, *Ipomoea macrantha*.

The number of species within *Pisonia* forests ranges from one to 14 (Table 14). As *Pisonia* becomes more dominant, their trees are taller (21 m), and species diversity is less (Table 14). Here the average number of species is 3.4. Species diversity is also very low at the other extreme of *Pisonia* development: in one young motu (Azure), only a single 6-m-tall *Pisonia* tree is present ($\bar{x}$ = 4.0 species). The smallest islet on which we found *Pisonia*, Azure is only 0.20 ha in area and 77 m wide (Fig. 55, Pl. 51); more than half of it is rubble. The width of its scrub is only 38 meters. Along a transect within the majestic *Pisonia* grove (100% canopy cover) on Brothers (Fig. 46), we found no other plant species, an extreme case of the barrenness of *Pisonia* understory. This grove, 13 m tall and extending 42 m from east to west, was sharply delineated from the 6-m-high *Tournefortia* forests on both sides and provides a striking example of complete ecological succession since its *Cocos* plantation days of the 1920s.

The highest species diversity occurred with mixed co-dominants (*Tournefortia, Cordia*) and *Pisonia* coverage 25-50% (Fig. 34, Table 14). Here, the average number of species was 6.2 (range 3-10). Regardless of the area or width of the motu on which they occurred, these mixed stands ($\bar{x}$ = 7 m tall) were always shorter than pure *Pisonia* forest.

Ecology

On Caroline, most plant species establish early in the evolution of individual motus, increasing in abundance and stature while the land area is quite small. *Pisonia* typifies this pattern: single trees occur on 2 motus whose areas are only 0.2 ha (Table 6), suggesting that *Pisonia* is partly salt-tolerant, at least in its early growth stages. In general, however, motus less than 0.7 ha on Caroline have little *Pisonia* (Table 6). It is difficult to imagine a freshwater lens on Motu Nautonga (1 ha), where an 11-m-tall *Pisonia* forest is found (Table 11). Further evidence for the salt-tolerant nature of *Pisonia* comes from Vostok, where a *Pisonia* forest, the sole woodland, extends to the edge of the shoreline rubble and herb mat. The trees, tightly pruned by wind and salt, have no buffer of coastal scrub. During storms, seawater reaches Vostok's interior forest, yet this 24-ha island supports one of the largest and tallest (25-m-high) groves in the Pacific (Clapp & Sibley 1971b, Fosberg 1977 and pers. obs.).

Many *Pisonia* trees were heavily infested with scale insects (Coccidae) and Neuropteran larvae (*Chrysopa* sp.), identified by Dr. Scott Miller (Bishop Museum, Honolulu, Hawaii). This appears to be a natural phenomenon, as they were also abundant on the virgin *Pisonia* forests on Vostok and also on secondary *Pisonia*s at Flint.

Relationships Between *Pisonia* Forest Height and Motu Dimensions

Contrary to expectations, the tallest, most mature forests did not all occur on the largest motus (Table 11). The 3 prime forests (90-100% canopy cover) were on Nake (total land area 107.46 ha), Pig (7.21 ha),

Table 14. Species diversity in _Pisonia_ forests of decreasing maturity, Caroline Atoll. Groves are arranged according to the degree of coverage of their constituent _Pisonia_ trees. Where _Pisonia_ is present, even in low percentages, it is always the tallest tree. Note that there is an inverse relationship between the purity of the _Pisonia_ forest and its species diversity.

Canopy Cover	Av. Canopy Hgt. (m)	Numbers of Species/Transect: Av. No. Spp.	Trees (incl. _Pisonia_)	Shrubs	Herbs	Total	No. Transects
100% (_Pisonia_ only)	13	1	1	0	0	1	1
100% (codominant present)	15	3.4	2	0	5	7	9
90 - 95%	10	5.2	5	1	7	12	9
50 - 90%	10	6.2	5	2	7	14	15
25 - 50%	7	6.2	4	1	6	11	5
<25%[1]	9	5.6	3	2	9	14	6
Single _Pisonia_ tree only	6	4.0	3	1	3	7	2

[1]South Island not included, as its _Pisonia_ is too rare.

and Booby (0.84 ha). Trees on Booby measure less in girth than those on Nake and Pig, but their height (20 m) is impressive. Evidently, Booby was never exploited for guano or planted in *Cocos*. Fine forests occur on other small, undisturbed motus; for example, *Pisonia* grew to 14 m on Raurau (3.48 ha) and to 11 m on Kimoa (1.80 ha).

A positive correlation exists between *Pisonia* height and island width (Fig. 33). Motus appear to reach a minimum width of 90 m before closed canopies of 13 m develop, and canopy height increases to 21 m as motu width enlarges to 200 m (Pig, topmost star in Fig. 33). Further increases in motu width did not result in taller trees. However, even on motus with sufficient width, *Pisonia* did not develop unless other environmental conditions were suitable. For example, on Long, *Pisonia* only occurred in the centers of its former islets, not in the scrubby areas where coalescence is more recent. Tridacna and Mannikiba, both ideal for *Pisonia*, have not yet recovered fully from their *Cocos* plantations.

Pisonia-Seabird Relationships

Seabirds are an integral part of *Pisonia* ecology. Its sticky fruits adhere to the feathers of, and are thus dispersed by, seabirds such as terns, boobies, and frigatebirds; thus, its early appearance on small motus is not surprising.

On Caroline, 6 species of seabirds nest in its branches, dropping considerable amounts of guano to the ground below. Black Noddies, amassing in dense colonies, nest almost exclusively in *Pisonia*, along with Brown Noddies, White Terns, Great and Lesser Frigatebirds, and Red-footed Boobies. Pig Islet, with 7.25 ha of excellent *Pisonia* forest, supported a dense colony of nearly 2,000 pairs of Black Noddies (Pt. II). Bristle-thighed Curlews feed on the ground beneath its open understory, and the Long-tailed Cuckoo forages within its canopy.

Seabirds may be so much a part of *Pisonia* ecology that a debate exists as to whether *Pisonia* actually *requires* guano for successful germination and establishment of seedlings (Shaw 1952, Fosberg 1953, Wiens 1962). Very high phosphate and nitrogen levels are associated with mature *Pisonia*, and concurrently the development of *Pisonia* forest results in greatly modified soils that perpetuate its existence (Wiens 1962, Spicer & Newbery 1979). The formation of a highly acid raw humus on the surface of the ground, sometimes in association with phosphatic hardpan, has also been documented on several atolls by Fosberg (1953, 1956, no date; Stoddart & Scoffin 1983), including Vostok (AKK and John Phillips, pers. obs.). We have no information on phosphatic hardpan in Caroline's *Pisonia* forests. For further discussion, see Section D, Substrata.

Remnant *Pisonia* Forests in the Pacific

Though naturally and widely distributed throughout Indo-Pacific islands (excluding Hawaii), *Pisonia grandis* forests have been subjected to great destruction and are now rare. Pure *Pisonia* forest was formerly the most widespread indigenous forest on Pacific atolls, and may have formerly covered the greatest area of any tree species in the Pacific (Wiens 1962, Fosberg 1976). Shaw (1952), summarizing its distribution, stated that it only occurs on remote, generally uninhabited islands ranging from the western Indian Ocean to the eastern Pacific, including Malaysia. However, more recent studies, particularly by Fosberg, indicate that because its habitat occupies, and is in part responsible for, the most fertile areas of inhabited islands, its formerly extensive forests have been largely replaced by coconuts. Though *Pisonia*'s soft wood is of little use to either atoll inhabitants or to the timber industry, its soils were rich sources of phosphate fertilizer and were thus greatly disturbed during the guano mining era. *Pisonia* is highly adapted for growth on coralline substrates, also having developed unique morphological and physiological characteristics associated with seabird colonies and mycorrhizal fungi (Walker 1991). Caroline, with 62.73 ha in *Pisonia* forest (36.94 ha in monotypic groves) holds some of the finest representatives of this ecosystem in the Pacific, even though much of it is not virgin.

One of the prime Pacific *Pisonia* stands (13.5 ha on Vostok) was partly burned in 1977 (Fosberg 1977). The Royal New Zealand Air Force found it smoldering 3 months later (Fosberg 1977, pers. comm.). In a March 1990 visit to Vostok, we found that approximately 1.5 ha were completely cleared (A. Kepler 1990c) and a further unknown amount of land was affected. Cays of the southern Great Barrier Reef have recently been found to harbor ca. 160 ha of uncut *Pisonia* forest. The largest stand (94 ha) is on Northwest Island (Walker 1991). Other fine groves exist on Palmyra and Washington (Northern Line Group), Rose Atoll (American Samoa), Bikar, Taongi, and Jabwelo (Marshall Islands), and Fanna (Southwest Palau Islands). Flint (Southern Line Group); Christmas (Northern Line Group); Nikumaroro (Phoenix Group); Jemo and Ujae (Marshall Islands); and Aitutaki, Penrhyn, Suwarrow, and Manihiki (Cook Islands) have relatively small stands. Not all are healthy. For example, groves on Bikar, Jabwelo, and Palmyra were recently devastated by typhoons (Flint et al. 1992, IUCN 1992) and that on Taongi is unhealthy (Thomas et al. 1989).

Coconut Woodlands (96.14 ha)

Figs. 14, 36; Pls. 17, 22, 23, 27-29, 32, 34, 37, 39, 40, 44

General Distribution

Cocos, although present on 15 motus and known to be planted intensively on at least 13, covers significant areas only on the 2 largest islets, South and Nake (Table 13). Individual trees and small

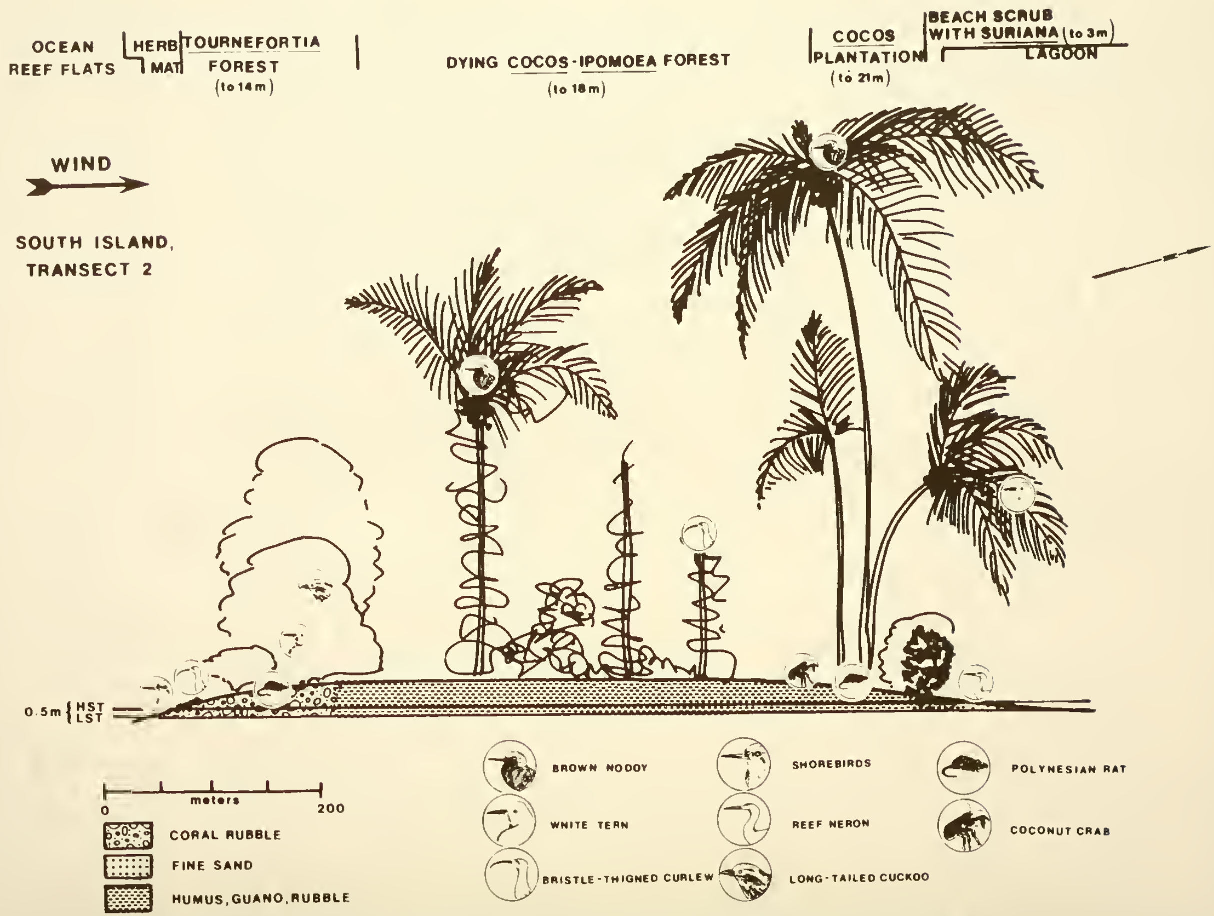


Figure 36. Schematic profile through South Island, where 77% of the land surface is covered with *Cocos* forests, primarily in a dying state. Vertical height is exaggerated.

groves elsewhere are drift-derived or remnants of plantings made from 1916 to 1920.

The following species occur in habitats containing *Cocos* (Table 2):

Trees: *Pisonia grandis, Morinda citrifolia, Pandanus tectorius, Cordia subcordata, Cocos nucifera, Thespesia populnea, Hibiscus tiliaceus*;

Shrubs: *Tournefortia argentea, Ximenia americana*; and

Herbs: *Boerhavia repens, Portulaca lutea, Laportea ruderalis, Achyranthes canescens, Phymatosorus scolopendria, Ipomoea macrantha, Lepturus repens, Tacca leontopetaloides, Psilotum nudum, Phyllanthus amarus, Sida fallax.*

The distribution of *Cocos* (Fig. 14) in order of decreasing abundance is as follows: SOUTH: Forests old and neglected. Living palms line the lagoon, currently shading out strip of native scrub. NAKE: Southern forests (50-80% *Cocos*) healthier, younger, with more native trees and *Pandanus* than on South; grove of about 50 palms on northeast. LONG: Range from <1% cover (Tr. C) to dense fringe adjacent to lagoon. EMERALD: Northeast and west-central patches. MANNIKIBA: Main grove, northeast: 40 palms, 20 m high, another patch in south center. ANA-ANA: House site, northeast point. BIRD, BLACKFIN, BROTHERS, NAUTONGA, NORTH BROTHERS, PIG, PISONIA, RAURAU, SHARK: Few trees each, primarily in *Tournefortia*. LONE PALM: One tree, central forests.

History

A relatively small coconut grove was planted on South Island prior to the 16th century by Tuamotuan settlers (Emory 1947, Maude 1968). In 1606 de Quiros noted "plenty of palms" and "many cocoa-nuts" (Markham 1904). Since then, every visitor has recorded them since they grew, and still grow, adjacent to the boat "landing." A smaller grove evidently also existed in the south-southwest portion of South Island (Lucett 1851). Palms were also periodically planted--and destroyed--"by whalers and other chance visitors to the island" (Maude ca. 1938).

Until Arundel's arrival in 1885, *Cocos* was basically confined to this single grove in the northwest sector of South (Maude ca. 1942). In 1885, land clearing began, and from then till 1929 nearly 38,000 palms were planted, 29,480 between 1916 and 1920 and another 7,000 young trees after 1927 to replace thousands that had perished (Young ca. 1922). Arundel's initial license gave him the exclusive rights to occupy Caroline and Flint, planting coconuts and other trees for 21 years, in return for an annual rental of 50 pounds sterling (Maude ca. 1942). In 1929 13,215 trees remained, after which no one has counted them. Our field work and scrutiny of aerial photographs indicate that far fewer exist today.

Caroline's plantations produced copra periodically from 1873 to 1934, but never profitably. They suffered greatly from the atoll's abandonment from 1901-1916. Dying and poorly planted palms presented continual setbacks (Young ca. 1922); in 1878 a hurricane wrought great destruction (N.I.D. 1943), and although no record exists of the effects of the 1906 hurricane on Caroline, waters reaching well inland on Flint threw warehouses off their foundations and flooded all buildings within the settlement (Campbell 1908). In addition, plantation managers lamented their poor productivity due to choking "by undergrowth and Pohue Vine,[6] destruction of inflorescences by great numbers of seabirds which roosted in the tops and broke off the flowers as they appeared," disease, and ruination of nuts by Polynesian rats and coconut crabs. As a result of this, the laborers slaughtered many crabs, and "greatly reduced the numbers of sea birds, who migrated to unoccupied islets." The rat problem was never resolved and appears to be the major reason for the eventual abandonment of plantations on both Caroline and Flint. Their enormous numbers and voracious eating habits greatly reduced both the crops of potentially healthy nuts as well as the volume of dried copra. In 1920, 4,600 were trapped on South Island, and hundreds more were killed by small terriers introduced specifically to control them (Young ca. 1922). Maude (pers. comm.) recalls that one terrier still survived in the 1940s. Rats still abound, especially within coconut groves and *Pisonia* forests. Another serious problem was due to coconut crabs digging up recently planted nuts and pinching off young shoots. After the palms had attained one year's growth this was no longer a problem (Young ca. 1922).

Before abandonment (1902 to 1916, and after 1934), Caroline's plantations were owned by several companies whose average annual copra output was approximately 14 tons. From 1934 to the 70s copra was harvested sporadically by small parties from Tahiti (Garnett 1983), but within the last 2 decades it stopped altogether.

Despite the relatively fertile soils of South Island, the problems in the plantations hampered the establishment of permanent settlements on Caroline. In the 1930s Maude estimated that the atoll could support 400 Gilbertese, increasing to over 1000 "when the island has been fully planted" (Maude ca. 1938). Colonists were never established though, since the failure of the plantations was never cured (Maude 1953), leaving Caroline "one of the least spoiled islands in the Pacific" (Stoddart 1976). However, as plantation information in Young's (ca. 1922) unpublished "Memoranda" indicates, Caroline is not as pristine as it appears, but the rapid recovery of most of its windward forests is remarkable (see *Pisonia* Forests, this section).

---

[6]Said to be *Tuumfetta* (= *Triumfetta*) *procumbens*, most likely a misidentification of *Ipomoea macrantha*.

Distribution and Abundance

We recognize 4 subdivisions of the coconut woodlands: *Cocos* Plantations, Dying *Cocos-Ipomoea* Plantation, Scattered Groves on Small Motus, and Mixed Forest with *Cocos*.

1) *Cocos* Plantations (34.07 ha)

Superannuated palm forests dominate South Island and southwestern Nake. Although the planting of *Cocos* on South eliminated most of its original habitats, Nake escaped with less damage: *Cocos* covers 77% of the area on South but only 6% of Nake (11% including mixed forests). The 60 to 100-year-old trees form tall, closed canopy woodlands (Pl. 23) 21-25 m high, the customary maximum height recorded for old plantations (Fosberg 1953). Figure 51 shows the distribution and abundance of plant species along a transect running centrally through the island, while Figure 36 depicts a schematic profile of the same swath.

Pure coconut plantations harbor relatively few species: up to 7 trees, zero to 2 shrubs, and 5-11 herbs. The understory layers are almost exclusively indigenous, an unusual feature. However, skirting the edge of the lagoon, tall palms overhang the water, crowding native plants; *Suriana* and *Tournefortia* were less abundant in 1988 (Pl. 28) than in 1965 (Pl. 40).

2) Dying *Cocos-Ipomoea* Plantation (53.92 ha)

Mature plantations characteristically become overgrown with shrubs and vines (Fosberg 1953, 1956). *Ipomoea macrantha*, the sole vine on Caroline, forms tangled, impenetrable thickets. Indigenous, nonparasitic, and widely dispersed by ocean currents, it forms a very minor component of Caroline's natural habitats, but grows rampantly in disturbed areas. Vine-covered coconut woodlands cover two-thirds of South Island's interior (Fig. 50). This moribund forest is bordered by a belt of living palms, which in turn are sheltered by a narrow rim of indigenous vegetation (Figs. 36, 51).

While traversing the South Island transects, the authors stomped over intertwining thickets up to 3 m high (Pl. 8) and crawled through tightly-knit masses of vines descending from the crowns of old palms, *Pisonia*, and *Morinda* bushes, until this too, proved impenetrable. In sunny clearings dotted with dead or disintegrating palms, *Ipomoea*, *Boerhavia*, and *Phymatosorus* proliferated luxuriantly. Choking of the palms by *Ipomoea*, one of the prime reasons for the twice-abandonment of the copra enterprises, continues to destroy the coconuts, encouraging natural ecological succession to begin anew.

3) Scattered Groves on Small Motus (0.82 ha)

Drift-derived palms were observed as long ago as 1834 (Bennett 1840). In 1916, when planting operations were commenced after a break of 14 years, about 40 trees grew beyond the plantations (Maude ca. 1942). Today, small *Cocos* groves, up to 50 palms, drift-derived and plantation remnants, generally close to the shoreline (Pls. 28, 29), occur on 11 motus.

4) <u>Mixed Forest with *Cocos*</u> (6.24 ha)

This forest type is a simplified version of more complex and varied mixed forests that occur on most inhabited atolls. Composed of anthropogenic and indigenous elements, it contains a high proportion of *Cocos* (50-80%) mingled with variable proportions of *Tournefortia*, *Pisonia* and *Pandanus*. This forest type occurs primarily in southern Nake (Fig. 14), but also on Emerald, Shark, and southwest Long, where it mixes with *Cordia* and *Tournefortia*.

House Site: A clearing on Motu Ana-Ana, approximately 40 m x 70 m, contains a few *Cocos*, a vegetable garden and thatched former living quarters (Pl. 51).

Seabird Use

Cocos-dominated habitats were ornithologically the most depauperate on Caroline: only Brown Noddies and White Terns breed. The noddies nested high within the frond and inflorescence bases, whereas the White Terns preferred lower sites, occasionally atop an arching frond. The absence of other species suggests that anthropogenic *Cocos* forests seriously inhibit seabird use and may continue to do so for decades until they are replaced by native vegetation.

<u>Absent Plant Communities</u>

Caroline's impoverished flora and relatively simple physiography and geology has resulted in a limited variety of ecosystems. The atoll is thus notable not only for its *Pisonia* forests, extensive monotypic stands of *Tournefortia*, and *Cordia* groves, but also for the absence of several ecosystems that are generally considered typical of Pacific atolls:

1) *Sesuvium* Flats;

2) *Pemphis*, *Scaevola*, and *Sida* Scrub (2 *Scaevola* plants are present, and the only 2 *Sida* records are from 1884 and 1990); and

3) Mixed broadleaf forests including *Barringtonia*, *Calophyllum*, *Guettarda*, *Hernandia*, and *Neisosperma*.

4) Plant associations (except *Cocos*) typical of native cultures on atolls: breadfruit groves (*Artocarpus altilis*), taro pits (*Cyrtosperma chamissonis*, *Colocasia esculenta*, *Xanthosoma sagittifolia*), cultivated ornamentals (*Hibiscus rosa-sinensis*, *Plumeria* spp., etc.), or weedy grasslands/wastelands (*Paspalum*, *Sporobolus*, *Wedelia*, *Vigna*, etc.). Even widespread introduced strand

species such as *Terminalia catappa* and *Casuarina equisetifolia* are absent.

In addition, there are no mangroves, peat bogs, marshes, ponds, salt flats, or other habitats associated with fresh or brackish water. Poorly represented are:

1) *Lepturus* Grassland. Although *Lepturus* is present in coastal herb mats, and occasionally in patches within the forest understory, it does not form a separate plant community. However, it may once have covered the extensive clearings on South Island (Pl. 2, 3).

2) Mixed Forest. Though 6.24 ha of Mixed Forest (with *Cocos*) occurs (primarily on Nake), it is of such minor importance to Caroline's overall vegetation that it is treated as a subsection of Coconut Woodlands.

H. DESCRIPTION AND ECOLOGY OF THE MOTUS

These islet accounts synthesize the history, physiography, vegetation patterns, ecology, seabird colonies, miscellaneous biota, and the effects of human activity (if any) on Caroline's 39 motus (Fig. 2). Mapping is based on the coast-to-coast transects, perimeter surveys, complete surveys (smaller motus), color transparencies, and aerial photographs.

All motus are detrital reef islets representing many evolutionary stages from barely emerged coral rubble to large islets with relatively fertile "soils" supporting lush vegetation. There is one tiny old reef platform in its final stages of erosion.

We discuss and map them in geographic order beginning in the north with Nake and progressing down the windward reef through Long and the 13 Windward Islets to South Island. Beginning anew in the north, we move south through 7 South Nake Islets, 11 Central Leeward Islets, and finally the 5 Southern Leeward Islets.

Because of the variety of islet shapes, "long" or "length" refers to the longest dimension lying parallel to the outer reef edge (normally north-south) and "wide" or "width" to the longest dimension perpendicular to the outer reef edge (normally east-west). South Island, the only exception, is considered to lie adjacent to the southern reef edge, so its "length" is measured east-west. Seabird numbers are from Part II, Table 1. For convenience in locating particular islets, the order is as follows:

1) NAKE (Fig. 37)

2) LONG (Fig. 38)

WINDWARD ISLETS

3) Bo'sun Bird (Fig. 42)
4) Windward (Fig. 43)
5) Crescent (Fig.43)
6) Atibu (Fig. 43)
7) North Pig (Fig. 44)
8) Pig (Fig. 44)
9) Skull (Fig. 44)
10) North Brothers (Fig. 46)
11) Brothers (Fig. 46)
12) Noddy Rock (Fig. 47)
13) North Arundel (Fig. 47)
14) Arundel (Fig. 47)
15) Tridacna (Fig. 48)
16) SOUTH (Fig. 50)

SOUTH NAKE ISLETS

17) Pandanus (Fig. 52)
18) Danger (Fig. 52)
19) Booby (Fig. 52)
20) Coral (Fig. 52)
21) Lone Palm (Fig. 52)
22) Kota (Fig. 52)
23) Mouakena (Fig. 52)

CENTRAL LEEWARD ISLETS

24) Mannikiba (Fig. 53)
25) Blackfin (Fig. 54)
26) Matawa (Fig. 54)
27) Emerald (Fig. 54)
28) Shark (Fig. 55)
29) Scarlet Crab (Fig. 55)
30) Nautonga (Fig. 55)
31) Azure (Fig. 55)
32) Reef-flat (Fig. 55)
33) Bird (Fig. 55)
34) Fishball (Fig. 55)

SOUTHERN LEEWARD ISLETS

35) Raurau (Fig. 57)
36) Eitei (Fig. 57)
37) Pisonia (Fig. 57)
38) Kimoa (Fig. 57)
39) Ana-Ana (Fig. 57)

1) NAKE ISLAND (91.72 ha) Figs. 30, 37; Pls. 17, 22, 35-37, 43

History: Nake's large size and underground water lens, coupled with topography and soils more varied than elsewhere on Caroline, attracted Polynesian settlers. Because early European visitors stayed primarily on South Island, there is only a single reference to *Cocos* prior to the late 19th century (1 tree seen in 1825 by Paulding 1831).

The far northwest of Nake (also North Island in Young ca. 1922) houses the only true archaeological site on Caroline--a large *marae* (Figs. 3, 37; Pl. 36). Discovered during the guano era, the site is marked as "graves" on Arundel's map. Arundel, who was living on the atoll when the *marae* was discovered, describes it thus: "On the north-west end of Caroline are some curious old native remains, whether places of burial or of sacrifice I cannot determine. I opened one of these, but could find no indication whatever to guide me in a decision" (Arundel 1890). AKK, R. Falconer, and G. Wragg located, measured, and photographed this *marae* in 1990. The entire courtyard was approximately 18 m long by 14 m wide. All 10 peripheral stones and the central one were easily identifiable from the 1883 plan (Fig. 3), although a few had fallen over or broken due to encroaching vegetation. The lower wall, partly destroyed by Arundel, had not been reconstructed. It is probable

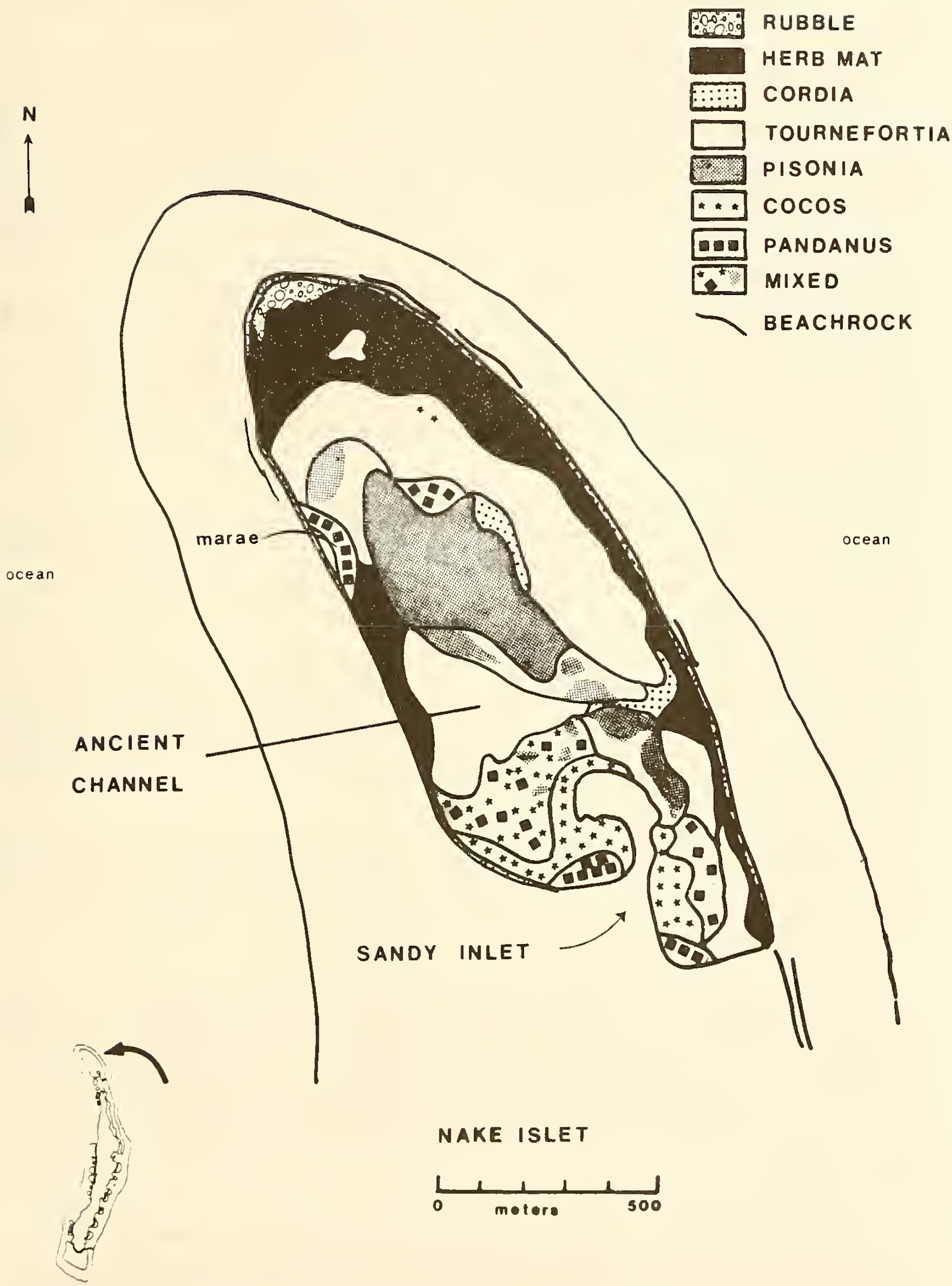


Figure 37. Nake Island: vegetation and physiography.

that this *marae* had not been seen since the 1880s; though discussed by Emory (1947), he never visited Caroline personally.

Northwest Nake is particularly suitable for a place of worship and sacrifice: it fits most of the environmental criteria indispensable to ancient Tuamotuan religious ritual (Emory 1947). First, flat ground was necessary, preferably lying at right angles to, or parallel to, the lagoon. Second, it was important to have the wind blowing across the *marae* to waft away the smells of sacrificed animals. Third, ceremonial items included branches of the *Pisonia* tree, leaves of *Cocos* (for leaf charms/"rosaries"), and the aerial roots of *Pandanus*. Fourth, feathers from "black terns" (Black Noddy), frigatebirds, and Red-tailed Tropicbirds were also necessary for rituals. Rather than a smooth substrate, the early Polynesians would have had to be content with leveled coral rubble and distance from the lagoon. The only organism not living near the *marae* today is the tropicbird; however, their elongated tail feathers could have been plucked from adults nesting on nearby motus.

Since *marae* are sacred places, there is possibly a significance to the location of the main "courtyard" close to the atoll's northern tip. It is well known that the northern extremities of islands were auspicious places for all Polynesians; in such places, they believed, disembodied spirits were whisked to the netherworld.

In 1938 a cistern was built in southwest Nake, which is still visible (see Sect. D, Hydrology). We failed to find evidence of occupation, but in September 1974 there was "a small, barely-furnished thatched hut," a stack of approximately 3 tons of copra on a raised platform, and a "three fathom canoe of Polynesian construction" (Ward 1974).

Physiography: Largest in area, Nake is the northernmost motu, separated from Long by a 40-m channel (Pl. 17). With maximum dimensions 2,000 m long and 685 m wide, it is basically rectangular with rounded corners and a peninsula-like extension in the southeast.

Nake lies north of the lagoon, having a southern, dry "bay" (Sandy Inlet), in which silt, sand, and fine coral debris are being actively deposited (Pl. 22). This hard, flat expanse of silty and sandy sediments is 145 m wide at its mouth, extending 200 m north into the main islet. Its 3.50 ha provide a favorite feeding location for shorebirds, especially Bristle-thighed Curlews. If Arundel's chart (Fig. 4) is correct, Sandy Inlet has increased its land area during the last century.

On the reef flats off the west side are extensive remnants of jagged upraised reef of unknown age (Pl. 11) and occasional beachrock. The exposed beaches and reef flats at Nake's north point are especially broad, characteristic of reef flats at the exposed corners of islands. Comparisons of the northern sweep of rubble on recent aerial photos with Arundel's map indicate that much coral debris, curved shingle ridges (Pl. 16), has been added since 1883. This area, the northernmost tip of the atoll, is subjected to heavy wind, wave and swell action. It is possible that particular ridges can be attributed to individual storms as has been documented for some other atolls (Stoddart & Steers 1977). In 1990, the deep, fine coral rubble mixed with sand east of the *marae* yielded 3 old turtle nests. Overall, only 6% of the land area was unvegetated. However, sparsely vegetated expanses of hardpan occupied the south-central sector (immediately inland of the coast within a belt of *Tournefortia* forest), and pure sand at least to 0.5 m deep bordered Sandy Inlet.

Nake's windward coast, complete with a peaked beach crest and discontinuous beachrock, is 30 m wide in the north, narrowing to 3 m in the south. Offshore, submerged reef flats form a sandy moat.

In the distant past, Nake consisted of 2 separate motus: aerial photos (Frontispiece) reveal an oblique, ancient channel about two-thirds of the way down the isletwhich is now well vegetated centrally but scrubby peripherally.

Vegetation: Before the major clearing for coconut plantations, Nake's native forests were "80 to 100 feet high" (Arundel 1875). Today there are 16 plant species (5 trees, 1 shrub, 10 herbs), 62% of Caroline's flora. It is the lushest motu, with woodlands (82.39 ha) about 80% native and 20% *Cocos* (Pl. 37). Although in 1916 there were about 260 palms, and the entire island was evidently planted with 10,544 palms in 1918-1919 (Young ca. 1922, Table 13), substantial tracts of each major vegetation type occur today. Its interior is rich in *Pisonia*, with the largest acreage (20.79 ha) and some of the tallest trees (20 m high) and largest trunks on the atoll (Pl. 43, Table 11). In addition, *Cordia* is well-represented: 2 major groves of *Cordia-Tournefortia* forest occupy 11.8 ha, 2% of Nake's area. Extensive pioneer herb mats, flanked on their inner sides by *Tournefortia* scrub, occur in the north and east. The remaining *Cocos*, essentially in the southern quarter, comprise Caroline's second largest coconut grove.

Birds: Nake, with 80% of Caroline's breeding seabird species, shows a direct correlation between islet size and bird species diversity. Nine species of seabirds breed, all with larger populations (pairs) than previously reported (Clapp & Sibley 1971a): Masked Booby (105), Brown Booby (1), Red-footed Booby (496), Great Frigatebird (522), Lesser Frigatebird (56), Brown Noddy (390), Black Noddy (814), Sooty Tern (nesting in 1989; Anne Falconer, pers. comm.), and White Tern (1,094).

2) <u>LONG ISLAND</u> (75.98 ha) Figs. 30, 35, 38-41; Pls. 9, 17, 19, 27, 32, 47, 54

Third largest in area, this longest of motus covers nearly one-third of the atoll's windward side. In the north it is separated from Nake by a narrow channel; from its southern tip a chain of smaller motus extends south along the windward reef.

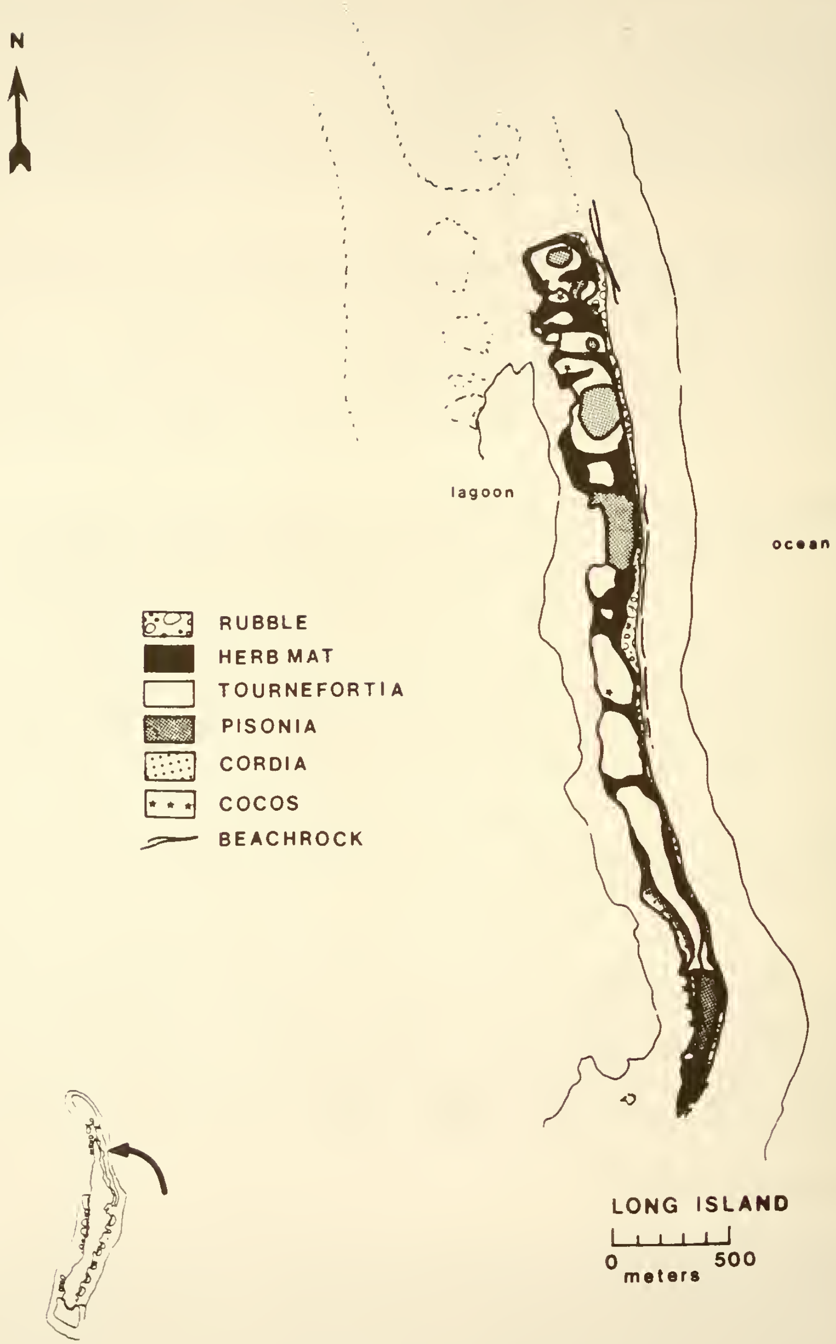


Figure 38. Long Island: vegetation and physiography.

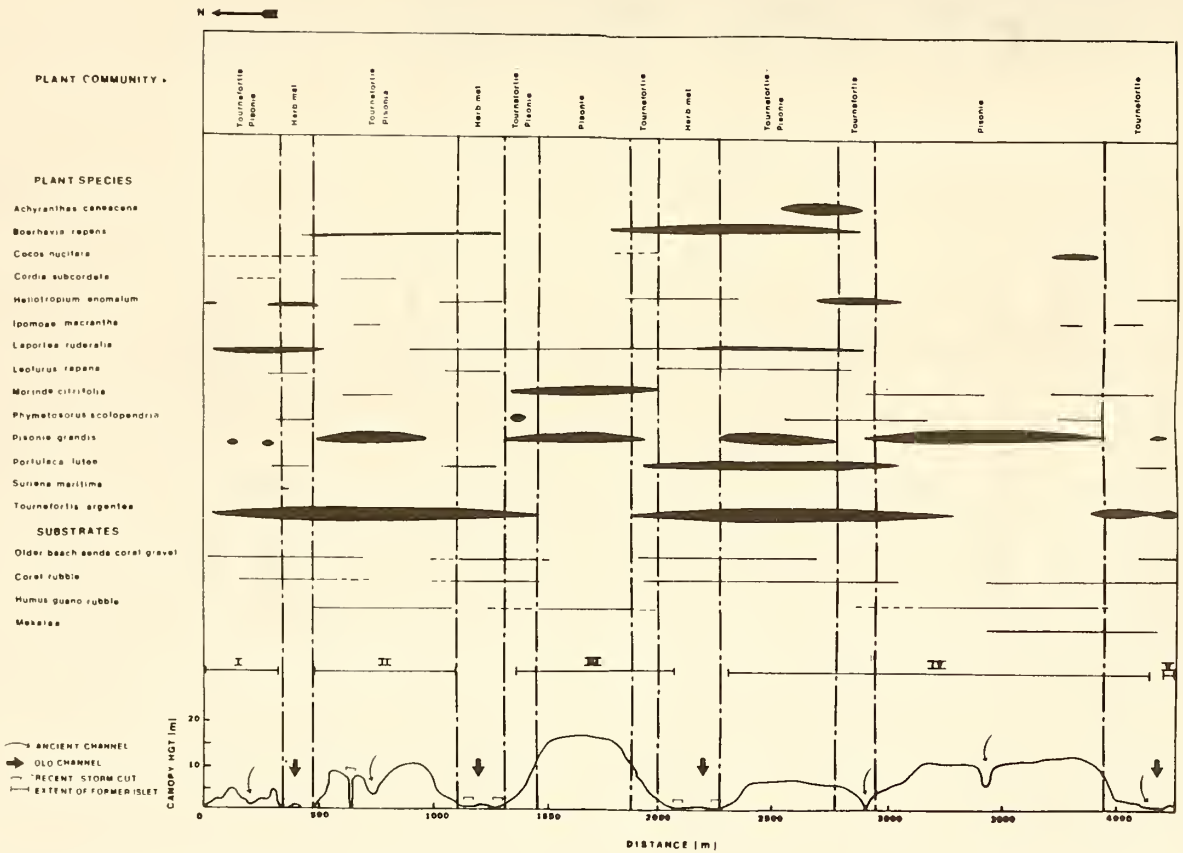


Figure 39. Long Island: north-south transect showing division into former islets, floristic composition, relative abundance of plant species, degree of species overlap, and canopy heights. Vertical height is exaggerated. The exact locations of the formerly more extensive *Cocos* plantations are unknown.

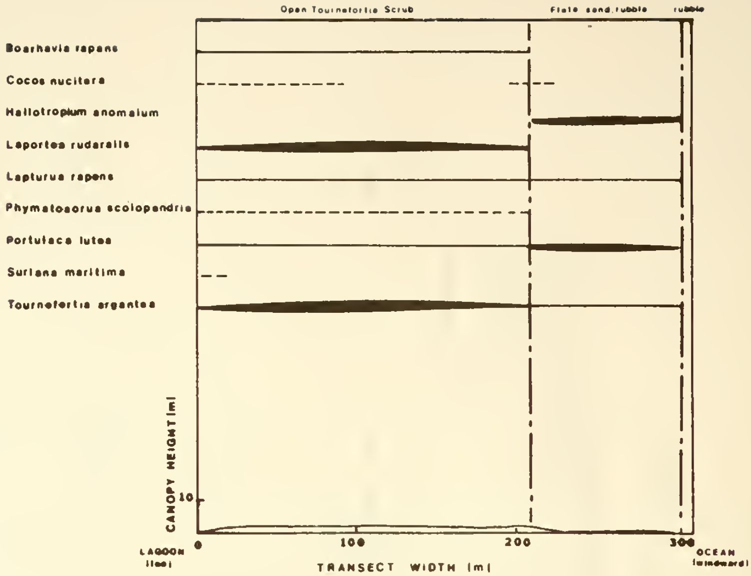


Figure 40. Long Island: east-west cross-section through Transect C, a former inter-islet channel, showing floristic composition, relative abundance of plant species, degree of species overlap, and canopy heights. Vertical height is exaggerated.

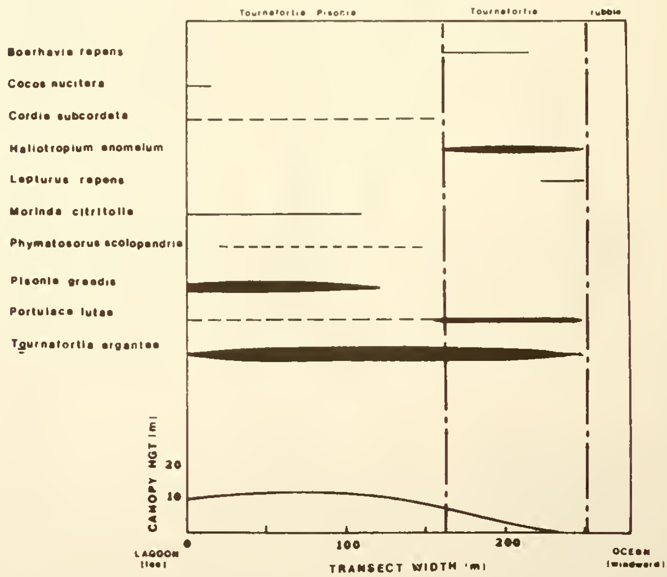


Figure 41. Long Island: east-west cross-section through Transect B, which passes through mature interior *Pisonia* forest of largest of Long's coalesced motus. Data includes floristic composition, relative abundance of plant species, degree of species overlap, and canopy heights. Vertical height is exaggerated. Note the absence of low vegetation on the leeward shore.

Physiography and History: Long, 4,226 m long and 330 m wide, is somewhat snake-shaped, with an enlarged northern "head" and attenuated "tail." From a distance its vegetation appears as a series of humps. Long has experienced a fairly complex geological history, noted by the Solar Eclipse Party: "On some of the islands there are spaces void of vegetation, extending from lagoon to beach, which indicate the existence at a former time of a water separation" (Holden & Qualtrough 1884).

At present, Long is composed of 5 distinct former motus separated by sparsely vegetated channels of coarse sand and coral gravel. Aerial photographs also reveal further, older subdivisions (see below). Coalescence and fracturing of the original motus probably occurred repeatedly. Since erosion proceeds faster on an atoll's windward reefs, providing coral fragments, coralline algae, and pulverized molluscs, it is no surprise that the first series of Caroline's motus to fuse were those facing this rich source of parent material.

Long's coarse rubble beaches (Pl. 19) are a mirror image of those on Nake: they widen progressively southward. The swath of unvegetated rubble above high tide line in the upper two-thirds of Long averages 8 m wide, while in the lower third it is 40 m wide. Unvegetated coral debris accounts for 10% of the island's area (Fig. 30). Beachrock, flanking the windward shoreline for most of its length, is more abundant than elsewhere (Pl. 54).

Long's lagoon flank is edged with submerged sand and silt, and is one of the most sheltered parts of Caroline. Sand and rubble deposition off the south point has formed a lagoon islet (Bo'sun Bird), which could, in the future, coalesce with Long's south point to form a hook.

An uncommon substrate on Caroline, upraised reef forms a low rampart (generally <1 m high) paralleling the ridge crest inside the vegetation for much of the lower quarter of Long. Although we camped in this area and conducted 4 transects through this upraised reef, we found no plant species that indicated the presence of *feo*, such as can be found in the Tuamotus (Fosberg, pers. comm.).

In 1990 G. Wragg found some scattered large stones, similar to those of the Nake *marae*, located centrally 100 m north of the southern tip of Long, confirming the report of the remains of a smaller *marae* on Long Island (Holden & Qualtrough 1884). Wragg noted that the *marae* was small, measuring approximately 3 m wide by 8-10 m long. Its orientation appeared to be northeast-southwest. The wall on one end was evidently smashed by storm waves. Only 2 of the peripheral upright stones were standing, of similar size to those on Nake. The platform was in reasonable condition, with a huge *Pisonia* tree growing through it. Some rock slabs were large (2 x 2 m). The entire *marae* was situated within a *Pisonia* grove, with nearby *Cocos*. We do not know if this coconut grove (1.6 ha) was present before 1,343 palms (20% of the islet's area) were planted in 1918-19 (Young ca. 1922). The sheltered location and a *Pisonia-Cocos* forest, which suggests an old clearing, further indicate prior occupation.

In 1990, Wragg also uncovered an RNZAF survey marker just inland of Long's southernmost tip.

Vegetation: There are 15 plant species (4 trees, 2 shrubs, 9 herbs), on Long, 58% of the total flora. Long's variety of habitats, vegetation heights, substrata, and birds make it the most diverse islet on Caroline. Only 3% of its area remains in *Cocos*. All the atoll's seabirds have bred here. Its ecology is best understood with reference to Figures 35 and 39-41.

Within the basic pattern of 5 coalesced motus, it may be seen that:

1) From north to south (measured from the midpoint of each former channel) the motus, of divergent size and shape, are approximately 320, 620, 700, 1,840, and 100 m long.

2) Each former motu, crowned by *Pisonia* forest, contains concentric rings of decreasing fertility around its core and is morphologically similar to motus surrounded by water, except that the coarse coral gravel along the former perimeter is less marked. More specifically, beach sands and gravel extend for 200-300 m north and south of the old channels, after which they increasingly accumulate coral rubble, humus, and guano.

3) *Tournefortia* dominates, interspersed with 4 patches of taller *Pisonia* forest and scattered clumps of *Cocos* and *Cordia*. Interrupted herb mats parallel the windward coast and often extend across the island along former interislet channels (Pl. 32). Vegetation height varies from 2 cm to 15 m.

4) Plant species diversity is highest in *Tournefortia-Pisonia* and lowest in *Pisonia* forests.

5) Long's tallest, most mature *Pisonia* groves (up to 100% *Pisonia*) occur on the largest of the former islets. The *Pisonia* forest near the south end (Tr. 10), although healthy, is only 12 m tall. This may be due to its impoverished upraised pitted reef substrate barely covered with "soil." Since it lies adjacent to Long's most luxuriant *Cocos* grove, its land could well have been cleared in 1918-19, with the *Pisonia* forest taking longer than elsewhere to recuperate. Because tern guano increases soil fertility, contributing to *Pisonia* growth, it is of interest that neither Black nor Brown Noddies nested here.

6) Deep dips in Figure 39 (lower graph) correspond to east-west corridors formed from old channels. Vegetation in these relatively infertile, sandy flats is low, similar to that on small developing motus (i.e. native herbs with scattered *Tournefortia* <2 m high). One sandy channel (Tr. C, Pl. 32) supported sparse *Suriana*. During the February 1990 cyclone, all vegetation was either uprooted, washed away, or smothered with fresh sand and coral gravel along Transects A and C (Pl. 33). Storm erosion was particularly marked within the channel that almost bisects the island (Tr. A).

7) Secondary dips mark even older interislet channels ("ancient channels"), visible on aerial photographs (Frontispiece) but barely recognizable in the field. They are overgrown with *Tournefortia* and/or *Pisonia*.

8) Sharp dips within established forests or herb mats denote relatively recent channels gouged out by storms ("recent storm cuts"). These were also altered during the winter 1990 storm.

Figures 40 and 41 illustrate some differences between the windward and leeward coasts. Transect C (Fig. 40) crosses the north end of Long through an old interislet channel now filled with sand and rubble. Its low profile reflects the simple habitat harboring halophytic herbs and *Tournefortia* shrubs less than 2 m high. Although the shrubs are scattered, the lagoon half of the transect passes through slightly higher ground, which encourages denser *Tournefortia*. This transverse section is similar to that of a formative motu such as Fishball (Fig. 56). This exposed, scrubby swath, 300 m wide, harbors Red-footed Boobies, Great Frigatebirds, and a discrete population of Masked Boobies. Approximately 127,000 pairs of Sooty Terns nested in a similar sandy channel 740 m to the south (Tr. A) in 1988.

Transect 8 (Fig. 41) crossed the islet nearer the southern tip (Fig. 8). This profile departs significantly from the usual parabolic cross-section seen on most of the small motus and which exists further north on Long Island. From east (windward) to west, there is first a wide expanse of coarse, unvegetated rubble, followed by rubble dotted with herbs, then *Tournefortia* scrub increasing to 9 m high. Further inland, a forest of 10-m-high *Tournefortia*, *Pisonia* and *Cordia* continues westward to the lagoon. This leeward margin of Long, extending southward nearly to its tip, is the only location on Caroline where tall, indigenous vegetation overhangs and shelters the lagoon. No herb mat is present.

In summary, Long contains examples of all major plant communities, as well as 2 minor ecosystems, *Pisonia-Cordia* (3.2 ha) and *Cocos-Cordia* (0.82 ha). Its woodlands total 49.60 ha. Coconut crabs inhabit all areas containing *Cocos* and *Pisonia*; our rough population estimate is 200.

Birds: In 1988 Long supported 9 (10 in 1965) species of breeding seabirds, as follows (pairs): Red-tailed Tropicbird (5), Masked Booby (69), Brown Booby (12), Red-footed Booby (659), Great Frigatebird (808), Sooty Tern (179,800), Brown Noddy (207), Black Noddy (986), and White Tern (751). From 1988 through 1990, Sooty Terns occupied 19 large colony sites (Fig. 11, Pt. II).

Comments: Polynesian rats were abundant, especially in *Cocos* and *Pisonia* habitats. It was often possible to see 3 or 4 simultaneously while conducting daily surveys, and 20 or more around camp. At night, their numbers increased substantially. Azure-tailed skinks (*Emoia cyanura*) were noted.

WINDWARD ISLETS

This chain of 13 islets occupies the southern half of Caroline's east coast. All rest on the same reef flat, separated by channels varying in width and depth. They can be waded with care at low tides, but most harbor black-tipped reef sharks: up to 4 were visible in the shallows within 50 m of an observer. Several motus have altered shape since 1883, including Brothers, which has incorporated a small cay into its present confines.

The motus range in size from Noddy Rock (0.02 ha) to Windward (11.42 ha). They support every major vegetation type from simple herb mats to *Pisonia* forests, 21 m tall. Because of their constant exposure to trade winds, the seaward vegetation is wind- and salt-shorn. Though appearing primarily untouched, all of the Windward Islets were planted with *Cocos* (Table 13) from 1916-20 (Young ca. 1922). However, these incipient plantations experienced difficulty and appear to have been abandoned within a few years, and their vegetation recovered remarkably (see Sect. G).

Flanking the lagoon of the southern motus (Brothers through Tridacna), and extending westward, are reefs densely studded with *Tridacna* clams, which add to Caroline's outstanding natural assets (Pl. 25; Pt. II, Sect. G).

3) BO'SUN BIRD ISLET (0.86 ha) — Figs. 29, 42

We named this motu for its Red-tailed Tropicbirds, commonly called Bo'sun birds. The sizeable population is the largest on Caroline. In addition, our 1988 records constituted the first known breeding of this species on the atoll.

Physiography: Bo'sun Bird Islet, 165 m west of Long's southern tip, is the only motu lying within Caroline's lagoon. It shares the same reef as Long, however, and is not a true "lagoon motu."

Amoeboid in shape, Bo'sun Bird is greatly affected by the tidal waters that spread across the shallow reef flats and gush through the channels separating Long and Windward. Because it sits near the inner edge of a wide windward reef flat, the layering of sediments around it is complex and transitory; our observations indicate that more rubble was deposited on the islet's western edge since the aerial photos were taken in 1985. Its western shoreline rises gradually to a high water mark, and slight changes in water level greatly change its overall size and shape. At high tide its perimeter is ovoid with a long westerly extension. The "head" is approximately 70 m wide and 115 m long, while the "nose" is 45 m long and 15 m wide.

Vegetation and Birds: Bo'sun Bird Islet, composed of coral rubble and sand, supports only natural herb mats (*Heliotropium*, *Portulaca*, *Lepturus*) and *Tournefortia* scrub (to 4 m tall). These 2 simple plant communities cover 35% and 55% of the land area, respectively. For its

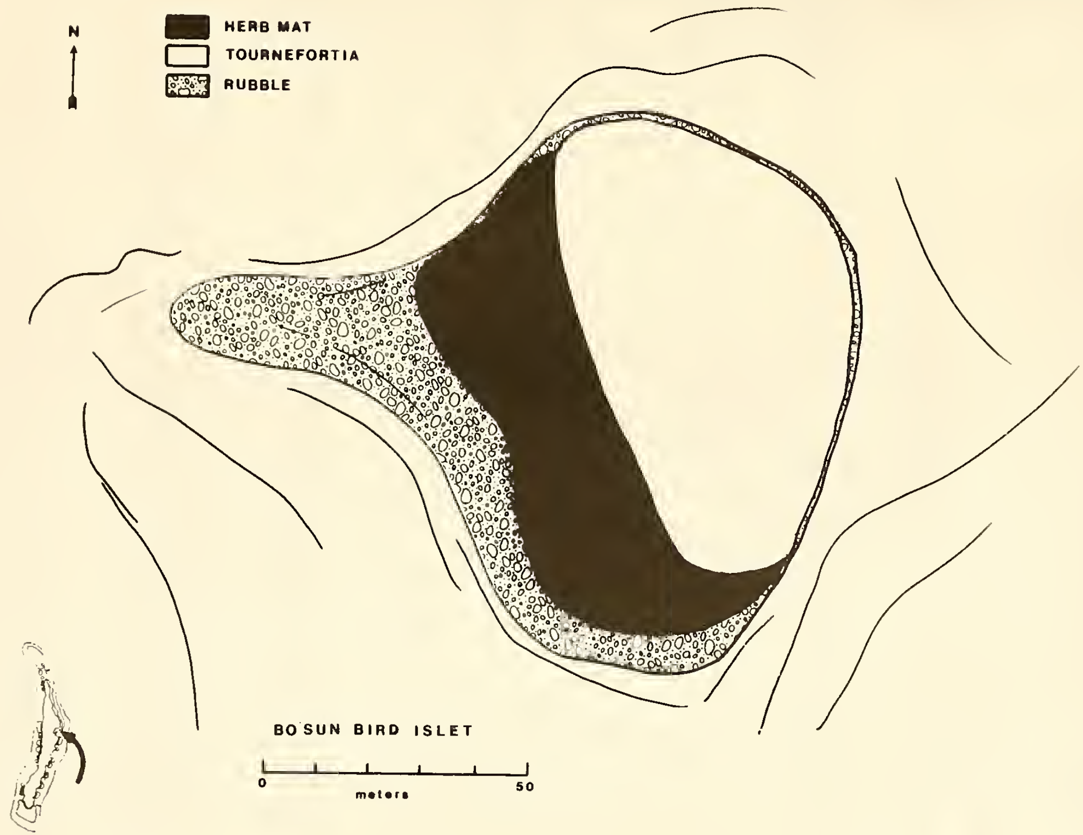


Figure 42. Vegetation and physiography of Windward Islet no. 1: Bo'sun Bird Islet. Scale is larger than on the vegetation maps of other islets.

size, the motu is sparsely vegetated, with only 4 plant species (1 shrub, 3 herbs), 15% of Caroline's total flora. There are no introductions.

Bo'sun Bird's most notable attributes are its 4 species of breeding seabirds: Red-tailed Tropicbird (47 pairs in 1988, 130 pairs in 1990), Sooty Tern (8,400 pairs), Brown Noddy (10 pairs), and White Tern (6 pairs).

4) **WINDWARD ISLET** (11.42 ha) Figs. 29, 43

We named this "Windward" because it is the first major, and largest, Windward Islet.

Physiography: Broadly crescentic in shape, 508 m long by 287 m wide, it parallels the reef's longitudinal axis and is set close to the lagoon. Its seaward beach is quite narrow (3 m wide); there is no lagoon beach.

Vegetation: Windward has 11 species of plants (3 trees, 1 shrub, 7 herbs), 42% of the total flora. A windward crescent of halophytic herbs borders a zone of *Tournefortia* scrub, which mixes quite densely with *Pisonia* and *Cordia* over most of the interior in a bilobed pattern. These latter forests, reaching 14 m high in the south and 9 m in the north, total 8.67 ha. This unusual distribution of central forests undoubtedly reflects *Pisonia*'s recovery from 100% land clearing for *Cocos*--1,299 palms--in 1920 (Young ca. 1922, Table 13). It is remarkable that not one *Cocos* remains as a legacy of this disturbance.

The east-west profile of Windward, similar to that of Transect 8, Long Island (Fig. 41), is typical of most motus, except that lagoon-facing herb flats are almost nonexistent. *Scaevola taccada* var. *taccada*, a new plant record for the atoll, was only found on this motu, although *S. t.* var. *tuamotensis* was found on South Island in 1990.

Birds: Five species of breeding birds were present, all in appreciable numbers (pairs): Red-footed Booby (163), Great Frigatebird (207), Brown Noddy (20), Black Noddy (28), and White Tern (134).

Comments: In May 1990, AKK noted a possible motu midway between Windward and Crescent Islets during midtide. It appeared an upraised reef platform like Noddy Rock, but because of extensive shallow reticulate reefs in this area, its presence at high tide has not yet been confirmed.

5) **CRESCENT ISLET** (3.10 ha) Figs. 29, 43

We named this islet for its cupped shape.

Physiography: Crescent Islet is 190 m long by 225 m wide. It is almost entirely composed of coral rubble, with a little humus in the interior. The seaward beach is variable (up to 50 m wide), the lagoon beach, insignificant.

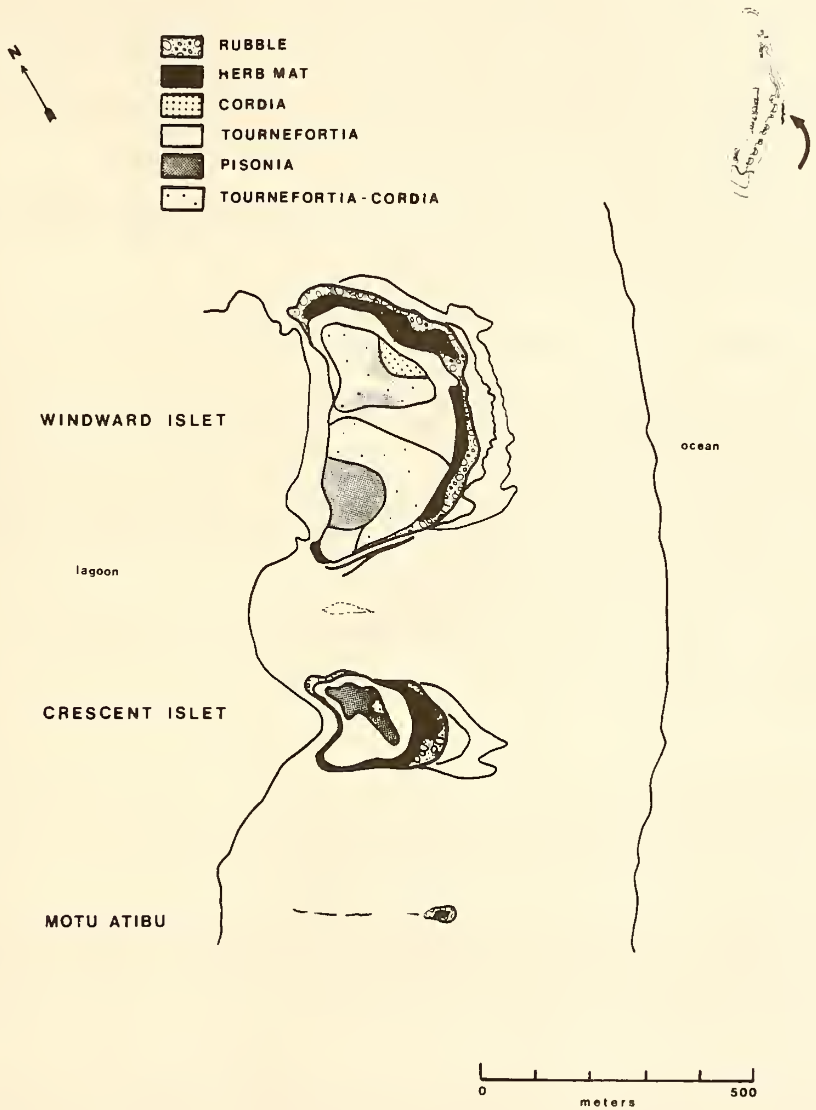


Figure 43. Vegetation and physiography of Windward Islets nos. 2, 3 and 4: Windward and Crescent Islets, and Motu Atibu ("Coral Rubble Islet"). Atibu appears to have been severely damaged during the February 1990 storm.

Vegetation: There are 10 species (3 trees, 1 shrub, 6 herbs), 39% of Caroline's flora. No introduced plants occur. Plant diversity is poorer than on Windward, a reflection of small size, poor soils, and scant herb mats. However, woodlands cover two-thirds of its area, and the central stand of *Pisonia* and *Cordia* is 87 m wide and up to 13 m high. Crescent was heavily planted (80% of total area, 228 palms) in *Cocos* in 1920 (Table 13), but today none remain.

Birds: Crescent Islet was used by the following numbers of breeding pairs: Red-footed Booby (28), Great Frigatebird (5), Brown Noddy (36), Black Noddy (60), and White Tern (8).

6) **MOTU ATIBU** **("Coral Rubble Islet")** (0.02 ha) Figs. 27, 43

Motu Atibu was Caroline's smallest and least vegetated islet. Third in the windward chain, it measured 13 x 18 m. We named it for its basic rubble character. Vegetation covered only 2% of the land surface and consisted of a few *Tournefortia* shrubs (<1 m high) encircled by narrow swaths of low herbs and rubble. Its 3 plant species (1 shrub, 2 herbs)--12% of Caroline's flora--were among the most meager on the atoll. Atibu's profile was similar to that of Fishball (Fig. 56). There were no breeding birds.

Comments: Since a February 1990 storm, Atibu has apparently disappeared, having been reduced to a thin strip of coral gravel below high tide level.

7) **NORTH PIG ISLET** (5.44 ha) Figs. 29, 44; Pls. 55

We named the fourth windward islet "North Pig" for its location immediately north of Pig Islet.

Physiography: Classically crescentic, North Pig is 350 m long and 230 m wide. Though approximately half of Pig's area and less wooded overall, North Pig has a similar distribution of sediments (including sand on the lee side), vegetation, and breeding birds. Profiles of the 2 motus are nearly identical (Fig. 45).

Vegetation: There are 11 plant species (3 trees, 1 shrub, 7 herbs), 42% of Caroline's flora. No introduced plants are present. Proceeding south along the windward islets, lagoon-side herb mats develop and islet cross-sections assume a more perfect symmetry--low at the edges and forming a hump in the middle.

North Pig's 3 vegetation zones are predictably symmetrical: a peripheral band of herbs (more extensive on the "horns"), curved belts of *Tournefortia*, and a spacious central forest of mixed *Pisonia*, *Cordia*, and *Tournefortia*. The latter (to 20 m tall) covers more than one-half the islet's width and one-third its area, and includes fine *Cordia* groves (Fig. 44). This excellent forest is surprising because 402 *Cocos* palms were planted on 93% of North Pig's usable land in 1920 (Young ca.

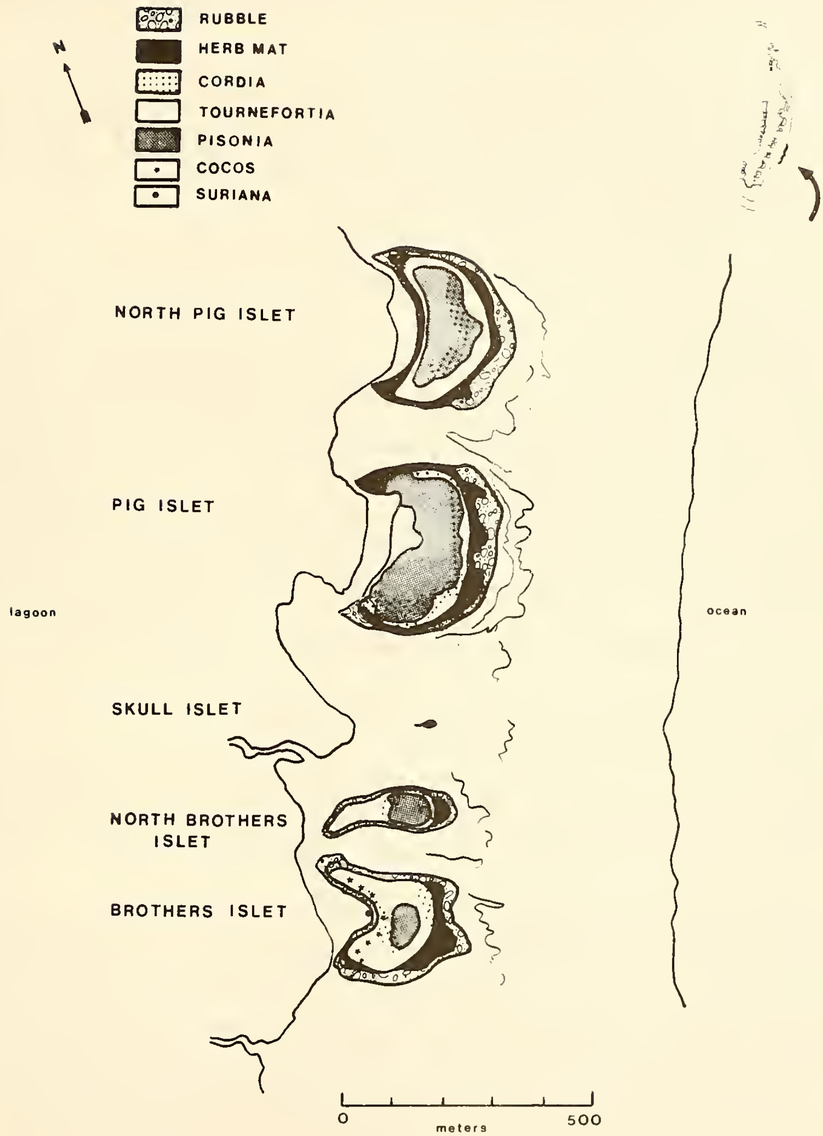


Figure 44. Vegetation and physiography of Windward Islets nos. 5 through 9: North Pig, Pig, Skull, North Brothers, and Brothers Islets. Note the reefs extending westward into the lagoon.

1922, Table 13). Measurements from 25 *Pisonia* trees (main trunks) averaged 19 m in height, 221 cm cbh and 261 cm in base circumference (Table 12).

Birds: Five species of seabirds bred: Red-footed Booby (31 pairs), Great Frigatebird (17 pairs), Brown Noddy (76 pairs), Black Noddy (3,199 pairs), and White Tern (110 pairs). The largest colony of Black Noddies on Caroline nested in the tall *Pisonia*s.

Comments: Rats and coconut crabs were common.

8) PIG ISLET (7.21 ha) Figs. 29, 44; Pls. 26, 41, 50, 55

Number 5 down the chain, Pig was named prior to 1883. Domestic pigs were introduced to Caroline in 1828 by Captain Stavers but evidently died out before 1834. Reintroduced in 1848 with the first recorded settlers, it is not known how long they lasted. One would expect that they were only on South Island, but the statement that "about one-third the distance up the lagoon a canvas hut exists on one of the smaller islets on the eastern side of the lagoon" (Holden & Qualtrough 1884) suggests that perhaps domestic animals also inhabited Pig. Though this is weak evidence, there must have been some reason for this curious name. Today no pig devastation is evident anywhere on the atoll.

Physiography: Bean-shaped, Pig is 330 m long and 255 m across. It is separated from North Pig by a channel 60 m wide.

Vegetation: The islet has 11 plant species (4 trees, 1 shrub, 6 herbs), 42% of Caroline's flora. *Cocos*, the only introduction, is rare (0.03 ha). In 1920, 538 palms were planted (Young ca. 1922), which covered approximately 79% of Pig's usable area (Table 13).

Pig's vegetation profile (Fig. 45) is classic: a wide, windward herb mat, bordered by *Tournefortia* and *Cordia*, which, in turn, grades rapidly into an outstanding *Pisonia* forest (to 21 m tall, 3.36 ha), one of Caroline's best groves. Measurements from 5 trees, mostly multiple-trunked, averaged 16 m in height, 338 cm in circumference (at 1.5 m), and 282 cm in base circumference (Table 12). This *Pisonia* also occupies the largest proportion (46%) of any islet area. It is striking that such quality forests could regenerate in about 65 years (see Sect. G). In the *Cordia* forest (Pl. 26), also the finest on Caroline, 6 trees averaged 12.6 m in height, 116 cm in circumference (at 1.5 m), and 99.8 cm base circumference. On the lee side of Pig, *Tournefortia* extends directly to the lagoon shore.

Birds: Five species of seabirds bred: Red-footed Booby (14 pairs), Great Frigatebird (118 pairs), Brown Noddy (82 pairs), Black Noddy (1,928 pairs), and White Tern (164 pairs).

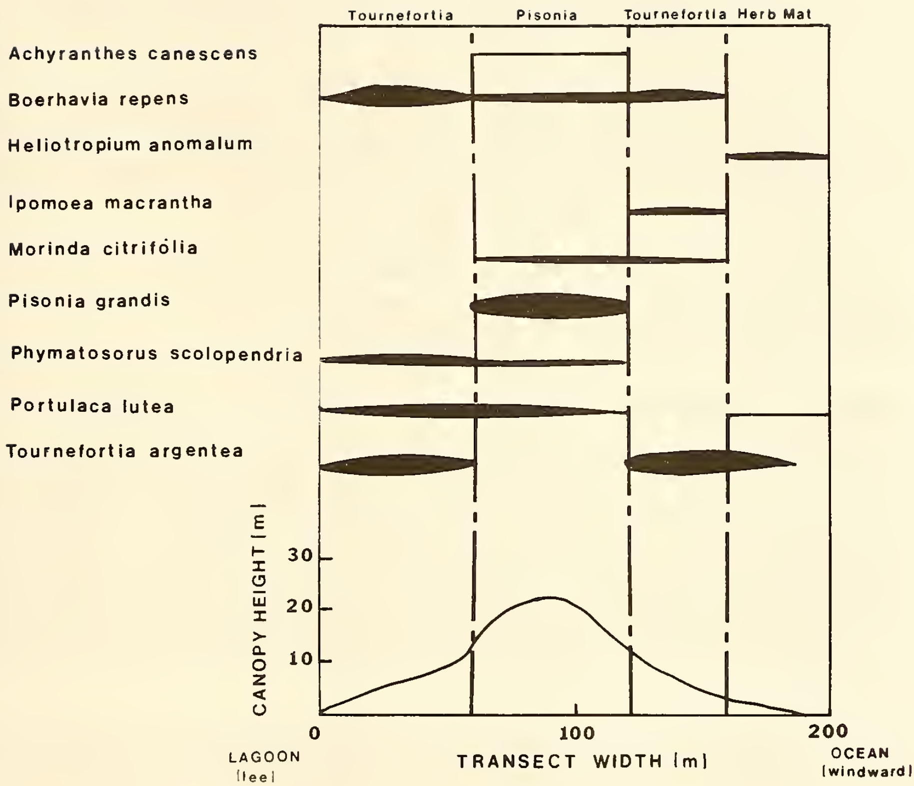


Figure 45. Pig Islet: east-west cross-section through center of islet. Data includes floristic composition, relative abundance of plant species, degree of species overlap and canopy heights. Vertical height is exaggerated. Pig's profile is especially symmetrical. It is remarkable that this islet was totally felled for coconuts in 1920.

Comments: Rats and coconut crabs were common. In 1990 a grayish gecko (possibly mourning gecko, *Lepidodactylus lugubris*) was seen by A. Garnett.

9) **SKULL ISLET** (0.02 ha) Figs. 27, 44; Pls. 46, 49

Sixth in the windward chain, we named Skull Islet after finding the skull, tail feather, and eggshell of a Red-tailed Tropicbird, the first evidence that this species bred on the atoll. A low shelf of coral rubble and sand, barely above high tide mark, this motu is barren except for a small herb mat under 5 *Tournefortia* bushes (1 m high) on the lagoon side. Only 2% of the surface area is vegetated. There are 3 plant species (1 shrub, 2 herbs), 11% of the atoll's flora. Although appearing young, the motu is marked on Arundel's chart (Fig. 4). After February 1990, several large storm blocks rested in the channel close to Skull Islet.

In 1988 there were no birds. However, in March 1990, a colony of 150 Brown Noddies was in a prelaying phase, accompanied by 6 Sooty Terns, a Brown Booby and a Wandering Tattler.

10) **NORTH BROTHERS ISLET** (1.71 ha) Figs. 29, 44; Pl. 55

The seventh windward motu, we named this islet North Brothers because of its location directly north of the named motu, Brothers.

Physiography: North Brothers is shaped like an oval that curves lagoonward toward Brothers, 40 m away. The concave shorelines and lack of herb mats on the opposite shorelines of these 2 islets suggest that they might have been formerly connected. Composed primarily of rubbly substrates, with slightly better soils centrally, it is 95 m long and 250 m wide.

Vegetation: Plant species number 10 (3 trees, 1 shrub, 6 herbs), 39% of Caroline's flora. A few *Cocos* trees are present, remains of the 180 planted in 1920 (Young ca. 1922), which covered 100% of all available land on the islet (Table 13). Plant communities on North Brothers are simple: *Tournefortia* (more open in the west) rises to an excellent *Pisonia* forest, 80 m wide and 18 m tall, on the east end. Average measurements from 3 *Pisonia* trees were: height 18 m, base circumference 314 cm, and number of trunks, 2.3 (Table 12).

Birds: Five species of seabirds bred on the islet in 1988 (pairs): Red-footed Booby (25), Great Frigatebird (9), Brown Noddy (23), Black Noddy (40, plus hundreds of old nests), and White Tern (69). In September 1989, Sooty Terns nested on the windward beach (Anne Falconer, pers. comm.), and in May 1990, a prebreeding swirl of thousands of Sooty Terns swarmed above Brothers and North Brothers.

Comments: Gecko eggs were seen on *Pisonia* trunks in 1990.

11) BROTHERS ISLET (4.31 ha) Figs. 29, 44, 46; Pls. 29, 55

The eighth windward motu, Brothers Islet was named last century after Captain Brothers, who managed a stock-raising venture on Caroline. In 1873 his rights to the atoll passed into the hands of John Arundel.

Physiography: Crescentic in shape, with longish horns extending toward the lagoon, Brothers Islet lies about two-thirds of the way down Caroline's windward reef. It is 198 m long x 178 m wide through the center. A *Tridacna* reef extends westward almost completely across the lagoon.

An interesting aspect of Brothers' structure is that Arundel's chart (Fig. 4) indicates a tiny, separate motu off the southwest point. Our survey and the 1986 aerial photos show that this motu is now joined to Brothers Islet. Its former identity is marked by a small patch of *Tournefortia*, around which the recently deposited sand and rubble is sparsely dotted with native herbs.

Vegetation: There are 11 plant species (4 trees, 2 shrubs, 5 herbs), 42% of Caroline's flora. *Cocos*, along the leeward shore, is the only introduced plant. Three distinct plant communities are present: peripheral herb mats (including leeward *Portulaca* with *Suriana*), *Tournefortia* scrub and forest (to 6 m high) bordered with *Cordia*, and a central *Pisonia* forest. Larger trees had up to 15 trunks and multiple root suckers. Measurements of 10 trees (main trunks) averaged 15 m in height, 140 cm in circumference (at 1.5 m), and 243 cm base circumference. Distances to nearest neighbor for 10 trees averaged 4.2 meters. As on its neighbor islets, the *Pisonia* forest on Brothers is striking, especially since it has matured to a closed-canopy monotypic stand devoid of any subcanopy species (Fig. 46), evidently in about 65 years. In 1920, Brothers Islet was planted with 315 *Cocos* palms, which covered approximately 97% of the usable land area (Table 13).

Birds: Four species of seabirds bred: Red-footed Booby (25 pairs), Brown Noddy (8 pairs), Black Noddy (15 pairs), and White Tern (50 pairs). In May 1990, large numbers of Sooty Terns swirled over Brothers and North Brothers.

Comments: Many mature *Pisonia* trees contained capacious cavities in their boles that housed large coconut crabs. In March 1990, several of these holes had feathered skeleta of Sooty Terns (and possibly also Brown Noddies) outside their entrances, along with freshly-snipped *Pisonia* branches (see Pt. II, Sect. F).

12) NODDY ROCK (0.02 ha) Figs. 27, 47; Pl. 18

We named this ninth motu in the Windward Islets for its only known breeding seabird, the Brown Noddy. In September 1988, at least 80 pairs were incubating their eggs on the *Portulaca* mat that covers its central lee section.

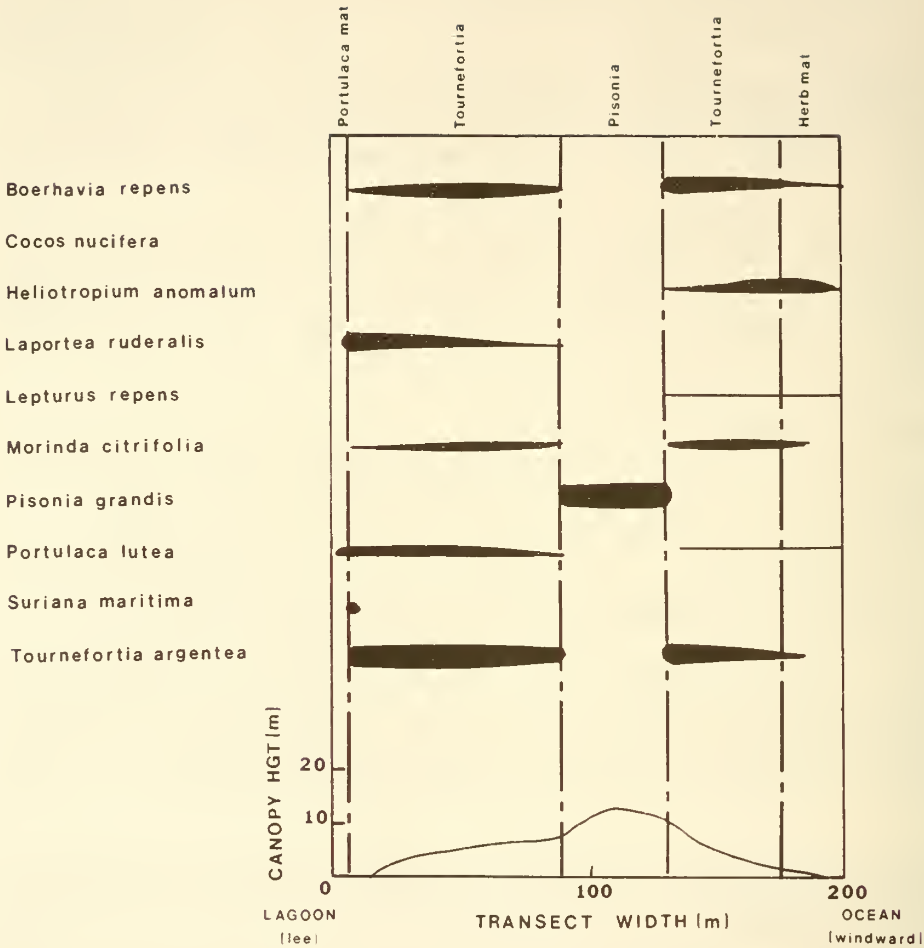


Figure 46. Brothers Islet: east-west cross-section through center of islet. Data includes floristic composition, relative abundance of plant species, degree of species overlap and canopy heights. Vertical height is exaggerated. Note the central monotypic stand of *Pisonia* forest. This islet's forests were totally felled in 1920.

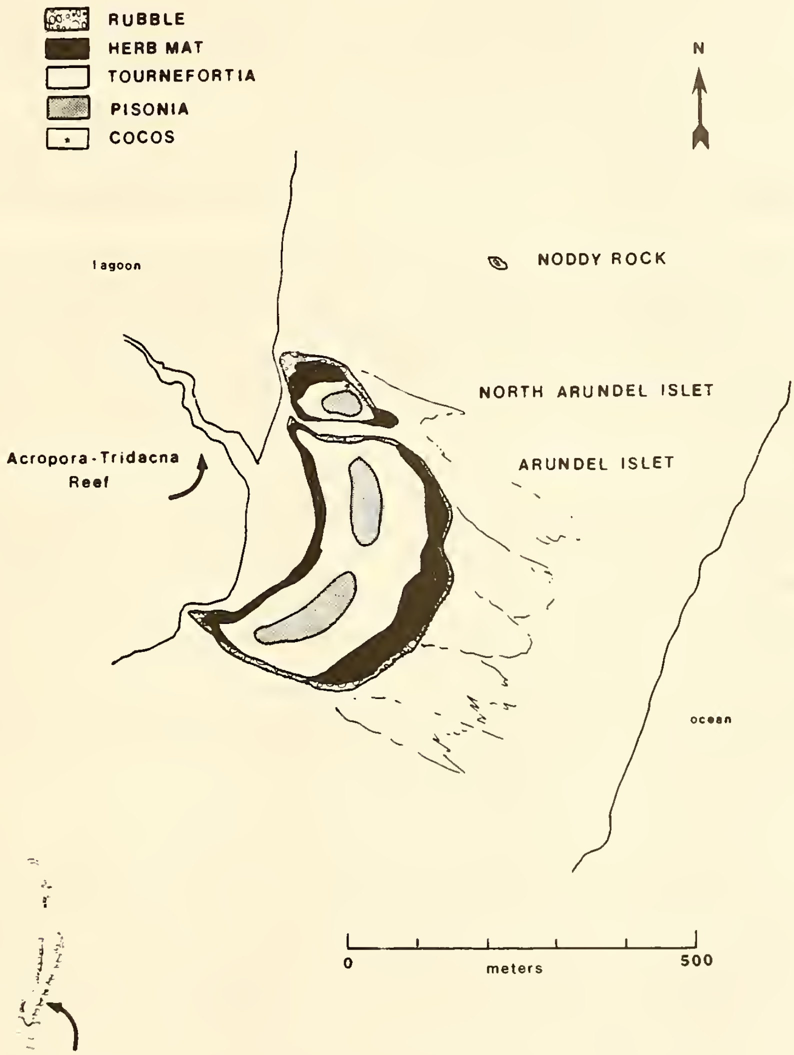


Figure 47. Vegetation and physiography of Windward Islets nos. 10 through 12: Noddy Rock, North Arundel, and Arundel. See text for explanation of the relatively small amount of *Pisonia* cover (Sect. H).

Noddy Rock, an eroded limestone plateau of unknown age, is 26 m wide by 9 m long and 0.5 m above high water. It is windswept and salty, with waves generally splashing over its eastern edge. During storms it is completely awash (Anne Falconer, pers. comm.). Only 3 species of plants (11% of Caroline's flora) grow here, thinly covering the western (leeward) third of the island in the following proportion: 75% *Portulaca*, 20% *Lepturus*, and 5% *Tournefortia*.

13) **NORTH ARUNDEL** (0.91 ha) Discussed below
14) **ARUNDEL** (7.34 ha) Figs. 29, 32, 47; Pls. 14, 56

Arundel Islet was named last century in honor of John T. Arundel. A British trader and guano digger, Arundel was one of the leading figures in the Pacific phosphate industry, directing guano and coconut planting operations on Caroline and other islands from 1873 to 1897. His most valuable contributions, however, were his excellent surveys and maps of several central Pacific islands, including Caroline (Fig. 4). The islet immediately to its north, Arundel's "cap," we named North Arundel.

Physiography: Arundel is crescentic, with wedge-shaped North Arundel lying across a short channel immediately to its north. North Arundel is 80 m long x 130 m wide, while Arundel is 375 m long x 210 m wide. They are composed almost exclusively of coarse coral rubble, flanked on their inner edges by *Acropora-Tridacna* reefs. Arundel's lagoonward "horns" have evidently added more sand and rubble since 1883 (Figs. 4, 47).

Vegetation: There are 11 plant species (3 trees, 1 shrub, 7 herbs) on Arundel, 42% of Caroline's total. There are no introductions. North Arundel also has 11 (4 trees, 1 shrub, 6 herbs), 42% of Caroline's flora, including one introduction, *Cocos*.

The vegetation on the motus, along with Tridacna to the south, consists of extensive herb mats, low scrub and small interior forests (Fig. 32), slightly less lush than the more northerly windward motus. Their woodlands are primarily *Tournefortia*, with thin belts of *Cordia* and central *Pisonia* groves (a bilobed pattern on Arundel). *Morinda* is unusually common on Arundel, and *Achyranthes* abundant on North Arundel. *Pisonia* occupies only 13% of the land area on Arundel, compared to 46% on Pig. Their poor soils are a possible legacy of the guano era.

Both motus were heavily planted with *Cocos* in 1919-20 (69 and 646 palms, respectively). All usable land was cleared (Table 13). Despite today's paucity of *Cocos*, the relatively scant *Pisonia*, compared to motus further north, suggests that their plantations were more successful and maintained more frequently.

Birds: Five species of seabirds bred on Arundel: Red-footed Booby (37 pairs), Great Frigatebird (on territory, September 1988; breeding confirmed, early 1989 by Anne Falconer), Brown Noddy (11 pairs), Black Noddy (249 pairs), and White Tern (227 pairs). In May 1990, thousands of Sooty Terns swarmed both motus.

15) <u>TRIDACNA ISLET</u> (9.08 ha) Figs. 29, 48, 49; Pls. 1, 25, 48, 56, 57

The 13th and southernmost motu in the windward chain was named by the present authors and Boris Sirenko for its outstanding coral reef densely studded with giant clams (*Tridacna maxima*).

Physiography: Somewhat crescentic, measuring 446 m long and 250 m wide, Tridacna is one of the largest motus on Caroline. Its terrain is heavily littered with coral rubble, having a sandy strip above the beach crest on the windward edge.

Vegetation: There are 13 plant species (2 trees, 2 shrubs, 9 herbs), 50% of the atoll's flora. For its size, Tridacna's vegetation is surprisingly lacking in tall forests, a legacy of the 910 *Cocos* palms planted on 82% of its available land area (Table 13). Vegetation patterns follow the usual concentric zonation: peripheral herb mats border a discontinuous belt of *Suriana* (windward side), while the large central mass is dominated by scrubby *Tournefortia-Morinda* woodlands, which cover 88% of the islet's area, yet only attain 7 m in height. In cross-section (Fig. 49), the short woodlands are particularly noticeable. Compare the present lack of *Cordia*, paucity of *Pisonia*, and richness of herbs, both in species numbers and abundance, with Pig (Fig. 45) and Brothers (Fig. 46). Although there are no introduced plants, thick patches of *Lepturus* also reflect past forest clearing.

Birds: Four species of seabirds were nesting in 1988: Red-footed Booby (111 pairs), Brown Noddy (11 pairs), Black Noddy (249 pairs), and White Tern (227 pairs). Tridacna is periodically a major breeding area for Sooty Terns. Clapp & Sibley (1971a) found 4 main colonies totalling 250,000 birds, and large numbers nested along the windward beach in August 1989 (Anne Falconer, pers. comm.). Nests were located under shrubs, or in open areas bordering them, and were evidently preyed upon by coconut crabs.

16) <u>SOUTH ISLAND</u> (104.41 ha) Figs. 30, 36, 50; Pls. 1-8, 12, 23, 34, 39, 40, 44, 45, 56

History: The history of South Island (called Rimapoto in Young ca. 1922) is essentially the history of Caroline, for most information about the atoll prior to 1965 is from here. It is the second largest islet, and the staging area for trips up-lagoon as it lies adjacent to both the "boat landing" and "blind passage."

South Island was inhabited in prehistory by Tuamotuans, who planted the first small coconut grove on its northwest point. The first Europeans to land, in 1606, found coconuts, fish, lobsters, and seabirds in abundance. They dug for fresh water in vain. Two hundred years later, in the decade after a cyclone in 1825, pigs, sweet potatoes, arrowroot, and South Sea chestnut were introduced. However, "the unfriendly character of the soil, and the number of land crabs that infest it, gave us but little hope of the experiment succeeding"

Figure 48. Vegetation and physiography of Windward Islet no. 13: Tridacna Islet. The best quality *Acropora-Tridacna* reefs extend clear across the lagoon from this motu. See Section H for explanation of unusual forest cover.

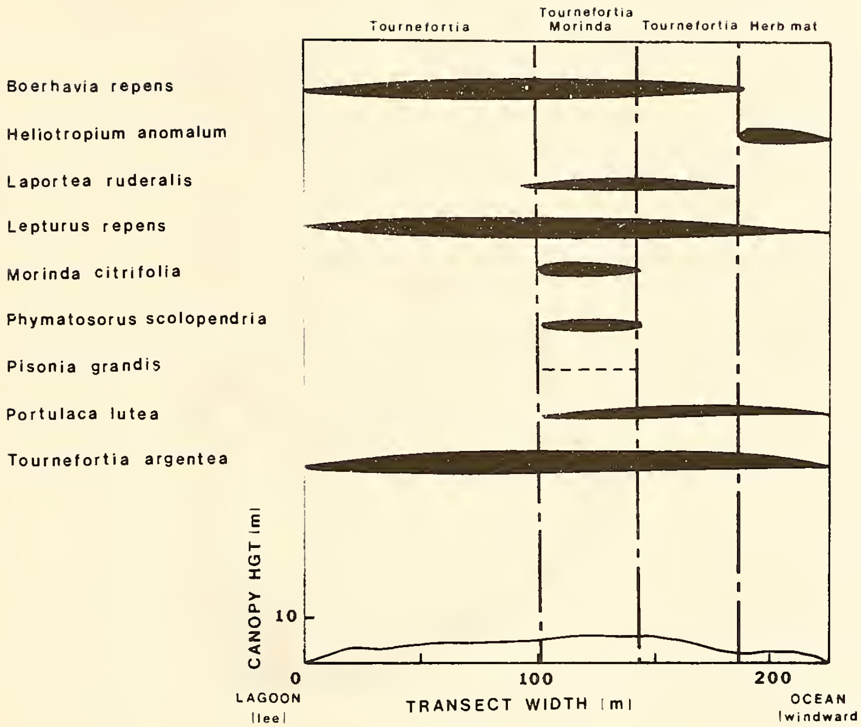


Figure 49. Tridacna Islet: east-west cross-section through lower center of motu. Data includes floristic composition, relative abundance of plant species, degree of species overlap and canopy heights. Vertical height is exaggerated. Note the absence of well-developed interior forests, unusual for a motu of this size (see Sect. H).

Figure 50. South Island: vegetation and physiography. Note the accepted landing route across its leeward reef flats.

(Bennett 1840). The pigs soon expired. The arrowroot, tenacious and adapted to island environments, still exists today (unless later immigrants brought it). Of the others, plus many other later food plants and ornamentals, no traces exist (Table 1). Tropical heat, droughts, storms, excessive shade from *Cocos*, poor germination, poor soils, terrestrial crabs, and lack of care all undoubtedly contributed to their demise.

The first recorded settlement on Caroline, and first for the Line Islands was in 1846, on the northwest point. These settlers, as well as subsequent ones, eked out a spartan living by raising stock, drying fish and copra, and digging for guano. Their managers built "proper" dwellings, so when U.S., British, and French astronomers arrived to observe the solar eclipse in May 1883, South Island was quite "civilized," far more than it is today. Three houses and 2 sheds "were in good repair," and a variety of "anchors, chains, spars, and pieces of the woodwork of vessels" littered its reefs (Holden & Qualtrough 1884). Large grassy clearings adjacent to the lagoon accommodated several European-style houses (Pls. 2-6). The astronomers' account of South, illustrated with pen-and-ink drawings (Pls. 2-7), is the only record of buildings on Caroline, apart from mention of the manager's house, reported in 1936 by the "H.M.S." *Wellington* to be "in excellent condition and spotlessly clean" (Maude ca. 1938), and a copra shed (Clapp & Sibley 1971a). Arundel took photographs, including the *marae* on Nake, which we have not examined.[7]

Today, the houses, sheds, brick piers (constructed in 1883 for telescopes and observatory frames), signboard, flagpole, marble slab with inscription "U.S. Eclipse Party, 1883, May 6," and all but one of the introduced plants have disappeared. In 3 trips we found no traces of the copra shed, nor have the Falconers, after repeated visits over 2 years. All that remains of the formerly extensive open areas are 2 small palm-shaded clearings, in 1988 used by the U.S. and Soviet scientists for a base camp and work area. In 1987, the Falconers lived in one clearing, and in 1990, fishermen expanded the other by burning an area 35 x 22 m, then erecting a tin shack, cookhouse, and fishtrap, all destroyed in a summer 1990 storm.

Our "civilization list" probably covered all that could be seen on South Island without digging: a 26-foot wrecked sloop (AK 6691 J.), complete with trail to a "Robinson Crusoe-type" campsite strewn with remnants of radio and navigational equipment, sail, cans, clothing, etc. (southeast coast); assorted flotsam and jetsam (whisky bottles, Japanese fishballs, plastic debris, etc.); a large rubber ship fender; a bench mark from the 1985 RNZAF survey team; a recently renovated concrete cistern (by the landing); and an old wooden canoe lying on its side just like de Quiros found in 1606.

---

[7]Arundel's memorabilia (photos, letters, diaries, a microfilm, etc.) are in the Rare Book Collection, National Library and Pacific Manuscripts Bureau, Research School of Pacific Studies, Australian National University, Canberra, A.C.T., Australia.

We assume that all the Polynesians, ancient and recent (Tuamotuans, Tahitians, Niueans as far as is known), lived in native thatched huts similar to the ones on Ana-Ana today. Fashioned from coconut palms and pandanus trees, they disappear quickly when abandoned. The largest number of inhabitants recorded for Caroline (probably all on South Island) was "two managers and 52 laborers" in 1873 (The Commercial Advertiser 1873).

The history of South Island's coconut plantations from 1885-1901, and from 1916-1929, is discussed under Coconut Woodlands (Sect. G).

Physiography: South Island forms the base of the thinly crescentic isosceles triangle whose limits define the atoll. Its own shape is that of an irregular parallelogram 858 m wide x 1,254 m long at its longest points (Fig. 50). The north coast, a curved bay, forms the lower boundary of the lagoon. This palm-lined shore, along with the adjacent northwest peninsula, has been the most trodden by man, one of the most picturesque spots on the atoll (Pls. 23, 39).

The reef flats surrounding the outer 3 sides of South are the widest on the atoll, averaging 231 m, 578 m, and 363 m on the east, south and west, respectively. The windward and leeward reefs immediately to its north are 530 m wide. To leeward is the small boat "landing," on a conglomerate platform (Pl. 20), and to windward, the "blind passage," a non-functional *hoa* (Pl. 72).

Vegetation: There are 23 plant species (7 trees, 3 shrubs, 13 herbs), 89% of the atoll's flora. *Cocos* dominates South Island, occupying 77% of its area. The superannuated closed-canopy plantations (21 m tall) that border its coastlines give no indication of the vast overgrown, dying groves that occupy 80 ha, two-thirds of its interior (Fig. 50; Pls. 8, 34). Here, 3 species of herbs (*Boerhavia repens, Portulaca lutea, Phymatosorus scolopendria*) have proliferated unnaturally to form dense carpets, and the vine (*Ipomoea macrantha*) climbs in tangled, strangling masses to the tops of the highest palms.

The natural communities that prevail on other motus are only minor components on South (Fig. 50): herb mats (13% of the total area), Coastal Scrub with *Suriana* (1%), and *Tournefortia* Scrub (4%). Conspicuously absent are prime scrublands and forests of *Tournefortia*, *Pisonia*, and *Cordia*, which undoubtedly once swept in a lush expanse from shore to shore, stratified and zoned as on other motus, and which were "80 to 100 feet high" before extensive cleaning began (Arundel 1875). Canopy heights of the plantations are uniform (21 m), and the outer fringe of indigenous scrub (*Tournefortia, Cordia, Suriana*) and herbs (*Heliotropium, Portulaca*) occupy a small proportion of the island's width (Figs. 36, 51). Note the abrupt transition of canopy heights as they drop to the level of coastal scrub on both sides of the plantation. *Pandanus*, too, is less extensive than formerly: Bennett (1840) called it "somewhat numerous." During our survey, we observed only one small *Pandanus* grove and a few scattered trees. Bennett also noted that the island was "covered with verdure," with "trees attaining the height of twenty feet." However, 9 or 10 years previous to Bennett's visit a

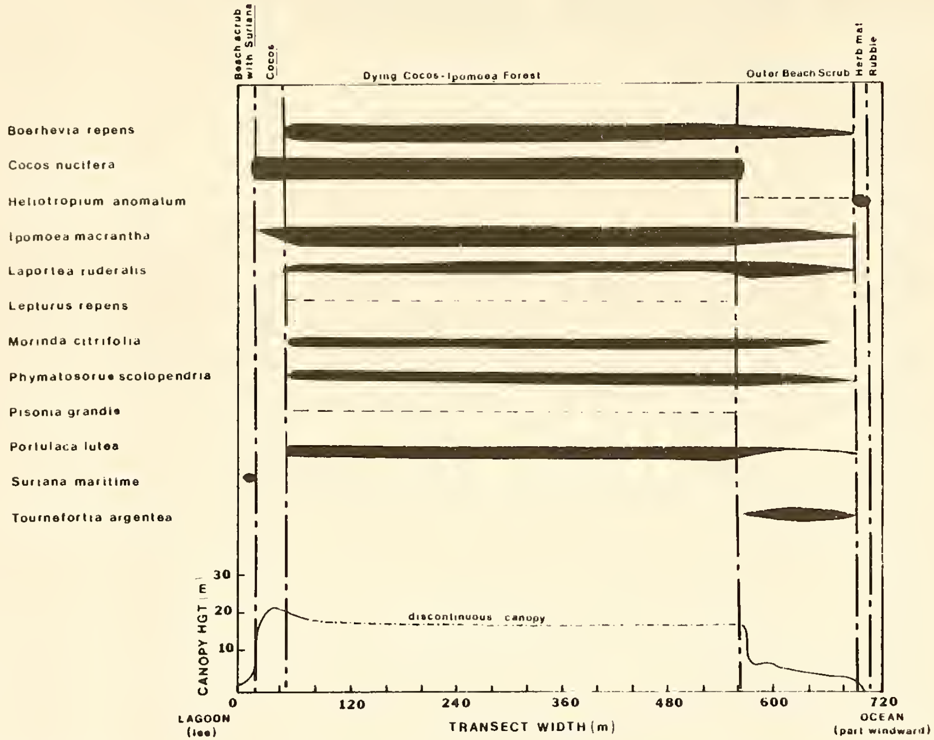


Figure 51. South Island: distribution and abundance of plant species along Transect 2, which runs at an angle of 60° from the lagoon to the south shore through the western center of the islet. Data includes floristic composition, relative abundance of plant species, degree of species overlap and canopy heights. Vertical height is exaggerated. Horizontal scale is half that of the profiles from smaller motus.

violent storm had whipped over the atoll. By the early 1870s, trees were approximately 30 m high again (Arundel 1875). Remnant *Tournefortia* and *Pisonia* are illustrated in drawings of South Island's lagoon shore in 1883 (Pls. 4, 5).

Apart from the coastal buffer zone, little native forest remains. Other sizable trees (*Pisonia*, *Cordia*), up to 17 m tall, are rare, but *Morinda*, tolerant to both sun and shade, is still quite common. Though we have not been able to trace any records to Caroline, it is possible that shiploads of *Cordia* logs were exported to San Francisco on guano ships, as was the case on Flint, worked simultaneously by Arundel's company (Young ca. 1922).

A final noteworthy aspect of South Island is that, despite its history of sporadic occupation and extensive forest felling for coconut plantations, *only one exotic* (a tiny patch of *Phyllanthus amarus*) *and no vegetable or garden ornamentals* (excluding Polynesian introductions) *have survived.*[8] The 19th century gardens, once drenched in sunshine, have long been buried beneath the deep shade of palm groves (compare Pls. 2, 3 and 23). In addition, rare hurricanes, periodic storms, droughts, irregular rainfall, nutrient-poor soils, rats, land crabs, and the harsh salty environment must have contributed to the eradication of alien species except traditional native food and medicinal plants, which are specifically adapted for atoll environments. Studies on other atolls, even those near high islands (Stoddart & Gibbs 1975, Stoddart & Fosberg 1972), have demonstrated also that many exotics do not survive, despite the proximity to source areas containing garden ornamentals and weed plants. On our last 2 visits (March, May 1990), however, we discovered a weed not previously reported (*Kyllinga brevifolia*) near the *Phyllanthus*, a consequence of recent clearing around the cistern. This area was an extension of the Falconers' vegetable garden on Motu Ana-Ana. *Kyllinga* is listed as a temporary species (Table 1).

Birds: Only 2 species of birds bred on South in September 1988, a reflection of its paucity of natural habitats: Brown Noddy (163 pairs) and White Tern (381 pairs). Bristle-thighed Curlews are very common, gathering in small flocks on the rubbly shores (Pt. II). They also forage in the open *Ipomoea-Cocos* forest, perching on dead coconut stumps 6-10 m high, then flying down to feed in the thick herb mats.

Terrestrial Crabs: Caroline's highest population of coconut crabs, having many huge individuals decades old, occupies the open *Cocos* forests (Pls. 21, 53). A crude minimum estimate for South Island is 500 mature individuals.[9] We also found a fist-sized blue hermit crab within

---

[8]We are unsure of the status of *Hibiscus tiliaceus*, *Thespesia populnea* or *Ximenia americana*. Although indigenous to the area, a recent analysis of the vegetation of Flint Island (Kepler, in prep.) indicates that these species were most likely introduced to both islands in the late 19th century.

[9]Since March 1990, these have become much reduced due to killing and preserving in formalin for curios.

a *Turbo argyrostomus* shell, possibly *Coenobita brevimanus* (Yaldwyn & Wodzicki 1979; E. Reese, pers. comm.). As elsewhere on the atoll, land crabs such as the reddish-purple *Cardisoma* sp. and scarlet hermit crabs, *Coenobita perlatus* (in *T. argyrostomus* shells) were abundant (Pl. 38). *Geograpsus* sp., closer to the shore, was less common.

Rats: Polynesian rats were abundant, constantly afoot in broad daylight, and at night flashlight beams often revealed a half dozen at a time.

SOUTH NAKE ISLETS — Fig. 52

This chain of 7 islets extends 1,500 m south from Nake on the west side. They range in size from 0.64 ha (Kota) to 7.36 ha (Pandanus). All are well-wooded and support every natural plant community. Proceeding south, the overall plant cover thins somewhat, but not to the dryness and openness of the Central Leeward Islets. The herb mats are more extensive than on the windward islets, especially to seaward. Aboriginal introductions (*Cocos*, *Pandanus*) are sparse. We have found no historical records indicating human disturbance to these islets, thus their vegetation, with the possible exception of Pandanus Islet, is evidently natural. The 2 scrawny *Cocos* are probably drift-derived.

On the Solar Eclipse Party's map of Caroline (Fig. 5), only the top 2 islets of this group are drawn. The South Nake Islets constitute the only cluster of motus that show appreciable differences between Arundel's chart (Fig. 4) and the 1985 aerial photos: most were shown as smaller, and with slightly different shapes, by Arundel. The interior vegetation on these motus includes mature forests of *Tournefortia*, *Pisonia*, and *Pandanus*, so it is unlikely that these differences reflect changes to the center of the motus. However, since the islets now appear larger, accretions of coral rubble and sand that may have occurred in the past 105 years, and are now barren or covered only with herb mats, could account for most of the differences (see Coral Islet discussion).

Although we have no actual records of Sooty Tern colonies on this chain of islets, in May 1990 AKK observed pre-breeding swirls over Lone Palm, Kota, and Mouakena (Pt. II, Fig. 11).

17) PANDANUS ISLET (7.36 ha) — Figs. 29, 52; Pl. 58

This motu was named by the present authors for its coastal *Pandanus* grove, probably a drift-derived offshoot from a parent colony on Nake.

Physiography: Pandanus Islet, first in the chain, is irregularly oval, 400 m long and 258 m across. It is nearly twice the size shown on Arundel's map (ca. 3.4 ha). It occupies a sheltered spot at the apex of the lagoon. Sand, actively filling in the adjacent lagoon, is an important substrate component on Pandanus, extending one-third of the

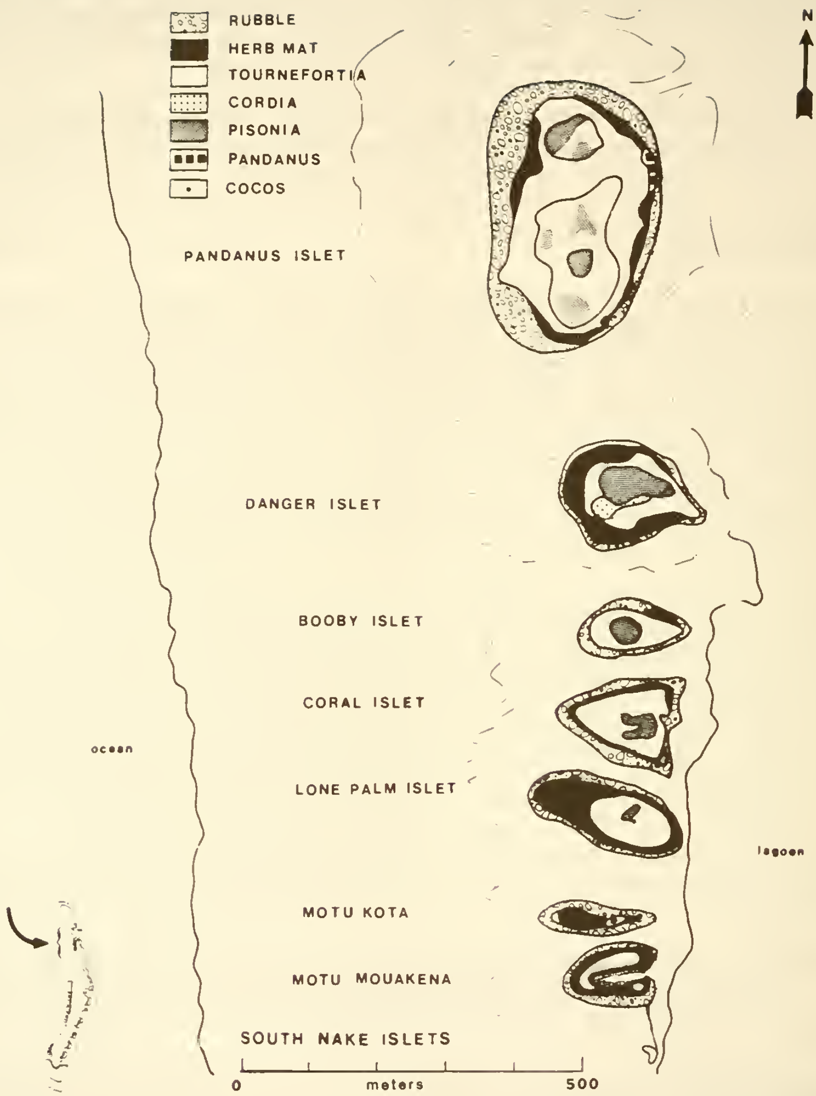


Figure 52. Vegetation and physiography of the 7 South Nake Islets: Pandanus, Danger, Booby, Coral, and Lone Palm Islets, Motu Kota ("Red-footed Booby Islet"), and Motu Mouakena ("Masked Booby Islet").

way across the islet. Although tidal reef flats are absent on the lagoon edge, they average 75 m wide on the seaward side, producing a fairly high proportion of rubble compared to the total land surface (32%).

Vegetation: Plant species total 10 (3 trees, 1 shrub, 6 herbs), 39% of Caroline's flora. *Cocos* is absent, despite the motu's close proximity to Nake. Pandanus Islet has 4 basic vegetation zones: natural herb mats, *Tournefortia* Scrub (with *Pandanus*), *Tournefortia-Pisonia* Forest, and pure *Pisonia*. Woodlands cover 62% of its area. The widest pioneer mats (13 m) of any leeward motu occupy its east edge and though sparsely vegetated (20% *Heliotropium*, 5% *Lepturus*, 5% *Portulaca*) reflect active growth toward the lagoon. Proceeding west across the island, *Tournefortia* scrub (2 m high), with pockets of pure *Pandanus* (10 m high), merges into *Tournefortia-Pisonia* Forest (to 14 m high), whose bimodal distribution suggests that the islet was once divided. The seaward coast supports open *Tournefortia* (5 m high), beneath which herbs eventually thin out onto the extensive reef flats.

Birds: Five species of seabirds breed: Masked Booby (2 pairs), Red-footed Booby (32 pairs), Great Frigatebird (26 pairs), Brown Noddy (26 pairs), and White Tern (52 pairs).

Comments: Skinks and rats were observed, along with the ubiquitous *Coenobita* and *Cardisoma* land crabs.

18) <u>DANGER ISLET</u> (2.71 ha) Figs. 29, 52; Pl. 59

We named Danger Islet to commemorate the deep, shark-infested channel to its north, a barrier that aborted our first attempt to survey the South Nake Islets.

Physiography: Danger, of rounded shape, is approximately 150 m long and 215 m wide. It is composed almost entirely of coral rubble; interior humus is scant. Its reef-channel flats are 21 m (north) and 14 m (south) wide. The east and west beaches, narrow and wide respectively, are typical of all the leeward motus.

Vegetation: Danger has 10 plant species (3 trees, 1 shrub, 6 herbs), 39% of the total flora. There are no introductions. The vegetation is concentrically zoned: herb mats, *Tournefortia* scrub and forest, central *Pisonia*, and *Cordia* in the southwest. The herb mats are wide, extending 22 m and 15 m on the north and south shores, respectively.

Birds: Four species of nesting seabirds were present in 1988: Red-footed Booby (139 pairs), Great Frigatebird (26 pairs), Brown Noddy (26 pairs), and White Tern (52 pairs).

19) BOOBY ISLET (0.84 ha) Figs. 29, 52; Pl. 60

We named this motu, third in the chain, for its 2 species of boobies, the common Red-footed and rarer Masked Booby.

Physiography: Booby, shaped like a teardrop, is 70 m long and 125 m wide. Its coral rubble flats extend 10 m and 30 m on the north and south sides, respectively.

Vegetation: Despite its small size, the most notable feature of Booby is its *Pisonia* forest, 20 m tall and undoubtedly virgin. It occupies the exact center of the islet in a circle about 40 m in diameter. Surrounding this is *Tournefortia* scrub (to 8 m tall), thinning out to peripheral bands of coral rubble. Although less than one hectare in size, Booby Islet's woodlands occupy two-thirds of this area. Booby Islet has 9 species of plants (2 trees, 1 shrub, 6 herbs), 35% of Caroline's flora, and no introductions.

Birds: Five species of seabirds breed: Masked Booby (7 pairs), Red-footed Booby (52 pairs), Brown Noddy (2 pairs), Black Noddy (1 pair), and White Tern (6 pairs).

20) CORAL ISLET (1.70 ha) Figs. 29, 52; Pl. 60

Fourth from the north, Coral Islet was named for its reef-derived coralline substrate.

Physiography: Arrowhead-shaped, Coral is approximately 130 m long by 200 m wide, more than 3 times the size mapped by Arundel (Fig. 4). Most of its area is barely higher than the surrounding inter-islet channels. The shallow reef flats between Coral and its 2 southern motus are only several centimeters deep at low tide; all 3 may be destined to unite. Unless closely inspected, they appear to have already merged, a fact which, together with Bryan's incorrect map (Fig. 6), helps account for the widely differing number of motus attributed to Caroline.

Vegetation: There are 9 species of plants (2 trees, 1 shrub, 6 herbs), 35% of Caroline's flora, and no introductions are present. Plant communities comprise a small *Pisonia* forest (0.13 ha), which is surrounded by the predominant *Tournefortia*, in turn fringed with a narrow band of native herbs. "Soils" are extremely coarse.

Birds: Five species of seabirds bred in 1988: Masked Booby (1 pair), Red-footed Booby (28 pairs), Great Frigatebird (2 pairs), Brown Noddy (6 pairs), and White Tern (15 pairs).

21) LONE PALM ISLET (1.99 ha) Figs. 29, 52; Pls. 60-61

We named Lone Palm, fifth in the chain, for its single coconut palm which towers, flag-like, above a dense mound of *Tournefortia*.

Physiography: Similar to Kota (to its south), Lone Palm is sausage-shaped, 97 m long and 240 m wide, and 4 times the size mapped by Arundel. Although composed almost entirely of coral rubble, some sand borders the lagoon. Following a pattern prevalent on all leeward motus, its lagoon beach is 2 m wide, while the seaward beach is 17 meters.

Vegetation: Eleven species of plants are present (3 trees, 1 shrub, 7 herbs), 42% of Caroline's flora. Plant communities are simple: a wide band of herb mats and open *Tournefortia* flanks an oval of *Tournefortia* forest (to 10 m tall). A line of *Pisonia* trees, with a lone *Cocos* surmounting the scrub, identifies this islet from lagoon or ocean.

Birds: Three species of seabirds bred in 1988: Masked Booby (2 pairs), Red-footed Booby (48 pairs), and White Tern (9 pairs). In May 1990, we saw a large pre-breeding swarm of Sooty Terns.

22) <u>MOTU KOTA</u> "Red-footed Booby Islet" (0.64 ha) Figs. 28, 52; Pls. 60

We named this motu for its high density of Red-footed Boobies (*kota* in Gilbertese).

Physiography: Sixth in line south of Nake, sausage-shaped Motu Kota is 50 m long and 175 m wide. At low tide it is almost connected to Motu Mouakena. Both surveys indicate that coral rubble, the islet's predominant substrate, had further accumulated on its south side since the 1985 aerial photos, and also since 1988.

Vegetation: Though barely wooded, Kota has 11 species of plants (3 trees, 1 shrub, 7 herbs), 42% of Caroline's flora. One introduced species is present, one tattered *Cocos*. Plant communities include: peripheral herb mats and a central *Tournefortia* scrub (to 10 m tall), with a few *Pisonia*s.

Birds: Three species of seabirds bred in 1988: Brown Booby (1 pair), Red-footed Booby (12 pairs), and White Tern (3 pairs). In May 1990, a single Masked Booby was on territory, and Sooty Terns swirled overhead.

23) <u>MOTU MOUAKENA</u> "Masked Booby Islet" (1.00 ha) Figs. 29, 52; Pls. 15, 62

This islet was named for its nesting Masked Boobies, a relatively uncommon seabird on Caroline.

Physiography: Somewhat U-shaped, Motu Mouakena is seventh, and southernmost, in the South Nake chain of islets. Both sides of the "U" were, in the recent past, separate islets. By joining on the west, a narrow, V-shaped inlet was created on the lagoon side. Motu Mouakena, 100 m long and 160 m wide, is extremely rubbly and infertile; much rubble was reorganized during the February 1990 storm. Seventeen meters to its south lies a newly emerging shoal of sand and gravel (Pl. 15), perhaps destined to be Caroline's fortieth motu. Since the above storm, rubble has further accumulated on this shoal, its adjacent reef flats, and in the channel separating it from Mouakena. It already supports one *Tournefortia* shrub, 2 dozen *Heliotropium* plants, and scant *Lepturus* and *Portulaca*.

Vegetation: Mouakena has 8 species (1 tree, 1 shrub, 6 herbs), 31% of Caroline's flora, with no introductions. It is thinly vegetated with open *Tournefortia* scrub (to 9 m tall, 26% cover), a few small *Pisonia*, and sparse herb mats.

Birds: This motu supports less vegetation and fewer birds than its overall area implies, since 38% of the land consists of unshaded, coarse coral rubble (Fig. 29b). Although unproductive botanically, this provides ideal nesting grounds for Masked Boobies, one of its 2 species of 1988 breeding seabirds: Masked Booby (3 pairs) and Red-footed Booby (8 pairs). In May 1990, we also saw one Great Frigatebird nest with eggs and a swirl of Sooty Terns.

CENTRAL LEEWARD ISLETS

This chain of 11 motus occupies the central west side of Caroline. All are separated by channels, wadable only at low tide but prowled by belligerent sharks. Approximately 1,600 m south of Motu Mouakena lies a sandy shoal (0.5 m high, 7 m wide, 4 m long), close to the lagoon edge of the reef flats and connected only by a thin thread of rubble to Motu Mannikiba to its south.

The islets range in size from Mannikiba (28.50 ha), the most northerly, to Fishball (0.46 ha), the most southerly. All support good seabird populations. Although most are well-wooded, they are nonetheless the least lush motus on Caroline. Historical records are meagre: much of Mannikiba's forest was felled to make room for a *Cocos* seedling "nursery" (Young ca. 1922). The bulk of "40 trees on other islets," in Young's plantation totals, were most likely from Shark and Emerald. The rest of this group is evidently pristine; Bird Islet is particularly notable.

In common with all western motus on Caroline, the lagoonside beaches are narrow and leeward reef flats wide. The latter exhibit a greater variety of substrata than the former, including older raised reefs and beachrock. Periodically, thousands of nesting Sooty Terns occupy their open spaces (Clapp & Sibley 1971a; AKK, pers. obs.; Anne Falconer, pers. comm.).

24) MOTU MANNIKIBA "Seabird Islet" (21.49 ha) — Figs. 29, 53; Pls. 63-65

We named this motu for its teeming seabirds, *mannikiba* in Gilbertese.

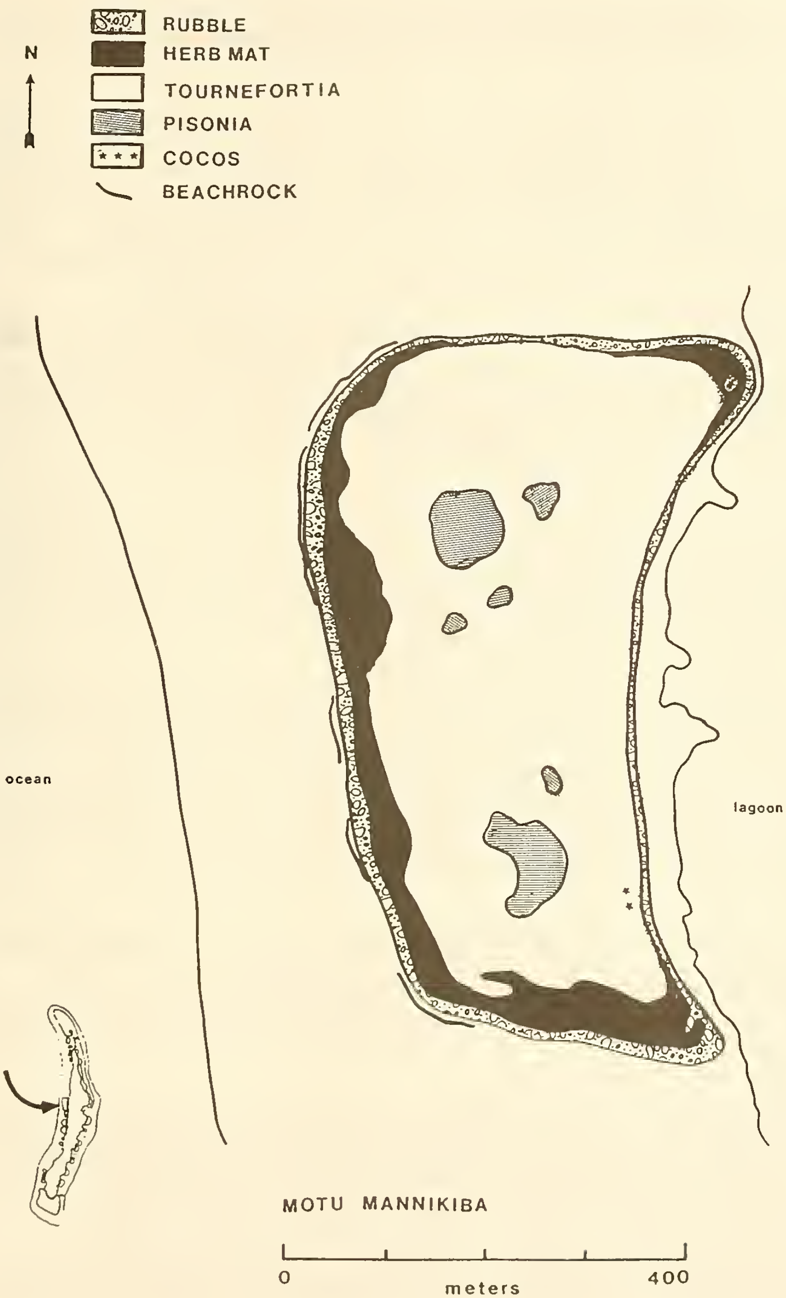


Figure 53. Vegetation and physiography of Central Leeward Islet no. 1: Motu Mannikiba ("Seabird Islet").

Physiography: Largest and most northerly of the Central Leeward Islets, Mannikiba is somewhat rectangular with rounded corners. Its reef flats, supporting an incipient islet, stretch 2.0 km north to the South Nake Islets.

Mannikiba's maximum dimensions are 700 m long and 375 m wide. On the lagoon side, the scrub skirts high water, but when the tide drops, a strip of blinding white sandy coral lines the lagoon. To seaward, upraised reef, beachrock, and successive layers of rubble stretch in a wide swath (40 m) toward the outer reef, 130 m distant. The primary inland substratum is coral rubble with hardpan in the northeast.

Vegetation: Mannikiba, the fourth largest motu, harbors 13 plant species: (4 trees, 2 shrubs, 7 herbs), 50% of Caroline's flora. The only introduction is *Cocos*, occupying 0.1% of the land area. The single, sterile *Ximenia americana* is indigenous, but may have grown from a seed derived from the other patch of this species on South.

Mannikiba's vegetation, denser toward the north end, is clearly zoned: herb mats, *Tournefortia* scrub and forest, and scattered *Pisonia* groves. The few clumps of peripheral *Cocos* are probably not drift-derived, but the remnants of 6,000 "seed sets" brought from Flint Island in June 1920. These were stored on Mannikiba and "used to replant misses on other islets" (Young ca. 1922).

Pisonia, though present, occupies only 5% of the land area, a small percentage for such a large islet. This suggests that large areas of the interior forests were felled to accommodate the coconut "sets." This is also confirmed by the presence of several old cut stumps (*Cordia*?) in the interior, undoubtedly a legacy of S. R. Maxwell and Co., Ltd., who erected huts around 1920 (Young ca. 1922). Although nothing more is known of Mannikiba's history, collection of guano from its numerous seabirds may account for further past disturbance.

Transect 1 (north-central sector, Pl. 64) passed through the heart of a fine interior forest, while Transect 2 (south-central sector) passed through scrub and herb mats which may represent part of the former *Cocos* "nursery." Profiles through these 2 cross-island transects resemble those from Brothers (Fig. 46) and an old interisland channel on Long (Fig. 40), respectively.

The low, peripheral herb mats (absent from the lagoon side) are composed of 30% *Heliotropium*, 20% *Boerhavia*, 15% *Tournefortia*, and less than 1% of *Portulaca* and *Laportea*. They are best represented in the southern sector. The *Tournefortia* forest, 6 m high on both sides, is thick, having 95% canopy coverage. The *Pisonia* forests, though fragmented (12 m high, 100% canopy cover), contain *Morinda*, *Boerhavia*, *Achyranthes*, *Laportea*, and *Phymatosorus*, but none cover more than 10% of the ground area.

Seabirds: Six species are known to breed: Red-footed Booby (184 pairs), Great Frigatebird (287 pairs), Brown Noddy (161 pairs), Black Noddy (176 pairs), and White Tern (195 pairs). No Sooty Terns nested on this islet in 1988, but Clapp & Sibley (1971a) estimated 2,500 pairs in 1965, and the Falconers reported large colonies on Mannikiba, Blackfin and Matawa in July - August 1990.

Comments: Coconut crabs live in the *Cocos* grove. Azure-tailed and snake-eyed skinks (*Cryptoblepharus poecilopleurus*), as well as a gecko, were noted in 1990 (DHE, G. Wragg, pers. obs.).

25) <u>BLACKFIN ISLET</u> (2.62 ha) Figs. 29, 54; Pls. 29

We named this motu, second in the Central Leeward chain, for 2 shark attacks (near misses) within its northern channel.

Physiography: Blackfin, shaped like conjoined ovals, is 140 m long and 190 m across. Coral rubble covers 30% of its surface; all beaches and upper reef flats are of variable widths, due in part to the fact that it has recently incorporated a smaller, circular motu into its northern confines.

Vegetation: Blackfin Islet has 9 species of plants (3 trees, 1 shrub, 5 herbs), 35% of Caroline's flora. The only introduction, *Cocos*, is rare. Four plant communities were present. Herb mats are well represented, especially around the newly incorporated islet. The *Tournefortia* scrub, 21 m wide in the east, is short (to 2 m), but approaches the stature of a forest (to 6 m) in the west. The central forests of *Cordia* and *Pisonia* (0.41 ha) are 9 m high.

Birds: Three species of seabirds bred in 1988: Great Frigatebird (4 pairs), Brown Noddy (37 pairs), and White Tern (11 pairs). In May 1990, one Red-footed Booby sat tight on a nest, while 2 months later large numbers of Sooty Terns began laying.

26) <u>MOTU MATAWA</u> "White Tern Islet" (1.71 ha) Figs. 29, 54; Pl. 3 (Pt. II)

On arriving at this motu, the authors were greeted by 15 White Terns, *matawa* in Gilbertese.

Physiography: Of oval shape, Motu Matawa is third from the north in the Central Leeward chain. It is 105 m long and 190 m wide. The entire motu is composed of coral rubble of varying grades, whose unvegetated portion comprises one-fourth or more of the land area. Its lagoon beach is 2.5 m wide, while the seaward beach (sparsely vegetated) is 6 m wide.

Vegetation: Matawa has 10 species of plants (4 trees, 2 shrubs, 4 herbs), 39% of Caroline's flora. There are no introductions. Vegetation is less lush and more open as one progresses south on the leeward side. *Tournefortia* (to 7 m) covers half the islet, surrounding an east-central *Pisonia-Cordia* forest (to 8 m).

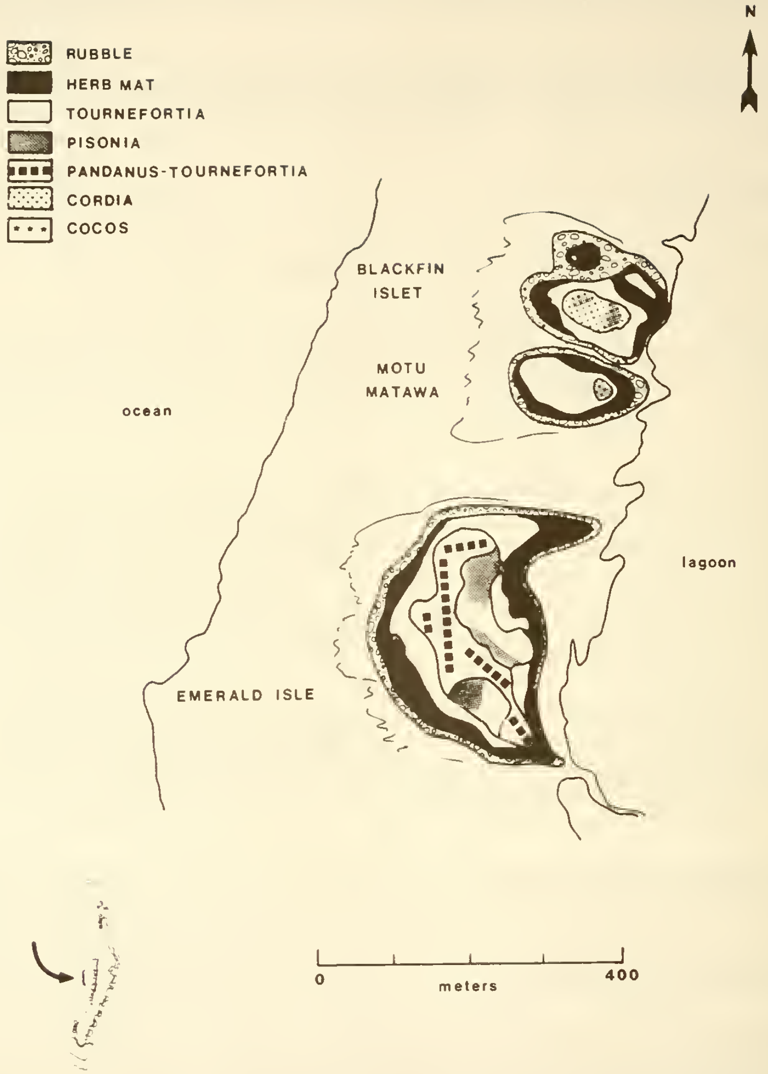


Figure 54. Vegetation and physiography of the Central Leeward Islets nos. 2 through 4: Blackfin Islet, Motu Matawa ("Fairy Tern Islet"), and Emerald Isle.

Birds: In 1988 four species of seabirds bred: Red-footed Booby (5 pairs), Great Frigatebird (1 pair), Brown Noddy (3 pairs), and White Tern (13 pairs). Most conspicuous were White Terns, with 9 pairs breeding on the 30-m-wide transect swath. One dark morph Reef Heron fished in the shallows. In summer 1990, Sooty Terns also bred.

27) EMERALD ISLE (8.34 ha) Figs. 29, 54; Pls. 24, 66, 67

Fifth down the chain, we named Emerald for the richly colored, translucent lagoon waters that fringe its shorelines.

Physiography: Crescentic Emerald, 330 m long and 240 m wide has lagoonside reefs, patch reefs, and coral knolls irregularly patterned with sandy channels.

Vegetation: Emerald Isle has 12 species of plants (5 trees, 1 shrub, 6 herbs), 46% of Caroline's flora. The only introduction is *Cocos*. Four plant communities, with a fairly high species diversity, are present: the herb mats, covering one-fourth of its land area, are composed almost exclusively of *Heliotropium* (35% cover) with scattered low *Tournefortia* (30% cover). The *Tournefortia* attains a maximum height of 8 m and, for variety, is mixed about equally with *Pandanus* over most of its seaward width (144 m).

The interior forest (to 11 m tall) is also mixed, with *Pandanus*, *Tournefortia*, *Pisonia*, and a little *Cordia* (Pl. 66). This 3.20 ha mixed forest, as on Shark, suggests that *Pandanus* may be both native and Polynesian-introduced, although we do not have specimens to verify this. *Cocos* is present as 2 small groves, complete with coconut crab sign (mounds of shredded fibers, Pl. 53), beside the east and midwest shores. We have been unable to trace the history of Emerald's forests; the *Cocos* and fragmented *Pisonia* suggest past disturbance.

Birds: Six species of breeding seabirds were present: Red-tailed Tropicbird (1 pair), Red-footed Booby (3 pairs), Great Frigatebird (230 pairs), Brown Noddy (7 pairs), Black Noddy (150 pairs), and White Tern (83 pairs).

Although we did not locate any Red-tailed Tropicbird nests, 2 adults circled steadily overhead. Two Reef Herons (1 dark morph, 1 light) foraged in the inshore reef shallows.

28) SHARK ISLET (7.98 ha) Figs. 29, 55; Pls. 28, 68

We named this islet to commemorate a particularly pugnacious shark charged shoreward and leaped to the beach toward our feet.

Physiography: Stoutly crescentic, Shark Islet is 280 m long and 310 m wide in the center. The sandy lagoon beach and rubbly seaward beach are each 3 m wide. The former is Caroline's prime stretch of sand, overlain by numerous pink granules, possibly due to Foraminifera tests, as in

Figure 55. Vegetation and physiography of the Central Leeward Islets nos. 5 through 11: Shark and Scarlet Crab Islets, Motu Nautonga ("Sea Cucumber Islet"), Azure Isle, Reef-flat, Bird and Fishball Islets.

common in the Tuamotus (Stoddart & Steers 1977). Beyond high water the seaward reef flats extend for 280 m.

Vegetation: There are 12 species of plants (5 trees, 1 shrub, 6 herbs), 46% of the atoll's flora. One introduction, *Cocos*, forms 3 clumps along the lagoon beach (1% of the islet's area). Shark's rings of vegetation approximate the islet's outline. Herb mats dot the fine sand lagoonward, while to seaward they grow in coarse rubble. The *Tournefortia* (to 7 m tall) eventually gives way to a 12-m-high *Pisonia* forest studded with *Cordia* and *Pandanus*. Centrally this mixed forest is unnaturally open, suggesting past disturbance.

Birds: Four species of seabirds bred in 1988: Great Frigatebird (118 pairs), Brown Noddy (37 pairs), Black Noddy (125 pairs), and White Tern (44 pairs). Red-footed Boobies were nesting in 1990. The notable colonies of Great Frigatebirds and Black Noddies are due in part to the extensive *Pisonia* forest, covering one-half of the islet.

29) SCARLET CRAB ISLET (0.46 ha) Figs. 28, 55

This motu was named by the authors in honor of *Coenobita perlatus*, the scarlet, fist-sized hermit crab that is abundant both here and on the entire atoll.

Physiography: Scarlet Crab, sixth in the chain and only 40 m long by 125 m wide, is a young oval motu. It skirts the southern shore of Shark, from which it is separated by a channel 16 m wide. Because its eastern end points into the lagoon, there is no true lagoon beach. Together with the next 3 islets, Scarlet Crab's seaward reef flats (480 m) are the most extensive on Caroline's lee side.

Vegetation: Vegetative cover is slight: less than 1% area coverage of *Heliotropium* and *Laportea*, interspersed with 10 small *Tournefortia* (to 1.5 m). Its species count is 6 (1 shrub, 5 herbs), 23% of Caroline's flora. There are no introductions.

Birds: Although during storms this motu is undoubtedly awash, 2 species of seabirds were breeding in 1988: Brown Noddy (1 pair, on ground) and White Tern (2 pairs, in low scrub).

30) MOTU NAUTONGA "Sea Cucumber Islet" (0.34 ha) Figs. 28, 55

We named this motu for the Gilbertese word for the black sea cucumbers or "beche-de-mer" (*Ludwigothuria* sp.) that are strewn ubiquitously within the lagoon shallows (Pl. 10).

Physiography: Semicircular in shape, Nautonga is seventh in the Central Leeward chain, measuring 70 m long and 80 m wide. Situated close to the lagoon, it is one of 3 small motus that barely protrude above the reef flats. Nautonga's perimeter beaches are all narrow (2 m), while its seaward reef flats are wide (495 m).

Vegetation: There are 9 indigenous species (3 trees, 1 shrub, 5 herbs), 35% of the atoll's flora. Though small, Nautonga's vegetation is concentrically zoned, comprising herb mats (10-14 m wide) and a central forest of *Tournefortia* and *Pisonia* (84 m wide), to 10 m tall.

Birds: Five species of seabirds bred in 1988: Red-footed Booby (11 pairs), Great Frigatebird (2 pairs), Brown Noddy (7 pairs), Black Noddy (32 pairs), and White Tern (10 pairs). Lesser Frigatebirds appeared to be preparing to nest in May 1990. One pair of Blue-gray Noddies, flying south, was seen in May 1990.

31) <u>AZURE ISLE</u> (0.20 ha) Figs. 28, 55; Pl. 51

We named this small, wedge-shaped motu for the striking colors of its nearby lagoon.

Physiography: Eighth from the north, this small, elongated triangle of land is 30 m long and 66 m wide. Its seaward reef flats are wide (512 m), while the adjacent channels are narrow and shallow.

Vegetation: Azure has only 7 species (1 tree, 1 shrub, 5 herbs), 27% of Caroline's flora. A young motu, Azure is a superb example of an early stage of biological succession. Its plant cover consists of a single mound of *Tournefortia* scrub crowned by a single *Pisonia* tree (6 m tall), growing only one meter above sea level. Only 45% of the motu is vegetated; the rest, primarily to seaward, is coarse rubble. Azure Isle illustrates the minimum width of vegetation (38 m) in which *Pisonia* develops on Caroline.

Birds: This motu illustrates the speed at which seabirds will utilize newly available habitats. Within its dozen or so *Tournefortia* shrubs (to 4 m tall), 3 species of seabirds nest: Red-footed Booby (7 pairs), Great Frigatebird (2 pairs), and White Tern (2 pairs). A pair of Blue-gray Noddies were seen in May 1990.

32) <u>REEF-FLAT ISLET</u> (0.09 ha) Figs. 27, 55

We named this young motu for its primary characteristic: reef flats. Ninth in the Central Leeward chain, this curved strip of coarse rubble lies parallel to the channels that surround and spawned it. It measures about 20 m long and 60 m wide. Three species of plants (1 shrub, 2 herbs), 12% of Caroline's flora, cover less than one-fourth of its area and are distributed so sparsely that not one bird was present.

33) <u>BIRD ISLET</u> (4.05 ha) Figs. 29, 55

This is one of the motus named on Arundel's chart (Fig. 4), probably because of numerous Black Noddies and/or Sooty Terns.

Physiography: Bird is ovoid, measuring 230 m long by 200 m wide. It sits close to the inner edge of the lagoon reef, whereas 400 m of seaward reef flats stretch westward.

Vegetation: There are 12 species of plants (4 trees, 2 shrubs, 6 herbs), 46% of Caroline's flora. A small *Cocos* grove is the only introduction. It is well-wooded, with very narrow herb mats (6% of total area). *Tournefortia* (to 8 m) and *Pisonia* (to 14 m) each cover 42% of its surface; the rest is rubble. The *Pisonia* forest is of good quality (90-95% canopy cover), having scattered *Morinda*, *Boerhavia*, and *Achyranthes* as an understory. One large clump of *Suriana* (14 x 14 m, 2.5 m high) grows centrally (A. Garnett, pers. comm.). Bird Islet shows very few signs of past disturbance, having prime plant communities, rich in breeding seabirds.

Birds: Five species of seabirds nested in 1988: Red-footed Booby (29 pairs), Great Frigatebird (6 pairs), Brown Noddy (42 pairs), Black Noddy (329 pairs), and White Tern (48 pairs). In June 1990, many thousands of Sooty Terns laid on Bird and adjacent Fishball.

34) <u>FISHBALL ISLET</u> (0.57 ha) Figs. 28, 55, 56

Eleventh and southernmost in the Central Leeward chain, we named Fishball after finding a large glass fishing float with a broken bottom, decorously placed in the islet's center amidst coral slabs.

Physiography: *Paramecium*-shaped, Fishball lies close to the lagoon and is separated from Bird by a shallow, rubble strewn channel 100 m wide. The motu is 45 m long by 144 m wide, with seaward reef flats 595 m in extent. South of the islet, the reef flats--wadable at very low tide--stretch 1.4 km to the Southern Leeward Islets.

Vegetation: The number of plant species is 8 (1 seedling "tree," 1 shrub, 6 herbs), 31% of Caroline's flora. Figure 56 depicts an east-west cross-section of Fishball, showing a vertical profile and the relative abundance and distribution of each species. Fishball exemplifies a young motu. All plants are low and halophytic; most are herbs. The motu is half-covered with a sparse herb mat of *Heliotropium* (10% cover), with scattered *Laportea*, *Lepturus*, and *Portulaca* (each <1% cover). Small *Tournefortia* shrubs (to 2 m tall) are scattered in the central sector, while a tiny drift seedling of *Morinda*, 7 cm high, struggled to gain a foothold in the exposed, salty rubble.

This motu is a fine example of the initial stages of islet formation and colonization, demonstrating that sea-dispersed, halophytic herbs first appear later becoming shaded out by *Tournefortia*, enabling a greater plant species diversity to establish. It is very unlikely that a ground water lens is present.

Birds: Two species of seabirds bred in 1988: Red-tailed Tropicbird (3 pairs) and Brown Noddy (5 pairs). In May 1990, many thousands of Sooty Terns covered the ground and swirled in the air, day and night. We

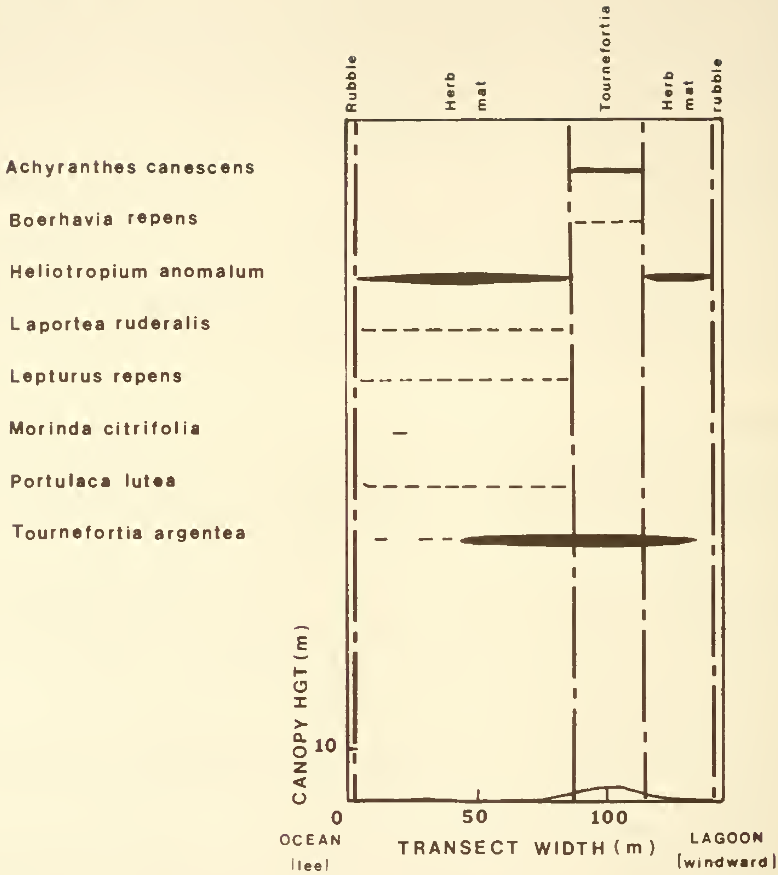


Figure 56. Fishball Islet (no. 11, Central Leewards): east-west cross-section through the center of this young motu, which exhibits early stages of geological and biological evolution. Data includes floristic composition, relative abundance of plant species, degree of species overlap and canopy heights. Vertical height is exaggerated.

found no eggs, but laying occurred in June here and on adjacent Bird Islet (Anne Falconer, pers. comm.).

SOUTHERN LEEWARD ISLETS

Pls. 14, 69

This chain of 5 small motus lies along the southwestern edge of the lagoon. All are built upon piles of rubble about 3 m high, oriented east-west, and separated by shallow, narrow channels. From 1.51 to 3.67 ha in size, their topography, vegetation, and breeding seabirds are similar. Although situated on the leeward side of the atoll, the Southern Leeward Islets exhibit some windward characteristics; they lie opposite and slightly north of a wide break in the windward reef which allows trade winds to sweep, uninterrupted, across the lagoon. This promotes their 60-80% cover of scrub or forest. Ana-Ana, the southernmost, was periodically occupied from 1987-1991 by the Falconer family.

Of particular botanical interest are the interior forests, composed of *Pisonia* mixed with more *Cordia* than elsewhere on the atoll. Pure *Cordia* groves (mostly too small to map accurately) typically occupy the forest peripheries.

Their history (previous to 1987) is unknown; all appear to harbor virgin plant communities mingled with occasional drift-derived *Cocos* or *Pandanus*.

35) MOTU RAURAU "Blue-Gray Noddy Islet" (3.48 ha)

Figs. 29, 57; Pls. 14, 69

Northernmost of the Southern Leeward Islets, we named this motu for the Blue-gray Noddies (*raurau* in Gilbertese) observed there.

Physiography: Raurau is ovoid, with a small lagoonside bay, and maximum dimensions of 180 m long and 231 m wide. It has the most expansive rubble of all the Southern Leeward Islets. This coarse coral clinker extends, apron-like, around the islet, widest (40 m) closest to the lagoon, and narrower (10 m) to seaward. The seaward reef flats extend 446 m to the ocean.

Vegetation: The number of plant species is 10 (5 trees, 1 shrub, 4 herbs), 39% of the atoll's flora. Raurau's 2 plant communities are simple: a very scant herb mat is sprinkled with *Tournefortia*, which rises to 6-m-high scrub all around the islet. *Laportea* forms a narrow band at the interface between coral rubble and scrub. Centrally a *Pisonia* forest (to 13 m), dotted with *Cordia* on the periphery, harbors much *Morinda* in the understory, including the tallest *Morinda* (13 m) seen on the atoll. A handful of drift-derived *Cocos* and *Pandanus*, the only introductions, dot the scrub.

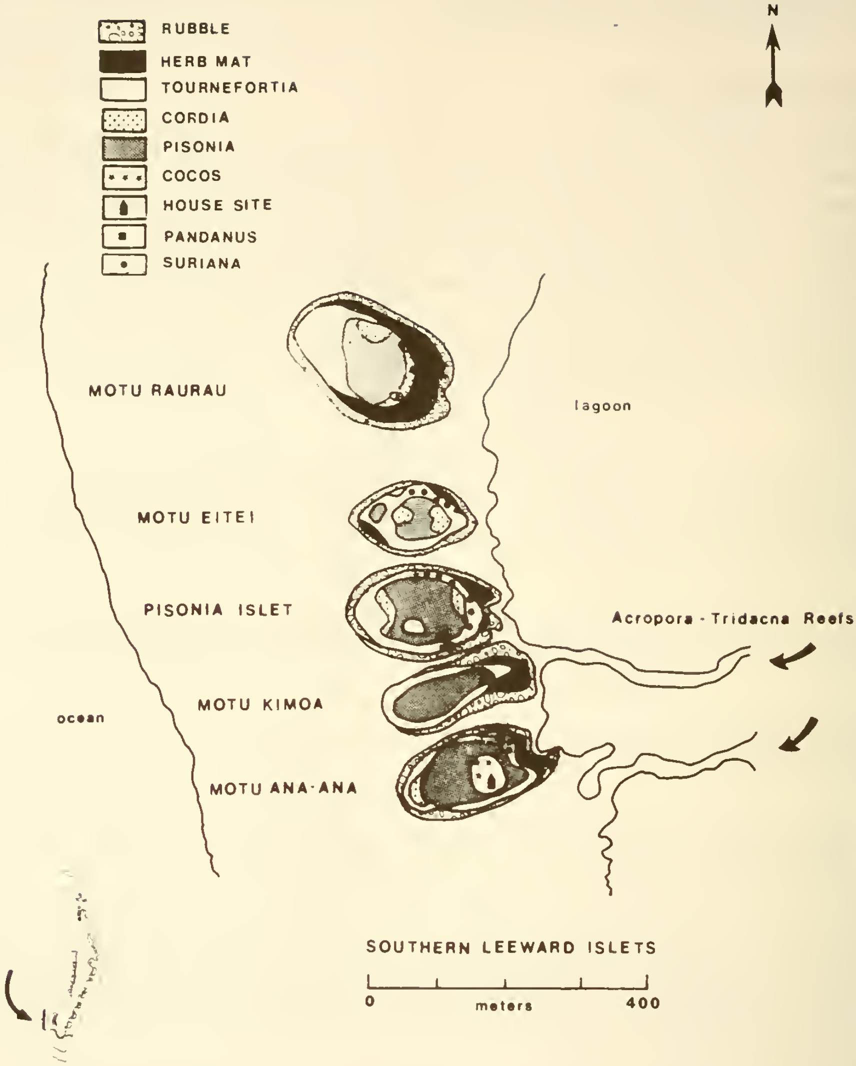


Figure 57. Vegetation and physiography of the 5 Southern Leeward Islets: Motus Raurau ("Blue-gray Noddy Islet"), Eitei ("Frigatebird Islet"), Pisonia Islet, Kimoa ("Rat Islet"), and Ana-Ana ("Anne's Islet").

Birds: No seabirds were found on transect, but a perimeter walk in 1988 revealed 4 species breeding in the leeward *Tournefortia*: Red-footed Booby (10 pairs), Great Frigatebird (31 pairs), Brown Noddy (1 pair), and White Tern (2 pairs). This islet, for its size, is particularly rich in frigatebirds.

Comments: Polynesian rats are present.

36) <u>MOTU EITEI</u> "Frigatebird Islet" (1.41 ha) Figs. 29, 57; Pls. 14, 69

Second in line from the north, we named this motu for its nesting Great Frigatebirds, *eitei* in Gilbertese.

Physiography: Motu Eitei is rounded, 105 m long and 280 m wide. Lying perpendicular to the reef axis, it touches the lagoon edge on its inner side. To seaward, the reef flats are 644 m wide.

Vegetation: There are 8 species of plants (3 trees, 1 shrub, 4 herbs), 31% of the atoll's flora, with no introductions. Eitei is carpeted with 3 plant communities in the usual concentric arrangement. However, there is a slight difference in the species composition of the herb mats: on transect, the southern mat (2 m wide) consisted solely of *Portulaca*, while the north side contained a 3-m swath of *Heliotropium, Laportea*, and scattered *Suriana*. Inside the mat is a ring of *Tournefortia* scrub (to 5 m) and a central *Pisonia-Cordia* forest (to 11 m). *Laportea* is particularly abundant, while *Portulaca*, normally confined to the edges, abounds in small openings within the interior woodlands.

Birds: Four species of seabirds bred on Motu Eitei in 1988: Red-footed Booby (17 pairs), Great Frigatebird (14 pairs), Brown Noddy (6 pairs), and White Tern (18 pairs). The atoll's first Blue-gray Noddy nest was found in 1990 (Pt. II).

37) <u>PISONIA ISLET</u> (2.45 ha) Figs. 29, 57; Pls. 14, 69

We named this motu for its fine *Pisonia* forest.

Physiography: Pisonia, third in the chain from the north, is almost circular, and lies closely appressed to its neighbor islets. Its maximum dimensions are 140 m long and 220 m wide. Like Raurau, it possesses a wide "apron" of coral rubble and sparse herbs on the lagoon side. Its seaward reef flats are 300 m wide.

Vegetation: The number of plant species is 15 (5 trees, 2 shrubs, 8 herbs), 58% of the atoll's flora. The only introduction is *Cocos* (few, scattered, north and south shores). Well-wooded, Pisonia harbors the customary 3 plant communities: the herb mat is almost pure *Heliotropium*, dotted with *Suriana*. One specimen of *Lepidium bidentatum* was found in 1990. The *Tournefortia* scrub and forest, covering half of the motu's length and width, grows to 9 m, while the *Pisonia-Cordia* forest, covering 0.86 ha (35% of the islet's area), reached 10 meters.

Birds: Despite the fine *Pisonia* forest, no Black or Brown Noddies nested. Only 3 species of seabirds bred in 1988: Red-footed Booby (26 pairs), Great Frigatebird (14 pairs), and White Tern (10 pairs). Best represented were Red-footed Boobies; a perimeter count yielded 18 tended nests, all in *Tournefortia* scrub. A Long-tailed Cuckoo was heard in the interior.

Comments: Rats were common: 6 were noted on a mid-morning transect survey.

38) <u>MOTU KIMOA</u> "Rat Islet" (1.80 ha) Figs. 29, 57; Pls. 14, 69, 70

Fourth from the north, we named this motu for Caroline's single mammalian inhabitant, the Polynesian rat, *kimoa* in Gilbertese.

Physiography: Kimoa, smallest of the Southern Leeward Islets and shaped like a flared teardrop, is squeezed between its neighbor motus. Its maximum dimensions are 92 m long and 218 m wide, almost 4 times the size mapped by Arundel (Fig. 4). The southeast rubble and herb mats are wide. The distance to the outer reef edge is 307 meters. Of special note is the emergent *Tridacna-Acropora* reef which stretches completely across the lagoon to Tridacna Islet. This reef is 15-20 m wide (Fig. 48; Pls. 25, 57) and 1,023 m long, which, together with an equal length in blind diverticulae, totals over 2 kilometers. The *Tridacna* clams aggregate in densities up to 80/sq m (Sirenko & Koltun, in press).

Vegetation: Kimoa has 11 species of plants (3 trees, 2 shrubs, 6 herbs), 42% of Caroline's flora. There are no introductions. Though small and narrow, Kimoa is well-vegetated. Its herb mats are composed of *Heliotropium* on the south side and *Portulaca* (plus *Suriana*) on the north. The interior *Tournefortia-Pisonia-Cordia* forests (to 11 m) cover nearly half the islet's area.

Birds: Four species of seabirds bred in 1988: Red-footed Booby (21 pairs), Great Frigatebird (3 pairs), Black Noddy (2 pairs), and White Tern (7 pairs). Red-footed Booby nests occupied perimeter sites.

39) <u>MOTU ANA-ANA</u> "Anne's Islet" (2.16 ha) Figs. 29, 57; Pls. 7a, 14, 52, 69, 71

This motu includes a small settlement with 3 thatched huts (cooking, eating, sleeping), a water tank, chicken coop, and garden. It was occupied from 1987-1991 by Anne and Ron Falconer, 2 small children, chickens, Muscovy ducks, and a dog. A wooden sign marked "Ana-Ana" indicated that the islet had been named.

It is interesting to compare Plates 7a and 71, identical profiles of Ana-Ana 105 years apart.

Physiography: Ana-Ana is the southernmost motu in the Southern Leeward Islets, 120 m long by 222 m wide at its widest point. Approximately 3 m high, it is roughly oval, with a hooked point and curved bay facing the lagoon. This point is actively growing as more and more rubble is deposited by the large flow of water passing through the channel (430 m wide) that separates Ana-Ana and South Island. This channel contains abundant clams that amass into an extensive *Acropora-Tridacna* reef stretching approximately 900 m across the lagoon to Tridacna Islet. The outer reef flats measured 281 meters.

Vegetation: Ana-Ana has 15 species of plants (5 trees, 2 shrubs, 8 herbs), 58% of Caroline's flora. Introductions include *Cocos*, vegetables, a few ornamentals and, as yet, no weedy exotics. Ana-Ana's vegetation is typical of the other Southern Leeward Islets except for the settlement. Narrow trails from the southern channel lead to a neat clearing, approximately 40 m x 70 m, the only inhabited portion of the atoll. We advised the Falconers against introducing alien plants with spreading seeds and requested them to destroy all introductions when vacating the island permanently.

Ana-Ana has sparse herbaceous mats: *Suriana*, *Heliotropium*, *Portulaca*, *Laportea*, and *Lepturus*. The *Tournefortia* strand includes *Cocos*, *Cordia*, and *Pandanus*. Quality *Pisonia* forest, 15 m high, covers 43% of the islet's area.

Birds: No breeding seabirds were found on any of the 3 visits to Caroline. However, the Falconers found a few White Terns and one Great Frigatebird nesting in the perimeter scrub, as well as groups of Brown Noddies sitting on the beach. Long-tailed Cuckoos were seen around the huts in March, April, and May 1990. It is to be hoped that seabirds return now that the motu is again uninhabited.

Comments: Rats and large cockroaches are abundant. Despite the tidy site, 12 rats occupied a pile of coconut debris, while others scurried amongst the forest litter. The Falconers trapped over 1,300 rats one 2-year period. Several pale geckos with a few spots and largish heads were seen in and around the huts (probably mourning geckos).

I. CONCLUSION

Lushly wooded Caroline Atoll, with the majority of its 39 islets (399 ha of land) either in near-pristine condition or having recovered remarkably from past disturbance, is one of the least spoiled atolls in the Pacific. Uninhabited, it harbors plant ecosystems and breeding seabirds (Pt. II) of national and international importance. Its marine and terrestrial ecosystems are prime outdoor ecological laboratories for research on geological processes including ground water, sea level changes, the dynamics of motu formation, fish poisoning, and numerous facets of ecology including plant succession and *Pisonia* growth rates.

Caroline boasts prime coral reefs thickly studded with *Tridacna* clams, substantial numbers of coconut crabs, breeding sites for green turtles, wintering grounds for shorebirds including the rare Bristle-thighed Curlew, ancient Tuamotuan *marae*, and a crystalline, unpolluted lagoon. The variety, abundance, and quality of its flora and fauna qualify it for status as an officially recognized international preserve (Pt. II, Sect. G). Efforts toward its conservation have thus far been unsuccessful: in 1992 it was leased to a private French businessman who is currently fishing the reefs for commercial profit, as well as disturbing seabird, turtle and coconut crab populations.

J. LITERATURE CITED

Admiralty Chart, No. 979. 1965. Central Pacific Ocean: islands between 160° east and 150° west longitude. J. D. Potter, London.

Arundel, J. T. 1875. Notes on guano islands in the South Pacific Ocean. Unpublished ms. Houlder Bros. and Co., London, 5 pp.

______. 1890. The Phoenix Group and other islands of the Pacific. "New Zealand Herald," Auckland, July 5 and 12, 1890.

Barber, R. T. & F. P. Chavez. 1983. Biological consequences of El Niño. Science 222(4629):1203-1210.

Bayliss-Smith, T. P. 1973. Ecosystem and economic system of Ontong Java Atoll, Solomon Islands. Cambridge University Ph.D. Thesis.

Bennett, F. D. 1840. Narrative of a whaling voyage around the globe from the year 1833 to 1836..., Vol. 1. Richard Bentley, London, vii + 402 pp.

Braley, R. D. 1987. Spatial distribution and population parameters of *Tridacna gigas* and *T. derasa*. Micronesica 20:225-246.

Broughton, W. R. 1804. A voyage of discovery to the North Pacific Ocean...performed in His Majesty's sloop *Providence*...in 1795, 1796, 1797, 1798. T. Cadell and W. Davies. Rep., London.

Bryan, E. H. 1942. American Polynesia and the Hawaiian chain. Tongg Publ. Co., Honolulu, 253 pp.

Butler, A. G. & H. Strecker. 1884. Memorandum of the butterflies, etc. of Caroline Island, *in* Report of the eclipse expedition to Caroline Island May 1883. Nat. Acad. Sci. Mem. 2:92-96.

Campbell, E. B. 1908. Flint Island eclipse expedition, January 3, 1908. Selected pages from an unpublished diary by the wife of Director W. W. Campbell, Lick Observatory, California. 51 pp.

Campbell, W. W. 1908. Unpublished letter from the Director of the Lick Observatory and leader of the U.S. Solar Eclipse Expedition to

Flint Island (Dec. 1907-Jan. 1908) to the Hydrographic Office, Navy Dept., Washington D.C., Aug. 14, 1908. 4 pp.

Cane, M. A. 1983. Oceanographic events during El Niño. Science 222(4629):1189-1202.

Catala, R. L. A. 1957. Report on the Gilbert Islands: some aspects of human ecology. Atoll Res. Bull. 59: Oct. 31.

Christopherson, E. 1927. Vegetation of Pacific equatorial islands. B. P. Bishop Mus. Bull. 44. 79 pp.

Clapp, R. B. & F. C. Sibley. 1971a. Notes on the vascular flora and terrestrial vertebrates of Caroline Atoll, Southern Line Islands. Atoll Res. Bull. 145. 20 pp.

______. 1971b. The vascular flora and terrestrial vertebrates of Vostok Island, south-central Pacific. Atoll Res. Bull. 144:1-10.

Clay, H. 1961. Narrative report of botanical fieldwork on Kure Island, 3 October 1959 to 9 October 1959. Atoll Res. Bull. 78:1-4.

Commercial Advertiser, The. 1873. From Caroline Island. Honolulu. Two-line note in newspaper, 3-5-1873.

Crough, S. T. & R. D. Jarrard. 1981. The Marquesan-Line Swell. J. Geophys. Res. 86:11763-11771.

Danielsson, B. 1954. Native topographical terms in Raroia, Tuamotus. Atoll Res. Bull. 32:92-96.

Darwin, C. R. 1842. The structure and distribution of coral reefs. Smith, Elder and Co., London, xii + 214 pp.

Degener, O. & E. Gillaspy. 1955. Canton Island, South Pacific. Atoll Res. Bull. 41: Aug. 15.

Dixon, W. S. 1884. Notes on the zoology of Caroline Island, *in* Report of the American expedition to Caroline Island May 1883. Nat. Acad. Sci. Mem. 2:90-92.

Doty, M.S. & J. P. E. Morrison. 1954. Interrelationships of the organisms on Raroia aside from man. Atoll Res. Bull. 35:1-61.

Duncan, R. A. 1983. Overprinted volcanism in the Line Islands and Pacific plate motion since 100 m.y. EOS (Trans. Amer. Geophys. Union) 64:843.

Ellis, D. H., C. B. Kepler, A. K. Kepler & K. Teeb'aki. 1990. Occurrence of the Long-tailed Cuckoo *Eudynamis taitensis* on Caroline Atoll, Kiribati. Emu 90:202.

Ellsworth, S. G., ed. 1990. The journals of Addison Pratt: being a narrative of Yankee whaling in the Eighteen Twenties, a Mormon mission to the Society Islands..., in the Eighteen Forties and Fifties. University of Utah Press, Salt Lake City, Utah, 606 pp.

Ely, C. A. & R. B. Clapp. 1973. The natural history of Laysan Island, northwestern Hawaiian islands. Atoll Res. Bull. 171:xi + 361.

Emory, K. P. 1947. Tuamotuan religious structures and ceremonies. B. P. Bishop Mus. Bull. 191. 102 pp.

Findlay, A. G. 1884. Directory for the navigation of the South Pacific Ocean. Fifth ed. London.

Fosberg, F. R. 1936. Vegetation of Vostok Island, Central Pacific. B. P. Bishop Mus. Special Publ. 30:19.

______. 1949. Atoll vegetation and salinity. Pacific Science 3:89-92.

______. 1953. Vegetation of central Pacific atolls. Atoll Res. Bull. 23:1-26.

______. 1954. Soils of the northern Marshall atolls, with special reference to the Jemo Series. Soil Sci. 78:99-107.

______. 1955. Northern Marshalls expedition, 1951-1952. Land biota: vascular plants. Atoll Res. Bull. 39:1-22.

______. 1956. Military geography of the northern Marshalls, prepared under the direction of the Chief of Engineers, U.S. Army, and the U.S. Geological Survey, 320 pp.

______. 1959. Vegetation and flora of Wake Island. Atoll Res. Bull. 67:1-20.

______, ed. 1965. Man's place in the island ecosystem: a symposium. Tenth Pacific Science Congress, Honolulu, Hawaii, 1961. Bishop Museum Press, 264 pp.

______. 1968. Critical notes on Pacific island plants 2. Micronesica 4(2):255-259.

______. 1974. Phytogeography of atolls and other coral islands. Proc. Second Int'l. Coral Reef Symposium, Brisbane, Australia, Oct. 1974, pp. 389-396.

______. Coral island vegetation, *in* Biology and geology of coral reefs, Vol. III. By O. A. Jones and R. Endean. Academic Press, pp. 256-277.

______. 1977. An irresponsible scientific expedition. Atoll Res. Bull. 219:4-5.

Fosberg, F. R. 1983. The human factor in the biogeography of oceanic islands. C. R. Soc. Biogeogr. 59(2):147-190.

______. 1985. Present state of knowledge of the floras and vegetation of emergent reef surfaces, Vol. 5. Proc. Fifth Int. Coral Reef Congress, Tahiti, 1985.

______ & M.-H. Sachet. 1969. Wake Island vegetation and flora, 1961-1963. Atoll Res. Bull. 123:1-15.

______. 1987. Flora of the Gilbert Islands, Kiribati, checklist. Atoll Res. Bull. 295:1-33.

Fosberg, F. R., G. Paulay, T. Spencer, & R. Oliver. 1989. New collections and notes on the plants of Henderson, Pitcairn, Oeno, and Ducie Islands. Atoll Res. Bull. 329:1-18.

Fosberg, F. R. No date. Description and occurrence of atoll phosphate rock. Typescript, 12 pp.

______. No date. Flora of the Phoenix Islands. Unpub. mss. Pt. I, 85 pp.; Pt. II, 52 pp.

Fowler, H. W. 1901. Fishes from Caroline Island. Proc. Acad. Nat. Sci., Phila. 53:324-326.

Frisbie, R. D. 1944. The Island of Desire. Garden City, New York, 234 pp.

Garnett, M. C. 1983. *A management plan for nature conservation in the Line and Phoenix Islands*. Pt. I: Description, 318 pp.; Pts. II, III: Policy and recommendations, 131 pp. Unpublished reports.

Gessel, S. P. & R. B. Walker. 1992. Studies of soils and plants in the Northern Marshall Islands. Atoll Res. Bull. 359:1-70.

Gilbert and Ellice Islands Government. 1974. Line Island Expedition Report. Reports by the Minister and Secretary of Natural Resources, Director of Agriculture, and Fisheries Officer, 71 pp. See also Grossman & Grossman (Pt. II, this vol.) and Ward (1974).

Guppy, H. B. 1906. Observations of a naturalist in the Pacific between 1896 and 1899. Vol. II, Plant-Dispersal. MacMillan and Co., New York, 627 pp.

Haggerty, J. A. 1982. The geologic history of the Southern Line Islands. Ph.D. Dissertation, 202 pp. Univ. of Hawaii, Honolulu.

Hague, J. D. 1862. On phosphatic guano islands of the Pacific Ocean. Am. J. Sci. 34:224-243.

Hatheway, W. H. 1953. The land vegetation of Arno Atoll, Marshall Islands. Atoll Res. Bull. 16: April 30.

Holden, E. S. 1884. History, *in* Report of the eclipse expedition to Caroline Island May 1883. Nat. Acad. Sci. Mem. 2:20-22.

______ & E. F. Qualtrough. 1884. Description of the island, *in* Report of the eclipse expedition to Caroline Island May 1883. Nat. Acad. Sci. Mem. 2:22-26.

Hutchinson, G. E. 1950. Survey of existing knowledge of biogeochemistry. 3. The biogeochemistry of vertebrate excretion. Bull. Am. Mus. Nat. Hist. 96:1-544.

Hydrographer of the Navy. 1931, 1982. Pacific Islands Pilot, Vols. II, III. Ministry of Defense, Taunton, Somerset, England.

IUCN. 1991. IUCN directory of protected areas in Oceania. Prepared by the World Conservation Monitoring Centre. IUCN, Gland, Switzerland and Cambridge, UK. xxiii + 447 pp.

Jarrard, R. D. & D. A. Clague. 1977. Implications of Pacific island and seamount ages for the origin of volcanic chains. Rev. Geophys. Space Phys. 15:57-76.

Kepler, A. K. 1990a. Caroline Atoll: fact sheet, including conservation attributes and recommendations. Unpublished ms. 12 pp.

______. 1990b. Flint Island: fact sheet. Unpublished ms. 6 pp.

______. 1990c. Vostok Island: fact sheet. Unpublished ms. 6 pp.

______. 1990d. Report: ICBP 1990 Line and Phoenix Islands expedition, February 20 - May 31, 1990, International Council for Bird Preservation, Cambridge, England. Unpublished ms. 14 pp.

______. In prep. Ecological studies of Vostok Island, Republic of Kiribati.

______. In prep. Flint Island, South-central Pacific Ocean: its history and biota.

Kepler, C. B. & A. K. Kepler. 1989. Trip report, Soviet-American oceanographic expedition to the central Pacific: Hilo, Hawaii to Singapore, 9 Sept. - 31 Oct. 1988. Unpublished ms. 9 pp.

Lamberson, J. O. 1987. Natural history of terrestrial vascular plants of Enewetak Atoll, *in* Vol. II, The Natural History of Enewetak Atoll, Chapter 3, pp. 17-35. U.S. Dept. of Energy, 348 pp.

Lamoureaux, C. 1961. Botanical observations on leeward Hawaiian atolls. Atoll Res. Bull. 79:1-10.

Lucett, E. 1851. Rovings in the Pacific from 1837 to 1849, with a glance at California, Vol. II. By a merchant long resident at Tahiti. 2 Vols., Longman, Brown and Green, London, xi + 371 pp.

MacArthur, R. H. & E. O. Wilson. 1967. The theory of island biogeography. Princeton Univ. Press, Princeton, New Jersey, 203 pp.

Markham, Sir Clements. 1904. The voyages of Pedro Fernandez de Quiros, 1595-1606, Hakluyt Society, Series II, Nos. 14-15. 2 Vols. The Hakluyt Society, London.

Maude, H. E. Ca. 1938. Caroline Island. Unpublished ms. 8 pp.

______. Ca. 1942. Caroline Island: Part L. Ms. from author. 6 pp. (printed but not published).

______. 1953. The British central Pacific Islands: a report on land classification and utilization. Proc. Seventh Pac. Sci. Congr. 60:89-97.

______. 1968. Of islands and men. Oxford University Press, London and New York, 397 pp.

______. No date. Bibliography of books, pamphlets, and articles on the Phoenix and Line Islands. Ms., printed but not published, in author's possession. 4 pp.

Montaggioni, L. F. & P. A. Pirazzoli. 1984. The significance of exposed coral conglomerates from French Polynesia (Pacific Ocean) as indicators of recent relative sea-level changes. Coral Reefs 3:29-42.

Moul, E. T. 1957. Preliminary report on the flora of Onotoa Atoll, Gilbert Islands. Atoll Res. Bull. 57:1-48.

Mueller-Dombois, D., K. W. Bridges & H. L. Carson. 1981. Island ecosystems: biological organization in selected Hawaiian communities. Hutchinson Ross Publishing Company, Stroudsburg, Pennsylvania, 583 pp.

Newell, N. D. 1956. Geological reconnaissance of Raroia (Kon Tiki) Atoll, Tuamotu Archipelago. Bull. Am. Mus. Nat. Hist. 109:311-372.

Nicholson, E. M. & G. Douglas. 1969. Draft check list of Pacific oceanic islands. Micronesica 5(2):327-463.

N.I.D. (Great Britain Naval Intelligence Division). 1943. Pacific Islands. Vol. II, eastern Pacific. H. M. Stationery Office, London, xvi + 739 pp.

Niering, W. A. 1956. Bioecology of Kapingamarangi Atoll, Caroline Islands: terrestrial aspects. Atoll Res. Bull. 49:1-32.

______. 1963. Terrestrial ecology of Kapingamarangi Atoll, Caroline Islands. Ecol. Monogr. 33:131-160.

Orwig, T. L. & L. W. Kroenke. 1980. Tectonics of the eastern central Pacific basin. Mar. Geol. 34:29-43.

Parham, B. E. V. 1971. The vegetation of the Tokelau Islands with special reference to the plants of Nukunono Atoll. N. Z. J. Bot. 9:576-609.

Paulding, H. 1831. *Journal of a cruise of the United States Schooner* Dolphin.... G. & C. & H. Carvill, New York, iv + 258 pp.

Perry, R. 1978. Visit to the Southern Line Islands. Atoll Pioneer 4, Sixth January 1978, p. 4-6. Typescript.

______ & M. Garnett. No date. *The natural history and birdlife of Christmas Island.* ICBP, Cambridge, England, 36 pp.

Phillips, N. J. 1984. Spatial relationships of *Pisonia grandis* and *Cocos nucifera*. Cousin Island Research Station (ICBP, Seychelles Islands, Indian Ocean) Technical Report, 9 pp.

______ & V. E. Phillips. 1990. Monitoring vegetation changes on Cousin--a comparative summary of changes since 1976. Cousin Island Research Station (ICBP, Seychelles Islands, Indian Ocean) Technical Report, 43 pp.

Pilsbry, H. A. & E. G. Vanatta. 1905a. Mollusca of Flint and Caroline Islands, in the central Pacific. Proc. Acad. Nat. Sci., Phila. 57:291-293.

______. 1905b. On some Pacific Cerithiidae. Proc. Acad. Nat. Sci., Phila. 57:787-789.

Pirazzoli, P. A. & L. F. Montaggioni. 1988. Holocene sea-level changes in French Polynesia. Palaeogeog. Palaeoclim. Palaeoecol. 68:153-175.

Reese, E. 1987. Terrestrial environments and ecology of Enewetak Atoll, *in* The Natural History of Enewetak Atoll, Vol. I, 187-202.

Rehder, H. A. & J. E. Randall. 1975. Ducie Atoll: its history, physiography and biota. Atoll Res. Bull. 183:1-40.

Richard, G. 1985. Richness of the great sessile bivalves in Takapoto Lagoon. Fifth Intl. Coral Reef Congress, French Polynesia, pp. 368-371.

Ridley, H. N. 1930. The dispersal of plants throughout the world. L. Reeve & Co., Ltd., Ashford, United Kingdom, 744 pp.

RNZAF. 1986. Aerial photographs of Caroline Island (Gilberts), No. 6569, taken by the Royal New Zealand Air Force, Aerial Plan No. 1036 9d-h, Dept. of Survey and Land Information, Wellington, New Zealand.

Sachet, M.-H. 1967. Coral islands as ecological laboratories. Micronesica 3:45-49.

______. 1983. Takapoto Atoll, Tuamotu Archipelago: terrestrial vegetation and flora. Atoll Res. Bull. 277:1-46.

______ & F. R. Fosberg. 1983. An ecological reconnaissance of Tetiaroa Atoll, Society Islands. Atoll Res. Bull. 275:1-28.

St. John, H. 1973. List and summary of the flowering plants in the Hawaiian islands. Pacific Tropical Botanical Garden Memoir No. 1, 519 pp.

______ & F. R. Fosberg. 1937. Vegetation of Flint Island, central Pacific. Bernice P. Bishop Museum, Occ. Papers, Honolulu, Hawaii, 12(24):3-4.

St. John, H. & W. R. Philipson. 1960. List of the flora of Oeno Atoll, Tuamotu Archipelago, south-central Pacific Ocean. Trans. Roy. Soc. New Zealand 88(3):401-403.

Schlanger, S. O., M. O. Garcia, B. H. Keating, J. J. Naughton, W. W. Sager, J. A. Haggerty, J. A. Philpotts, & R. A. Duncan. 1984. Geology and geochronology of the Line Islands. J. Geophys. Res. 89:11261-11272.

Schreiber, R. W. & E. A. Schreiber. 1984. Central Pacific seabirds and the El Niño Southern Oscillation: 1982 to 1983 perspectives. Science 225:713-716.

Scoffin, T. P. & D. R. Stoddart. 1983. Beachrock and intertidal cements, pp. 401-425, *in* Chemical sediments and geomorphology (eds. A. S. Goudie & K. Pye). Academic Press, London, 439 pp.

Seelye, C. J. 1950. Rainfall and its variability over the central and south-western Pacific. New Zealand J. of Sci. and Tech. [B] 32(2):11-24.

Shaw, H. K. A. 1952. On the distribution of *Pisonia grandis* R. Br. (Nyctaginaceae), with special reference to Malaysia. Kew Bull., pp. 87-97.

Sirenko, B. I. & V. M. Koltun. 1992. A study of the benthic communities of Caroline Atoll (Line Islands, Pacific Ocean), *in* Results of the First Joint US-USSR Central Pacific Expedition

(BERPAC), Autumn 1988. P. A. Nagel, ed. U.S. Fish and Wildlife Service, Washington, D.C. Chapter 1.4, pp. 166-169.

Smith, G. J. & Y. L. Volodkovich. 1988. Preliminary report on marine plastics: methods of collection and quantification. Unpublished ms., 31 October, 1988, *in* Soviet-American Joint Expedition III (1988), Appendix III. I, 21 pp.

Spencer, T. 1989. Tectonic and environmental histories in the Pitcairn Group, Palaeogene to present: reconstructions and speculations. Atoll Res. Bull. 322:1-21.

Spicer, R. A. & D. McC. Newbery. 1979. The terrestrial vegetation of an Indian Ocean coral island: Wilingili, Addu Atoll, Maldive Islands. I. Transect analysis of the vegetation. Atoll Res. Bull. 231:1-21.

Stevens, H. N. & G. F. Barwick. 1930. New light on the discovery of Australia as revealed by the journal of Captain Don Diego de Prado y Tovar, Hakluyt Society, Series II, No. 64. London, The Hakluyt Society.

Stoddart, D. R. 1976. Scientific importance and conservation of central Pacific Islands. Unpublished ms. 28 pp.

______ & F. R. Fosberg. 1972. Reef islands of Rarotonga with list of vascular plants. Atoll Res. Bull. 160:1-22.

Stoddart, D. R. & P. E. Gibbs. 1975. Almost-atoll of Aitutaki: reef studies in the Cook Islands, South Pacific. Atoll Res. Bull. 190:1-158.

Stoddart, D. R. & M.-H. Sachet. 1969. Reconnaissance geomorphology of Rangiroa Atoll, Tuamotu Archipelago, with list of vascular flora of Rangiroa. Atoll Res. Bull. 125:1-44.

Stoddart, D. R. & J. A. Steers. 1977. The nature and origin of coral reef islands, pp. 59-105, *in* Jones, O. A. & R. Endean. 1977. Biology and geology of coral reefs, Vol. IV. Academic Press, 337 pp.

Stoddart, D. R. & T. P. Scoffin. 1983. Phosphate rock on coral islands, pp. 369-399, *in* Goudie, A. S. & K. Pye, eds. Chemical sediments and geomorphology: precipitates and residue in the near-surface environment. Academic Press, London, pp. 369-400.

Stone, B. C. 1968. Notes on *Pandanus* in the Line Islands. Micronesica 4(1):85-93.

Stone, E. L. 1953. Summary of information on atoll soils. Atoll Res. Bull. 23(?):1-6.

Taylor, R. C. 1973. An atlas of Pacific islands rainfall. Hawaii Inst. of Geophysics, Data Report No. 25.

Teeb'aki, K. 1988. Report of visit to Caroline Atoll, Southern Line Islands. Wildlife Conservation Unit, Christmas Island, Republic of Kiribati. Unpub. ms. 12 pp.

Thaman, R. R. 1987. Plants of Kiribati: a listing and analysis of vernacular names. Atoll Res. Bull. 296:1-42.

Thomas, P. E. J., F. R. Fosberg, L. S. Hamilton, D. R. Herbst, J. O. Juvik, J. E. Maragos, J. J. Naughton, & C. F. Streck. 1989. Report of the Northern Marshall Islands natural diversity and protected areas survey, 7-24 September 1988. South Pacific Regional Environment Programme, Noumea, New Caledonia, and East-West Center, Honolulu, Hawaii. 133 pp.

Thomas, W. L. 1961. The variety of physical environments among Pacific islands, *in* Man's place in the island ecosystem (F. R. Fosberg, ed.). Third ed. 1970. Bishop Museum Press, 1965, 264 pp.

Tracey, J. I., Jr., P. E. Cloud & K. O. Emery. 1955. Conspicuous features of organic reefs. Atoll Res. Bull. 46. Wash. DC: National Research Council.

Trelease, W. 1884. Botany of Caroline Island, *in* Report of the eclipse expedition to Caroline Island May 1883. Nat. Acad. Sci. Mem. 2:87-90.

Tsyban, A. V. & G. J. Smith. 1988. Protocol of the Third Soviet-American Joint Expedition. Part II, The Central Pacific Ocean and South China Sea, aboard the R/V *Akademik Korolev*, 9 September - 31 October, 1988. Unpublished Report. 6 pp.

Upton, W. 1884. Meteorology of Caroline Island, *in* Report of the eclipse expedition to Caroline Island May 1883, pp. 41-86.

U.S. Dept. of Energy. 1987. *The natural history of Enewetak Atoll*, Vols. I and II, 228 and 348 pp., respectively. Office of Scientific and Technical Information, U.S. Dept. of Energy.

Wagner, W. L., D. R. Herbst & S. H. Sohmer. 1990. Manual of the flowering plants of Hawai'i, Vols. I and II. University of Hawaii Press and Bishop Museum Press, 1853 pp.

Walker, T. A. 1991. Pisonia Islands of the Great Barrier Reef, Pt. I. The Distribution, abundance and dispersal by seabirds of *Pisonia grandis*. Atoll Res. Bull. 350:1-23.

Ward, Capt. E. V. Sailing directions for the Line Islands, *in* Line Islands Expedition Report (1974), 89 pp. Gilbert and Ellice Islands Government (1974).

Wester, L. 1985. Checklist of the vascular plants of the Northern Line Islands. Atoll Res. Bull. 287:1-38.

Whitehead, D. R. & C. E. Jones. 1969. Small islands and the equilibrium theory of insular biogeography. Evolution 23:171-179. Lancaster, Pennsylvania.

Wiens, H. J. 1956. The geography of Kapingamarangi Atoll in the Eastern Carolines. Atoll Res. Bull. 48.

______. 1962. Atoll environment and ecology. Yale Univ. Press, New Haven and London, 532 pp.

Wilkes, C., U.S.N. 1845. Narrative of the United States exploring expedition during the years 1838, 1839, 1840, 1841, 1842. Phila, Lea & Blanchard. 5 Vols. and an atlas.

Yaldwyn, J. C. & K. Wodzicki. 1979. Systematics and ecology of the land crabs (Decapoda: Coenobitidae, Grapsidae, and Gecarcinidae) of the Tokelau Islands, Central Pacific. Atoll Res. Bull. 235:1-53.

Young, C. A. 1884. Introduction, *in* Report of the eclipse expedition to Caroline Island May 1883. Nat. Acad. Sci. Mem. 2:11-20.

Young, J. L. Ca. 1922. Notes on Flint, Caroline and Vostock Islands, *in* Memoranda re Tahitian business. S. R. Maxwell & Co., Ltd., Pacific Manuscripts Bureau, Research School of Pacific Studies, Australian National University, Canberra, A.C.T. PMB Manuscript No. 23, 1-18. Unpublished ms.

APPENDIX I

Reef Information for Navigators

We include this section because no accurate hydrological chart exists, and the *Pacific Islands Pilot* (Hydrographer of the Navy 1982) section for Caroline is incomplete. Arundel's 1883 map (Admiralty Chart No. 979, Fig. 4) is still used today.

Caroline is visible "from aloft" at about 23 km (Ward 1974). It has neither a deep pass, nor navigable channels into the lagoon, nor a ship anchorage beyond the reef. In 1873 a set of moorings was placed off the west coast of South Island for the convenience of guano ships, approximately "a mile north of the south-west point, in about 60 fathoms of water and some distance from the shore" (Arundel 1875). These are long gone, although small boats can still anchor within the close lee of South Island during normal trade winds. Today's ships, however, must drift well offshore after approaching the atoll from the west (Pl. 12).

Of special note is a possible extension of the perimeter reef south and southwest of Caroline. Arundel's map notes: "Reef reported to extend four cables from southeast point." This information probably originated in Findlay's South Pacific Directory, quoted by Holden (1884). Evidently the windward reef of South Island extends approximately 1.7 km from its southeast point. From here "this reef sends out two branches to a distance of 2.5 km, one toward the southeast, the other toward the southwest and is consequently dangerous to approach at night." Arundel's map does not include this bifurcation which, according to Findlay (1884), extends at least across the width of South Island. He also states that "a landing (not always safe) may be effected on the north side of the southwest bifurcation, described above." No trace of these submerged reefs is evident on the RNZAF aerial photos.

The "boat entrance" (Figs. 4, 50), a narrow nick in the outer leeward reef, marked by the stock and ring of an anchor and immediately to the west of South Island's northwest point, is not necessarily the easiest route to the lagoon. Landing is possible across the steep-to reef at many locations along the leeward reef; opposite the southern end of Ana-Ana is good.

Landing adjacent to the anchor is fairly straightforward in calm seas, especially when one becomes familiar with the crooked notch which narrowly pierces the outer reef. After negotiating a powerful backwash, one's boat is swept onto the shallow reef flats--liberally laced with chunks of jagged reef--which is exposed at low tide and barely covered at high tide. A swift current passes west out of the lagoon between South Island and Ana-Ana, sweeping over the reef at the notch. Only small craft with virtually no draft can effect the 500-m journey to South Island. Because the shallows are unchanneled and not navigable even at high tide, skiffs must be carefully hauled through the water to a sheltered landing spot adjacent to South's northwest point (Pl. 12).

An alternative landing method used by yachts in calm weather is via the "blind passage" (Sect. D, Fig. 50), between northeast South and Tridacna Islet. Despite the fact that the inner one-third of this narrow diverticulum is calm, the outer two-thirds are rough most of the time. Its channel leading to and from the open sea is particularly turbulent and should not be attempted without land-based assistance, and only at first light.

Landing is also possible across the reef flats off leeward Nake, but there is no boat passage into the lagoon. Ward (1974) states that at high water, light draught boats can land over the reef opposite the middle of the western side of South Island. This would be the only cross-reef landing which does not involve walking a boat across the uneven reef flats.

APPENDIX II

Weather Data, Caroline Atoll, 1989-1990

A. Wind Direction and Speed (mph), 1989

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	NNE 15	NW 18	E 25	E 12	E 20	E 15	E 25	E 20	-	NE 10	N 20	NE 8
2	NE 10	W 5 Variable	E 15	E 16	E 20	NE 18	SE 20	E 12	-	NE 12	N 15-17	NE 10
3	NE 10	NE 20	E 12	SE 14	S 15-20	E 18	E 20	SE 25	-	NE 15	NE 15	NW 20
4	NE 15	NE 15	E 12	SE 15	E 15	E 15	E 20	SE 20	-	NE 15	NE 12	NW 20
5	NE 20	NE 15	NE 15	E 12	NE 8	E 15	E 18	E 18	-	NE 12	E 12 big swells	NW 18
6	NE 20	NE 20		SE 10	NE 8	E 15	E 10	E 18	-	NE 12	E 10	N 10
7	NE 12	SE 18	E 12	E 14	NE 10	NE 25 E 10	-	E 12	-	NE 15	NE 12	NW 18
8	NE 12	E 15	calm	SE 10	E 10	NE 20	SE 12 squalls	NE 18	-	NE 15	calm	NW 18
9	NE 12	E 18	SE 10	E 20	E 15	NE 18	SE 20	E 12	-	NE 12	N 10	NE 10
10	NE 15	E 16	NW 10	E 20	E 15	E 15	SE 16	E 12	-	NE 10	NE 12	NE 10
11	NE 10	NE 16	calm	SE 25-E 10 squalls	E 15	NE 15 E 15	E 15	calm	-	NE 10	E 18	NE 5
12	NE 20	SE 14	E 10	W 14	E 15	E 15	E 12	E 12	-	NE 16	E 17	NE 12
13	NE 15	E 12	E 12	E 16	NE 16	NE 16	E 12	-	-	NE 11	E 14	NE 12
14	NE 15	E 10	NE 10-18	E 20	NE 16	NE 8	E 12	calm	-	ENE 10	E 10	NE 14
15	NE 15	NE 8	E 8	E 18	E 15	E 10	E 10	-	-	NE 10	calm	NE 14
16	NE 15	SE 8	E 12	E 18	E 22 squalls	E 10	NE 10	-	-	NE 12	calm	NE 15
17	NE 18	E 20	NE 15	E 18	E 25	E 15	E 10	-	-	NE 14	calm	NE 12
18	NE 12	E 12	E 8	E 18	NE 18	E 15 big swells	E 15	-	-	NE 15	N	NE 14
19	NE 12	E 12	E 10	E 18	NE 14	E 10	E 16	-	-	NE 13	NW 10	E 12
20	NE 18	E 12	E 10	E 18	NE 14	E 15	E 18	-	-	E 15	NW 15	E 10
21	NE 15	NE 10	SE 8	E 14	E 12	NE 20	E 20 squalls	-	-	E 16	N 16	E 10 big swells
22	NE 20	E 15	calm	E 14	E 12	E 10	E 15	-	-	NE 14	NE 14	E 12-NE 10
23	NE 18	thunder squalls	N 18 thunder	SE 14	SE 10	E 10	E 15	-	NE 20-30	E 20	NE 16	calm
24	NE 15	E 25	N 12	SE 14	SE 10-25	E 10	E 12	-	E 20-30	NE 15	NE 12	NE 15
25	NE 12	E 15	N 12	E 12	E 18	SE 17	E 10	-	E 20	NE 15	NE 12	NE 16
26	NE 12	E 15	N 10	E 10	NE 14	E 10	calm	-	E 20	NE 15	N 10	NE 15
27	NE 12	E 25	SE 10	NE 10	E 18	E 10	calm	-	NE 17	E 9	E 9	NE 15
28	NE 12	E 14	E 12	E 13	E 18	E 10	E 15-35	-	E 15	NE 10	E 8	NE 15
29	NE 15		E 14	E 18 big swells	E 15	E 18	E 15	-	N 10	NE 8	E 7	NE 12
30	NE 12		E 12	E 13	-	E 18	E 15	-	calm	calm	-	E 10
31	calm		E 18				SE 18	-		N 20		E 16

B. Rainfall, 1989-1990

Month/Year	Mean Monthly Rainfall (mm)	Mean Number of Rain Days
Jan '89	71.1	7
'90	177.8	22
Feb '89	160.0	14
'90	640.1	10
Mar '89	259.1	20
'90	215.9	14
Apr '89	190.5	16
'90	48.3	6
May '89	66.0	10
'90	325.1	8
Jun '89	48.3	11
'90	78.7	11
Jul '89	45.7	12
'90	68.6	8
Aug '89	35.6	12[a]
'90	109.2	14
Sep '89	50.8	3[b]
'90	81.3	6
Oct '89	73.7	11
'90	175.3	9[c]
Nov '89	78.7	7
'90	134.6	14
Dec '89	162.6	11
'90	154.9	9
Annual '89	1,242.1	134
'90	2,209.8	131

Source: Ron Falconer, Caroline Atoll (pers. comm.).
[a]Based on 16 days' data.
[b]Based on 9 days' data.
[c]Based on 18 days' data.

Plate 1. A 1988 dawn view of Caroline as seen from its leeward seas, very similar to that seen by the atoll's Western "discoverer," de Quiros, in 1606. Left to right: Motu Ana-Ana, Tridacna Islet, South Island. Open reef area in the foreground is the 1883 chart's "boat entrance."

Plate 2. A clearing on South Island from which the Solar Eclipse Party made their observations in 1883. Today the area is covered with dense *Cocos* forest (from Holden & Qualtrough 1884).

Plate 3. One of the 3 European-style houses that have ever been built on Caroline, drawn in 1883 (ibid.).

Plate 4. An artist's very free rendering of Caroline in 1883 (from Holden & Qualtrough 1884).

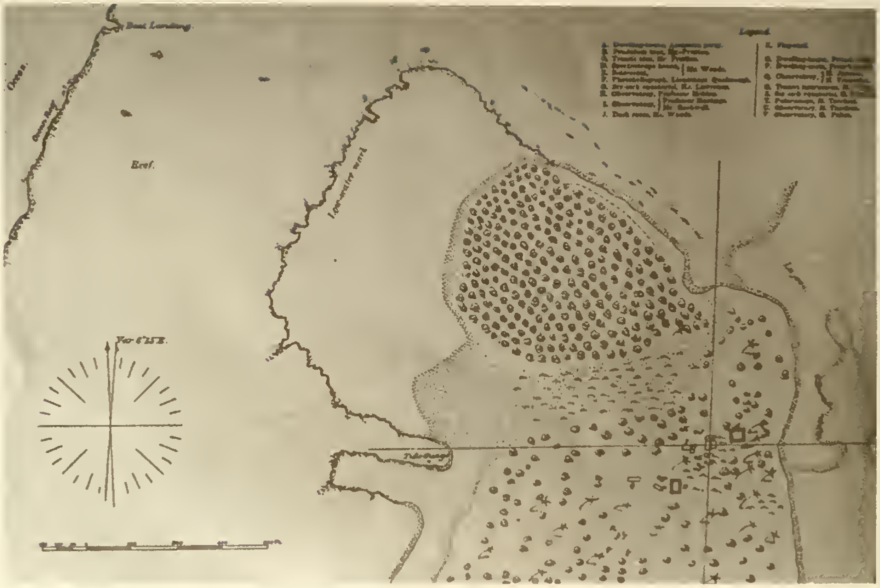


Plate 5. Map of the "settlement" on South Island, as drawn by the Solar Eclipse Party (ibid.).

Pl. 6a

Plate 6. Two lagoon views a century ago along the north coast of South Island (from Holden & Qualtrough 1884). Compare these drawings with Plate 23.

Pl. 6b

Plate 7a. Motu Ana-Ana, unnamed in 1883 (Holden & Qualtrough 1884) but appearing virtually identical then, as to today (Pl. 71).

Plate 7b. A large _Tournefortia_ tree along South Island's lagoon edge, 1883.

Plate 8. CBK in _Ipomoea macrantha_ thicket, dying _Cocos-Ipomoea_ forest, South Island.

Plate 9. "Rat City" base camp, southwest Long Island.

Plate 10. Black-tipped reef shark (*Carcharhinus melanopterus*), numerous and aggressive in Caroline's lagoon. Note the abundant sea cucumbers (*Ludwigothuria* sp.).

Plate 11. Laterally continuous, upraised older reefs of unknown age, southwest Nake. Note the wide reef flats.

Plate 12. Floating a small boat across the southwest reef flats in calm weather from the "boat entrance" to the "landing" on South Island. Note the wide reef flats. The *Akademik Korolev* drifts offshore.

Plate 13. Beach crest, sandy rubble, seaward moat and narrow reef flats off southeast Nake Island.

Plate 14. Extensive lagoon reef flats south of Arundel Islet on the windward side. Note the 5 Southern Leeward Islets in the distance.

Plate 15. An incipient motu, barely connected to Motu Mouakena's southern shore. See also Plate 62.

Plate 16. Successive ridges of coral rubble deposited by past storms, northeast Nake Island.

Plate 17. Channel between the 2 northern islets, Long and Nake. Note the mixed forest with *Cocos* and *Pandanus*, and filled-in upper lagoon.

Plate 18. Noddy Rock (0.02 ha), an emergent reef platform of unknown age along the windward reef flats. A northward view. Islet is completely awash during storms.

Plate 19. Windward beach, Long Island, showing wide rubble flats inland of the beach crest, rimmed by oceanic flotsam and jetsam.

Plate 20. Conglomerate platform, northwest point, South Island. Russian vessel *Akademik Korolev* drifts offshore and a lone *Suriana maritima* dots the blinding coral beach.

Plate 21. A large coconut crab (*Birgus latro*) shelters in a subterranean cavity in the *feo*. Some males were among the largest ever measured.

Plate 22. Sandy Inlet, a filled-in portion of the lagoon, extends its fishhook-shaped mudflat 300 m northward into Nake's landmass. Here grow the healthiest and most productive *Cocos* on Caroline. Note the Bristle-thighed Curlews in the foreground.

Plate 23. South Island's pure *Cocos* plantation, looking west along the lagoon. This extensive grove has now obliterated all traces of the former "settlement" (Pls. 2-6). Note the dead *Tournefortia* bush, killed by excessive shade.

Plate 24. Crystalline lagoon waters adjacent to Emerald Isle (Central Leeward Islets) are studded with submerged reefs and sandy channels.

Plate 25. A highly productive cross-lagoon reef of *Acropora* spp. corals and *Tridacna maxima* clam shells joins Tridacna Islet with Motu Kimoa. Sirenko & Koltun (in press) estimate 300,000 living *Tridacna*/km.

Plate 26. *Cordia* Forest (to 12.6 m tall), Pig Islet.

Plate 27. Sand, silt, rubble and hardpan mingle on the upper reaches of Long Island adjacent to the lagoon.

Plate 28. Caroline's sandiest beach flanks the lagoon shore of Shark Islet.

Plate 29. Sheltered bay, Brothers Islet. Raurau Islet lies across the lagoon. Note the sparse herb mat and silty shallow waters.

Plate 30. Narrow lagoon beach lined with *Tournefortia* scrub, Blackfin Islet (Central Leewards).

Plate 31. Recent sand additions to South Island's northeast point, partly covered with excellent natural herb mats and healthy *Suriana* scrub (right).

Plate 32. An old inter-islet channel (Tr. C, Long Island) filling in with herbs, *Tournefortia* scrub and *Cocos* in 1988, but smothered with fresh sand during the February storm of 1990 (see Pl. 33). Note the nesting Masked Boobies in middle right. A westerly view toward the lagoon.

Plate 33. The same area as Pl. 32, March 1990, 2 weeks after the severe cyclonic weather. The herb mats had been smothered with sand, and a large percentage of *Tournefortia*s were partly uprooted and defoliated. An easterly view, toward the windward ocean.

Plate 34. A clearing within the dying *Cocos-Ipomoea* forest, interior South Island. Note the prolific mats of *Boerhavia*, *Phymatosorus* and *Ipomoea*.

Plate 35. *Pandanus* forest, south Nake.

Plate 36. The north end wall of the ancient Tuamotuan *marae*, northwest Nake.

Plate 37. Mixed forest with *Cocos*, southwest Nake Island.

Plate 38. Orange, scarlet and green phalanges of *Pandanus* rest on a clump of *Portulaca*. The ubiquitous *Coenobita perlatus* forage on their stringy flesh.

Plate 39. Inner edge of lagoon, South Island, 1988. *Cocos* is progressively shading out the beach scrub with *Suriana maritima*.

Plate 40. Inner edge of lagoon, South Island, 1965, taken from approximately the same location as Plate 39. Note the greater extent of sand and *Suriana* coverage above high water than today, due to less encroachment and shading by the palms.

Plate 41. Heavy understory of *Achyranthes canescens*, *Boerhavia repens* and *Phymatosorus scolopendria* in a clearing adjacent to *Pisonia* forest, Pig Islet.

Plate 42. *Boerhavia* fruits on feathers and bill of a Great Frigatebird.

Plate 43. Inside a mature *Pisonia grandis* forest, interior Nake Island. Note the barren, dark aspect, virtually devoid of undergrowth except root suckers. Appearing virgin, this quality stand is possibly only 60-70 years old.

Plate 44. Fringe of *Suriana*, northeast point, South Island.

Plate 45. Well-developed natural herb mat, primarily *Heliotropium anomalum* and *Lepturus repens*. Scattered *Tournefortia* forms a "savannah." Here sandy soils support a lush *Heliotropium* cover, northeast point, South Island.

Plate 46. Detail of *Heliotropium anomalum*, Skull Islet, with remains of the first evidence of tropicbirds on Caroline.

Plate 47. *Tournefortia* scrub, fringed by a natural herb mat, and occupied by a colony of Sooty Terns. An old inter-islet channel, northern Long Island. Note the nesting Red-footed Boobies.

Plate 48. *Tournefortia-Morinda* forest, with nesting Brown Noddies, interior Tridacna Islet. This is secondary growth, as this motu was heavily planted with coconuts in the 1920s.

Plate 49. Skull Islet (0.02 ha), with Brown Noddy terns, looking east to the windward reef.

Plate 50. Mature *Pisonia grandis* canopy with incubating Black Noddies and a White Tern, Pig Islet. With a canopy height of 21 m, this was one of the most majestic interior forests on the atoll, although it is only approximately 65 years old.

Plate 51. Azure Isle (Central Leewards)--an example of a motu containing a single *Pisonia* tree. Note the narrow, but still shark-patrolled, inter-islet channel. View east from Motu Nautonga, with Brothers Islet in the distance.

Plate 52. Caroline's sole clearing, with now-abandoned Tahitian-style huts, Motu Ana-Ana.

Plate 53. Piles of fibrous shavings--coconut crab sign.

Plate 54. Beachrock at the lower, windward tip of Long Island, typically found at low water.

Plate 55. Windward Islets nos. 5-9 (left to right): North Pig, Pig, Skull (not visible), North Brothers and Brothers.

Plate 56. Arundel Islet (foreground), looking south-southwest across Tridacna Islet to South Island. Distant Motu Ana-Ana lies on the right.

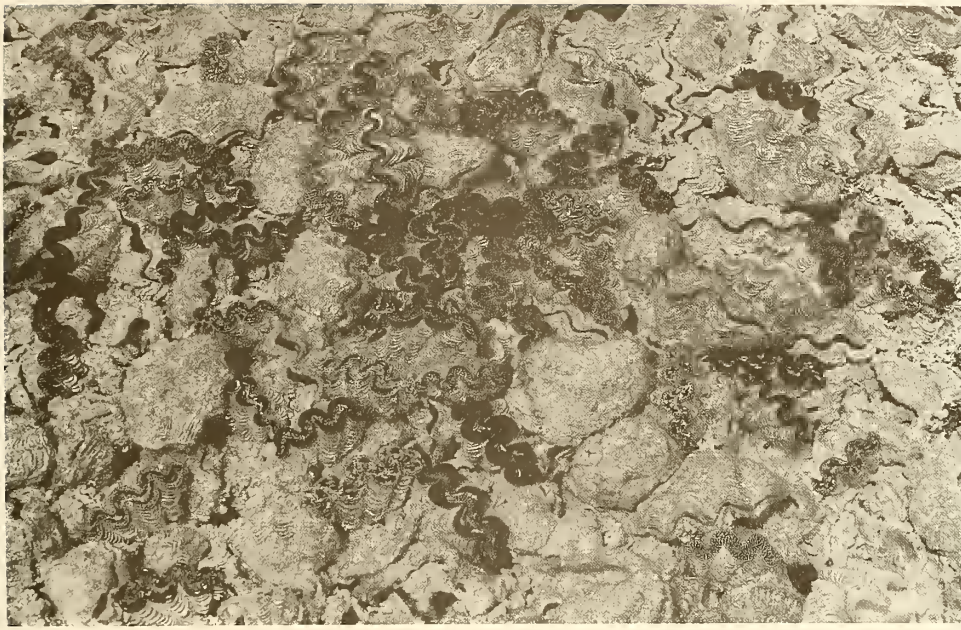


Plate 57. Detail, *Tridacna maxima* reefs, lagoonside of Tridacna Islet. This dense aggregation of giant clams amassed up to 80 per square meter.

Plate 58. View of Pandanus Islet (center) west down the channel separating Nake (right) and Long (left) Islands.

Plate 59. Danger Islet (South Nake no. 2), looking due west across the shallow upper lagoon from Long Island.

Plate 60. South Nake Islets nos. 3-6 (right to left): Booby, Coral, Lone Palm, and Kota. Westerly view across the shallow upper lagoon from Long Island.

Plate 61. Lone Palm Islet (South Nake no. 5): a southerly view from the shallow tidal flats of Coral Islet.

Plate 62. Motu Mouakena (South Nake no. 7), with connected cay. A westerly view from the upper lagoon. Compare with Plate 15.

Plate 63. North end, Motu Mannikiba "Seabird Islet" (Central Leewards no. 1) showing mounds of *Pisonia* and a closer *Cocos* grove. Note the circular patch reef at right.

Plate 64. Motu Mannikiba, looking east along Transect 1. Natural herb mats on coral rubble give way to *Tournefortia*, then a distant patch of *Pisonia*. The extensive interior forests of this motu were felled 70 years ago to support a well-maintained coconut nursery. Forest recovery has been much slower than on islets where the *Cocos* was not managed as intensively.

Plate 65. Motu Mannikiba, looking east along Transect 2. Low *Tournefortia* scrub covers a coarse rubbly substrate, probably a former inter-islet channel.

Plate 66. Mixed *Pandanus-Tournefortia* forest, interior Emerald Isle.

Plate 67. Emerald Isle, looking west across the open lagoonside scrub and hardpan to a densely vegetated interior.

Plate 68. Shark Islet (Central Leewards no. 5): view across patch reefs to a sandy beach.

Plate 69. Southern Leeward Islets nos. 1-5 (right to left): Motus Raurau and Eitei, Pisonia Islet, Motus Kimoa and Ana-Ana. View northwest from Tridacna Islet.

Plate 70. View of Motu Kimoa ("Rat Islet") from Pisonia Islet. Its central forest, typical of the Southern Leewards, is a mixture of *Pisonia* and *Cordia*.

Plate 71. Motu Ana-Ana ("Anne's Islet"): a view with giant ray, from the shallows of the lagoon's southern end adjacent to South Island. Note the similarity to Plate 7, dating from 1883.

Plate 72. The "blind passage" (non-functional *hoa*), looking west from its inner end across the shallow reef flats to the lower lagoon.

ATOLL RESEARCH BULLETIN

NO. 398

PART II. SEABIRDS, OTHER TERRESTRIAL ANIMALS, AND CONSERVATION

BY

CAMERON B. KEPLER, ANGELA K. KEPLER, AND DAVID H. ELLIS

ISSUED BY
NATIONAL MUSEUM OF NATURAL HISTORY
SMITHSONIAN INSTITUTION
WASHINGTON, D.C., U.S.A.
FEBRUARY 1994

Table of Contents

List of Figures

List of Plates

List of Tables

PART II. SEABIRDS, OTHER TERRESTRIAL ANIMALS, AND CONSERVATION

BY

CAMERON B. KEPLER[1], ANGELA K. KEPLER[2], AND DAVID H. ELLIS[3]

ABSTRACT

Approximately 1,000,000 seabirds of 11 species bred on Caroline Atoll between September 1988 and June 1990. The most abundant species, with over 900,000 birds, was the Sooty Tern. Two species (Red-tailed Tropicbird, Blue-gray Noddy) are reported breeding for the first time. The known seabird fauna now includes one tropicbird, 3 boobies, 2 frigatebirds, and 5 terns.

Seabird distribution on Caroline is determined by the distribution of plant communities and nonvegetated substrates, the prevailing trade winds, and to a lesser extent, rats and coconut crabs. Red-tailed Tropicbirds and ground-nesting Brown Noddies nested on small islets relatively free of rats and coconut crabs. Masked and Brown Boobies preferred exposed windward beaches, primarily on Long and Nake. The tree-nesting Red-footed Booby and frigatebirds attained their highest nest densities in areas with reduced wind speed. Black Noddies were found in dense colonies, generally high in pisonia trees, while the uncommon Blue-gray Noddies nested solitarily on open coral rubble. Sooty Terns nested in large colonies, generally near or under relatively open *Tournefortia* scrub, but also in open areas under *Tournefortia* and closed-canopy *Pisonia* forests. Not all sites were utilized annually. Tree-nesting Brown Noddies and White Terns, found throughout the native forests, were the only species utilizing anthropogenic forests. The lowest seabird population densities were found in the disturbed forests on South and southwest Nake, and no seabirds nested on inhabited Motu Ana-Ana.

About 300 Bristle-thighed Curlews overwinter on Caroline, foraging in all terrestrial habitats, including *Pisonia* and disintegrating *Cocos-Ipomoea* forests. We extended the known winter range of the Long-tailed Cuckoo by discovering a small population on the atoll, the first record for the Southern Line Islands.

The known lizard fauna was increased from 3 to 6 species. Approximately 2,200 coconut crabs inhabited 12 islets on Caroline. Although primarily associated with *Cocos*, we also found them in *Pisonia* and *Tournefortia*. Pacific green turtles breed in small numbers; we found the first known nests (old) in 1990. Polynesian rats are abundant, and Pacific bottlenose dolphins were seen close to the windward side in 1990.

---

1 National Biological Survey, School of Forest Resources, The University of Georgia, Athens, Georgia, 30602, USA

2 400 Snapfinger Drive, Athens, Georgia, 30605, USA

3 National Biological Survey, Patuxent Wildlife Research Center, Laurel, Maryland, 20708, USA

Manuscript received 8 April 1991; revised 26 October 1993

The populations of seabirds and coconut crabs on Caroline Atoll are of national and international importance. The Black Noddy (17,000 birds) and White Tern (8,000 birds) populations are the largest in the Republic of Kiribati, while the Red-footed Booby population (7,000 birds) is one of the largest in the world.

Caroline's conservation attributes are numerous: large, varied seabird populations, wintering grounds for several species of migratory shorebirds and the Long-tailed Cuckoo, plant ecosystems of national and international importance (lushly wooded motus with significant groves of *Pisonia grandis*, *Cordia subcordata*, *Tournefortia argentea*), virtually pristine coral reef ecosystems exceedingly rich in giant clams (*Tridacna maxima*), a coconut crab population of Pacific-wide importance, ancient Tuamotuan *marae* (religious sites), and a breeding site for green turtles. The marine ecosystems, terrestrial biota, and geology of its 39 motus of varied size, 22 of which are pristine or near-pristine, provide prime outdoor ecological laboratories for numerous areas of research. These qualities, plus its exceptionally clear, essentially unpolluted lagoon, and its relative lack of disturbance, render it worthy of permanent protection.

A. HISTORY OF ORNITHOLOGICAL STUDIES

"There were a great quantity of sea birds of several kinds, and so importunate that they seemed to want to attack the men" (Markham 1904). So wrote the Portuguese explorer de Quiros on 21 February 1601, the first European to see Caroline Atoll.

Precisely which seabirds were present remained a mystery until the island was surveyed 364 years later by the Pacific Ocean Biological Survey Program (POBSP) (Clapp & Sibley 1971a). Prior to that visit, accounts of the avifauna had been incomplete. Bennett (1840) described Red-footed Boobies, a frigatebird (species ?), White Terns, Bristle-thighed Curlews, tattlers, and "a great number of small pigeons" with white heads (certainly noddy terns, perhaps both *A. minutus* and *A. stolidus*). The "shoal birds" that greeted him were probably Sooty Terns. His most unusual contribution was mention of a possible flightless rail: "The other birds of the coast were a kind resembling a coot..." (p. 372).

The 1883 Solar Eclipse Party (Pt. I, Sect. B) published a few sketchy notes, adding Lesser Golden-Plover, Reef Heron, and Masked Booby ("gannet") to the bird list. Of dubious identity were 2 species of "seagull" and a "snipe" (Dixon 1884). Holden, one of the astronomers, heard "the notes of a singing bird," which prompted us to add mist nets to our equipment in the hopes of capturing an *Acrocephalus* warbler. This resulted in our discovery of the Long-tailed Cuckoo (Ellis et al. 1990) and piqued our curiosity about what Holden might really have heard.

The POBSP expedition spent 3 days on Caroline in June 1965. They found 10 species of seabirds (9 breeders), 4 migrant shorebirds, and a Reef Heron (Clapp & Sibley 1971a), providing rough population estimates for each species. This work laid the foundation for later expeditions. Brief visits to Caroline by the Kiribati government in 1974 (Gilbert & Ellice Islands Government 1974, Vickers 1974) and Roger Perry in 1977 (Perry 1974, Garnett 1983) added no further information.

The 1988 expedition to Caroline was longer and more extensive than all former visits. We found 3 new island records: a breeding seabird (Red-tailed Tropicbird), a shorebird (Sanderling), and a migratory land bird (Long-tailed Cuckoo), and mapped islet-by-islet distributions for each species. Our population estimates, calculated from numerous transect surveys, aerial photographs, and detailed vegetation analysis, indicate that Caroline's avifauna is far more important than had previously been suspected (King 1973, Garnett 1983). In March and May 1990, the ICBP 1990 Line and Phoenix Islands Expedition (Pt. I, Sect. C), of which AKK was co-leader, filled in minor gaps in our knowledge. Seven-year-old Alexandre Falconer, then living on Caroline, added another breeding seabird, the Blue-gray Noddy, in summer 1990.

B. METHODS

From 22-29 September 1988, C. B. Kepler, A. K. Kepler, D. H. Ellis, and K. Teeb'aki surveyed all of Caroline's 39 islets except North Arundel Islet, naming most of them (Fig. 1; see also Pt. I, Sect. C). We established 50 linear transects, extending 13,300 m x 30 m, laid out to ensure that at least 5% of each islet was sampled for birds and plants (see Pt. I, Sect. C and Fig. 9). Sampling was increased with 19,300 m of perimeter surveys along the windward and leeward coasts of 21 islets (Pt. I, Fig. 9). On Noddy Rock, Skull, Atibu, Bo'sun Bird, Coral, Reef-flat, and Fishball (Fig. 1) we made total counts of the breeding seabirds. All surveys were conducted during daylight hours. Some incidental data have been added from the 1990 ICBP expedition.

<u>Distribution and habitat preference</u>: We described 7 major plant communities on Caroline Atoll (Pt. I). With the use of aerial photos and the transect data, we mapped the communities found on each islet. Bird distribution was determined and plotted using these islet vegetation maps. If a species nested within a particular plant community, it was plotted on the distribution maps as occurring throughout that community unless determined otherwise.

<u>Population sizes and breeding phenology</u>: We measured transect distances for each islet using a hip-chain and biodegradable cotton thread. We recorded all birds seen within the 30-m-wide strips; transect width was estimated visually. We assigned birds to one of several mutually exclusive categories: adults present, adults on territory, adults on nests (contents unknown), eggs, naked chicks, downy chicks, chicks with remiges erupting, chicks with scapular feathers, or chicks in juvenile plumage. We created a range of possible laying dates for each egg and

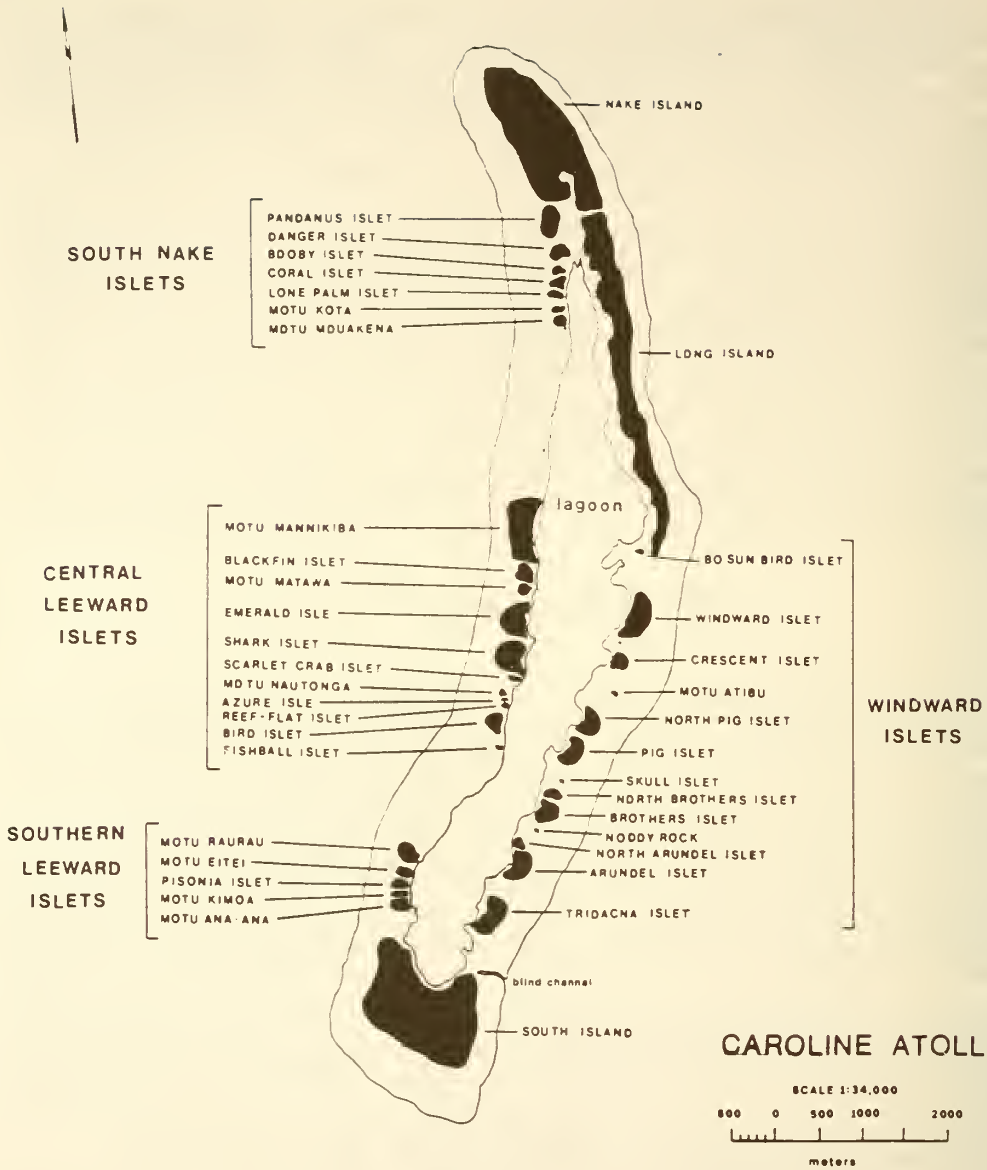


Figure 1. Caroline Atoll, Republic of Kiribati, with newly-named islets.

chick using known growth parameters for each species (C. Kepler 1978, Kepler & Kepler 1978). This enabled us not only to estimate seabird populations, but also to determine and plot a rough breeding phenology for each species (Figs. 3, 5, 7, 9, 10, 12). In these figures, the height of the bar for each category ("downy," "scapulars," etc.) represents the number of nests found or estimated with that development stage in September 1988. The bar width represents the approximate time span over which eggs could have been laid to produce that stage, while the "no. days" is a count back from the survey dates to accommodate growth and development that had occurred. Thus, while each figure shows what breeding stages we found, we extend those nests back in time to show roughly when they would have begun. The number of clutches begun per day is determined by dividing the number of nests per stage by the time span in days over which those eggs were laid.

Sooty Terns nested in dense colonies. Each colony was mapped, and its total size (m^2) was calculated. A minimum of 10 plots (3 m x 3 m or 3 m x 6 m), within which all eggs and chicks were counted, were randomly located along a compass line in each colony. The population size of each colony was estimated from these plot densities.

Mist nets: We operated 4 ATX 4-shelf 36 mm mesh mist nets (2.6 x 12 m) for 43.5 net hours, according to the following schedule: 14.5 net hours (daylight) beneath a 10-15 m *Cocos* canopy on South, 27.5 net hours (day and night) in *Pisonia-Cocos* interface (12 m tall) near Transect 10 on Long, and 1.5 net hours in *Pisonia-Tournefortia* within a 4-6 m canopy on Transect 4, Long. One cuckoo was collected (USNM 607191).

Collecting other vertebrates: Lizards that were active and conspicuous were collected at base camps on South and Long, either by hand or with a blowgun firing steel darts. No attempt was made to search for reptiles under coral, litter, or in other concealed locations. Rats were collected with a blowgun or snap traps baited with coconut, the former proving far more effective because most traps were sprung by hermit crabs. We preserved all specimens in formalin and sent them to the U.S. National Museum.

C. SEABIRD SPECIES ACCOUNTS

Eleven species of seabirds occur at Caroline, most of which breed in large numbers. They include one tropicbird, 3 boobies, 2 frigatebirds, and 5 terns.

RED-TAILED TROPICBIRD (*Phaethon rubricauda*) Figs. 2, 3; Pl. 1

Red-tailed Tropicbirds breed at widely scattered locations throughout the tropical Pacific and Indian Oceans. In the Line Group, they nest from Palmyra south to Starbuck (Perry 1980), with a large population (8,500 birds) on Christmas Island (Clapp 1967). Prior to our expedition it was unrecorded from Caroline, Vostok, or Flint.

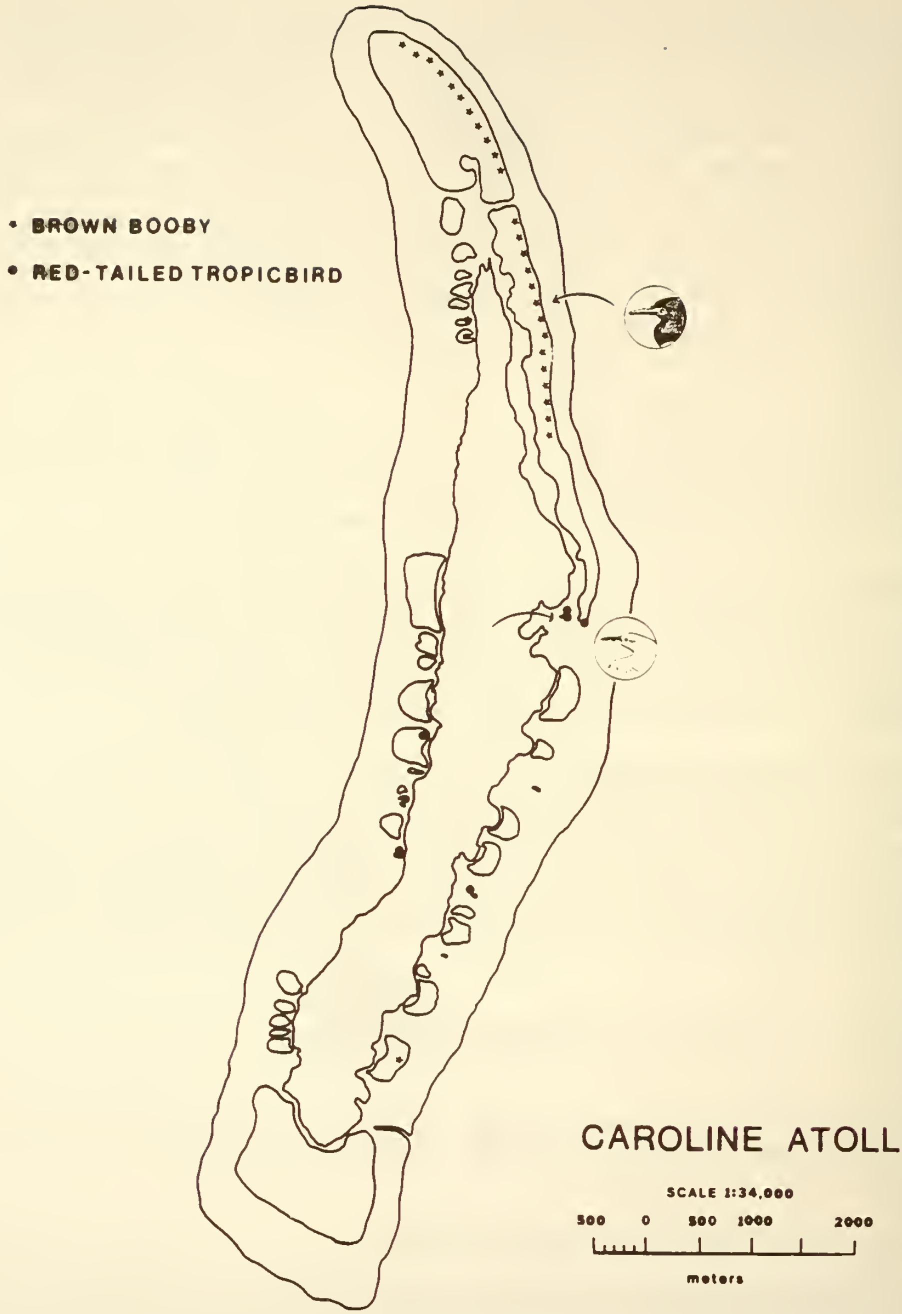


Figure 2. Distribution map of breeding Red-tailed Tropicbirds and Brown Boobies on Caroline Atoll, September 1988. In this and the following distribution maps, arrows indicate concentrations of breeding birds.

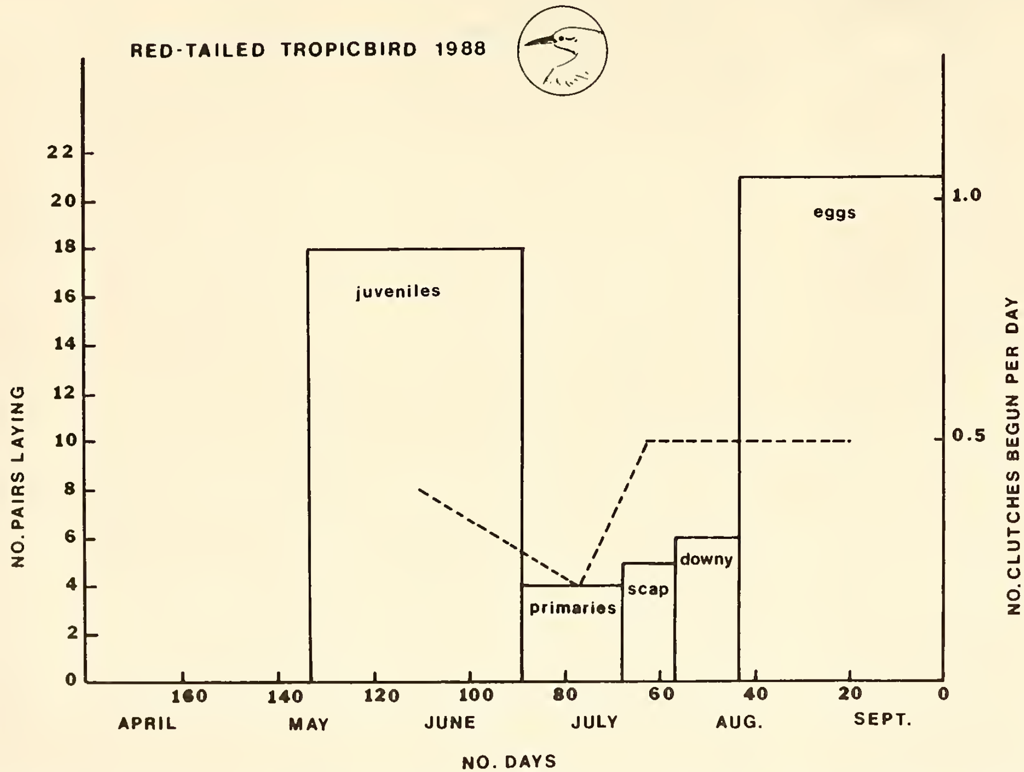


Figure 3. Approximate laying dates for Red-tailed Tropicbird nests found on Caroline Atoll in September 1988. In this and the following similar figures the numbers of nests begun during a given time period (bars) were determined by tallying each nest into one of several age classes (bar labels): bar widths indicate length in days for each class. The dotted line connects mean number of surviving clutches begun per day for each class. For example, a juvenile found in September began its egg stage in the previous May or June. The number of days are counted backwards from field observations.

<u>Distribution and habitat preference</u>: Our first indication that Red-tailed Tropicbirds nested on Caroline was the discovery of a skull, tail feather, and broken egg (Pt. I, Pl. 46) under a small *Tournefortia* bush on a previously unnamed islet between Pig and North Brothers Islets. We named this sparsely vegetated collection of rubble "Skull Islet" (Pt. I, Pls. 46, 49). We later found 47 nests on another islet, naming it Bo'sun Bird (Fig. 1) after the species' common name.

All nests were located under relatively open *Tournefortia* scrub less than 3 m tall in open, windy locations, with the majority (91%) on small islets (0.24-0.86 ha). All nests were under shrubs with few stems within a 0.5 m^2 nest space, and most had peripheral cover on the sides of the shrubs, both important factors in nest-site selection (Clark, Ricklefs, & Schreiber 1983). All nests were in areas relatively free of Polynesian rats (*Rattus exulans*) and coconut crabs (*Birgus latro*): five nests on Long were within 50 m of the island's south point.

There are large populations of Polynesian rats and coconut crabs on Caroline's bigger, more wooded islets. This rat, though basically vegetarian, is an effective seabird predator (C. Kepler 1967, Norman 1975) that in some years has taken 65% of the Red-tailed Tropicbird eggs and 100% of the chicks on Kure Atoll (Fleet 1972). Coconut crabs are also known bird predators (Helfman 1979, Reese 1987): on Caroline in 1965 they preyed upon Sooty Terns (Clapp & Sibley 1971a), and in 1990 AKK photographed the aftermath of predation or scavenging on at least one species of tern on Brothers Islet. It may be no accident that tropicbirds on Caroline occur only on small, relatively open islets that harbor few, if any, rats and crabs, and the southern tip of Long Island, where predator densities are low. We saw no rats on Bo'sun Bird Islet. Although rats could swim the 165 m to the islet, the nearly continuous presence of black-tipped reef sharks (Pt. I, Pl. 10) in the channels surrounding the islet provides protection to its nesting tropicbirds.

<u>Numbers</u>: In September 1988, we found 56 active nests on 5 islets (Fig. 2, Table 1) and estimated a minimum population of 60 pairs. The May 1990 expedition found 130 nests on Bo'sun Bird; our revised estimate for Caroline is approximately 300 birds. Bo'sun Bird Islet was surveyed by POBSP in June 1965, and no tropicbirds were located on the ground or in the air (F. Sibley, pers. comm.). It is unlikely that Red-tailed Tropicbirds were present but overlooked at that time, suggesting that they have colonized the atoll only recently. The Caroline population is now the second largest colony known from the Line Group, and Caroline is only one of 5 islands in the archipelago where Red-tailed Tropicbirds are known to breed.

<u>Phenology</u>: Of the 56 nests found in 1988, 54 contained eggs or chicks (Table 2). The 33 chicks were divided into 4 age classes (Fleet 1974, Diamond 1975a) which, together with the 21 eggs, provided an indication of laying phenology for 140 days prior to our arrival (Fig. 3). Eggs in surviving nests had been laid at a fairly even rate from early May (possibly starting earlier) through September. The finding of only 2 additional pairs on territory, and only one courtship flight, indicated

Table 1. Estimated number of breeding seabird pairs on Caroline Atoll, September 1988.

Location	Red-tailed Tropicbird	Masked Booby	Brown Booby	Red-footed Booby	Great Frigatebird	Lesser Frigatebird	Sooty Tern	Brown Noddy	Black Noddy	Blue-gray Noddy	White Tern
Nake	-	105	1	496	522	56	-	390	814	-	1,094
Long	5	69	12	659	808	-	179,800	207	986	-	751
Windward Islets											
Bo'sun Bird	47	-	-	-	-	-	8,400	10	-	-	6
Windward	-	-	-	163	207	-	-	20	28	-	134
Crescent	-	-	-	28	5	-	-	36	60	-	8
Atibu	-	-	-	-	-	-	-	-	-	-	-
North Pig	-	-	-	31	17	-	-	76	3,194	-	110
Pig	-	-	-	14	118	-	-	82	1,928	-	164
Skull	-	-	-	-	-	-	-	-	-	-	-
North Brothers	-	-	-	25	9	-	-	23	40	-	69
Brothers	-	-	-	25	-	-	-	8	15	-	50
Noddy Rock	-	-	-	-	-	-	-	80	-	-	-
North Arundel	-	-	-	*	*	-	-	-	-	-	*
Arundel	-	-	-	37	*	-	-	11	249	-	227
Tridacna	-	-	1	111	-	-	-	11	230	-	396
South	-	-	-	0	-	-	-	163	-	-	381
South Nake Islets											
Pandanus	-	2	-	32	26	-	-	26	-	-	52
Danger	-	-	-	139	-	-	-	33	33	-	37
Booby	-	7	-	52	-	-	-	2	1	-	6
Coral	-	1	-	28	2	-	-	6	-	-	15
Lone Palm	-	2	-	48	-	-	-	-	-	-	9
Kota	-	-	1	12	1	-	-	-	-	-	3
Mouakena	-	3	-	8	-	-	-	-	-	-	-
Central Leeward Islets											
Mannikiba	-	-	-	184	287	-	-	161	176	-	195
Blackfin	-	-	-	*	4	-	-	37	-	-	11
Matawa	-	-	-	5	1	-	-	3	-	-	13
Emerald	1	-	-	3	230	-	-	7	150	-	83
Shark	-	-	-	*	118	-	-	37	125	-	44
Scarlet Crab	-	-	-	-	-	-	-	1	-	-	2
Nautonga	-	-	-	11	2	-	-	7	32	-	10
Azure	-	-	-	7	2	-	-	-	-	-	2
Reef-Flat	-	-	-	-	-	-	-	-	-	-	-
Bird	-	-	-	29	6	-	-	42	329	-	48
Fishball	3	-	-	-	-	-	*	5	-	-	-
Southern Leeward Islets											
Raurau	-	-	-	10	31	-	-	1	-	-	2
Eitei	-	-	-	17	14	-	-	6	-	*	18
Pisonia	-	-	-	26	14	-	-	-	-	-	10
Kimoa	-	-	-	21	3	-	-	-	2	-	7
Ana-Ana	-	-	-	0	-	-	-	-	-	-	-
Total Estimated Pairs	56(+1)	189	15	2,221	2,427	56	188,200	1,491	8,392	-	3,957

* Breeding confirmed in 1989 or 1990.

Table 2. Stages in the breeding cycle of the Red-tailed Tropicbird, Caroline Atoll, 27-29 September 1988 (ages after Stonehouse 1962).

Nest Stage:	Juv.	Remiges	Scapulars	Downy	Egg	Pairs on Territory
Approximate Age in Days From Laying:	90-133	69-89	58-68	44-57	0-43	-
No. Nests:	18	4	5	6	21	2

that laying was ending. On 24 May 1990, many nests contained eggs and downy chicks (75% nests with chicks) and pairs were still courting.

On Christmas Island, peak laying generally occurs from June to October (Schreiber & Ashmole 1970), later than those parts of the 1988 and 1990 breeding seasons we observed on Caroline.

MASKED BOOBY (*Sula dactylatra*) Figs. 4, 5; Pl. 2

The Masked Booby is widely distributed in the Atlantic, Indian, and Pacific Oceans. Clapp (1967) estimated that 19,100 Masked Boobies bred in the Line and Phoenix Islands, with about 13,000 of them in the Line Islands, mostly (ca. 9,000) on Jarvis.

<u>Distribution and habitat preference</u>: Eighty-four percent of Masked Booby nests (159) were on the windward, rubbly shores of Long and Nake Islands, extending to the north end of the atoll. Fifteen additional nests were scattered along the lagoon edges of 5 South Nake Islets (Table 1). Nests consisted of bare scrapes with exposed sand, usually within a sparse ground cover of *Portulaca* and *Heliotropium* (Pl. 2). Over half the nests were amassed in one open colony on Nake that extended nearly 1,000 m, beginning approximately 150 m south of Transect 2 and extending about 50 m north of Transect 4 (Pt. I, Fig. 8). Here a nearly unbroken *Heliotropium* mat 30-80 m wide, with patches of *Tournefortia*, occupied the area between the leading edge of the *Tournefortia* scrub and the beach crest. Nests were 20-30 m apart in the densest section (near Tr. 3). All nests were exposed to the sun, unlike those of the Brown Boobies. Some adults and juveniles roosted under the scrub; guano deposits indicated regular occupancy.

A loose group of 7 breeding pairs was scattered on a broad plain of low herbs along a partially filled old interislet channel 370 m south of the north end of Long Island (Tr. C, Pt. I, Figs. 8, 40). Four more pairs nested in coral rubble along the channel separating Nake and Long,

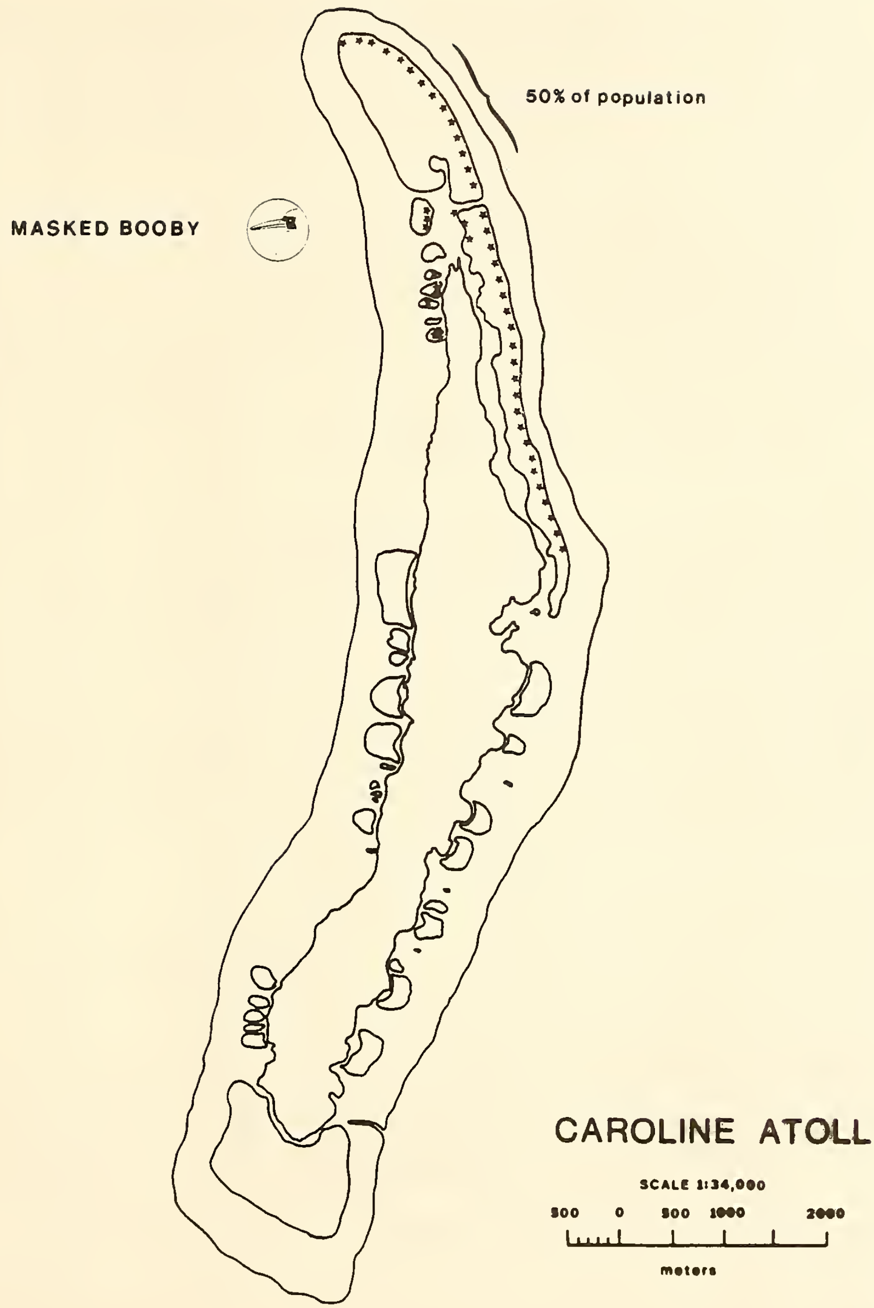


Figure 4. Distribution map of breeding Masked Boobies on Caroline Atoll, September 1988.

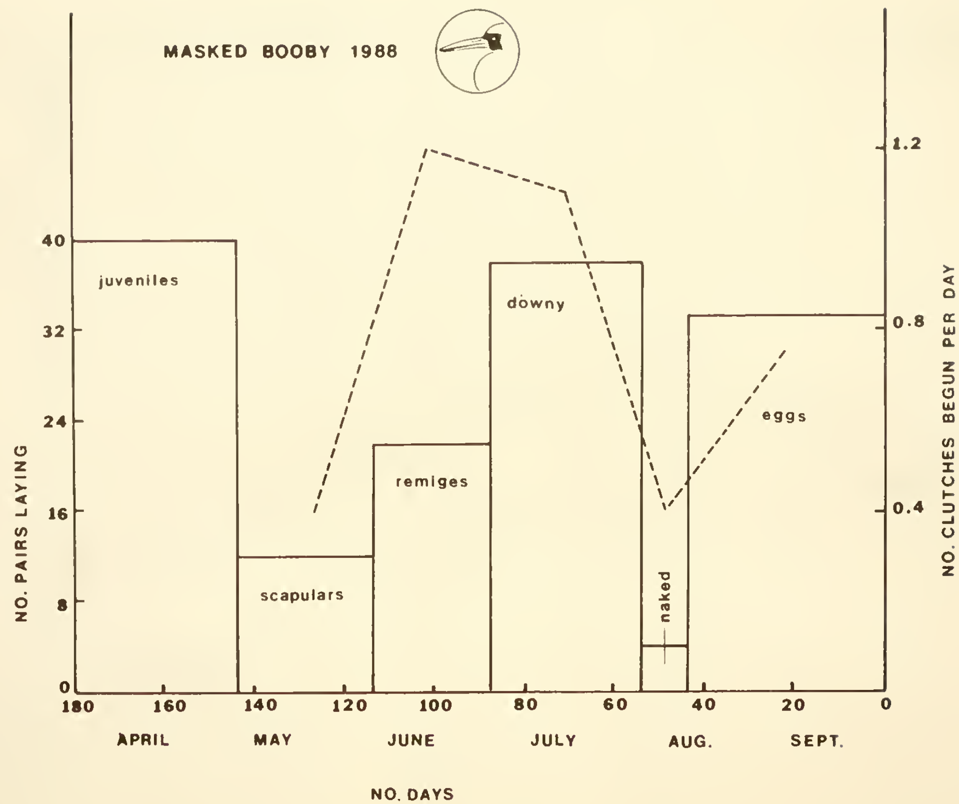


Figure 5. Approximate laying dates for Masked Booby nests found on Caroline Atoll in September 1988. See Fig. 3 for explanation.

one pair with a downy young only 2-3 cm above high-tide flow on an "islet" between fingers of the channel, a precarious location where nesting surely must fail in stormy periods. No birds were seen there in March and May 1990, following a severe storm in February 1990. Four pairs nested singly along a leeward 1,000 m stretch of lagoon shore on the northern end of Long (Fig. 4); hardpan was the primary substrate.

Numbers: In September 1988 we found 189 Masked Booby pairs (Table 3), including those on territory (with or without nest scrapes) and juveniles (with or without attending adults). We found no "clubs" of nonbreeding birds. We covered most of the habitat favored by this species except the northern 300 m of Nake Island; in 1990 a few scattered pairs nested there. Our population estimate, including pairs we might have missed, was approximately 200 breeding pairs. Other population estimates were "ca. 10" birds (Clapp & Sibley 1971a) and 50 ± 15% (Grossman & Grossman 1974). In 1965 POBSP biologists (F. Sibley, pers. comm.) surveyed all locations where we found breeding pairs. Thus, 200 pairs represents a major increase in the population on Caroline Atoll.

Phenology: In June 1965 only 4 Masked Booby nests containing eggs were found (Clapp & Sibley 1971a), indicating that nesting began in May or June. On 9-10 September 1974, Grossman & Grossman counted 23 nests containing "eggs and nestlings" on windward Long and part of Nake. We found nests in all stages in September 1988 (Table 3, Fig. 5). The large age class in April may include some juveniles that could fly (i.e. were older than 180 days). We may have undercounted naked chicks, not wishing to expose them to the sun by frightening the brooding adult. Laying began in April or earlier, peaked in June and July (Fig. 5), and continued until our survey in late September. The 34 pairs on territory, many with nest scrapes (Table 3), indicated that laying was still in progress and would continue into October.

Table 3. Stages in the breeding cycle of the boobies of Caroline Atoll, 21-29 September 1988.

	Nest stage[1]/Approximate age in days from laying							
Species	Flying Juv.	Juv.	Scapulars	Remiges	Downy	Naked	Eggs	Pairs on Territory
Masked	>164	145-164	115-144	89-114	55-88	45-54	0-44	
Brown	>164	144-164	114-144	88-114	54-88	44-54	0-44	
Red-footed	-	>150	111-150	75-110	54-74	45-53	0-45	
	No. nests in each stage							
Masked	-	40	12	22	38	4	33	34
Brown	1	-	-	-	-	-	3	8
Red-footed	many	-	-	-	29	-	919	1,270

[1] For descriptions of nest stages see C. B. Kepler (1978).

In March 1990, 31 pairs were on territory or were attending nests, eggs, or older chicks, indicating that a new breeding season was underway as the previous season was ending. By May 1990 there were 63 nests, mostly with eggs, and there were no older chicks. Thus, the 1990 season augments the 1988 data and suggests an annual cycle with egg laying beginning slowly in February and March, peaking in June and July, and declining to a low ebb from December to February.

The large number of fledged juveniles and nests with older chicks, in both September 1988 and in March 1990, indicated that the 1988 and 1989 breeding seasons were very successful. It also suggested that potential predators (rats and coconut crabs) posed little hazard to this hardy species.

BROWN BOOBY (*Sula leucogaster*) Fig. 2

This widely distributed pantropical species has an estimated population in the Line and Phoenix Islands of about 3,200 (Clapp 1967, Perry 1980), with over half of them (2,000) recently found on Malden Island, in the Southern Line Group. However, all other estimates of this species on Malden from 1964 to 1980 (the 16 years after pigs were eliminated) are below two hundred.

<u>Distribution and habitat preference</u>: Breeding Brown Boobies on Caroline were restricted to the windward edges of *Tournefortia* scrub and forest, generally within 15-20 m of high water. In 1988 we found nests on 4 islets (Fig. 2, Table 1). Long, with 12 pairs, was the only islet supporting more than a single pair. They were located on the northern two-thirds of the island: 4 pairs formed a loose colony near the head of Transect A (Pt. I, Fig. 8). All nests were under *Tournefortia* bushes approximately 3 m tall. In March 1990, we found 20 pairs of Brown Boobies, all on windward Nake as far as the islet's northern extremity. There was no evidence of nesting on Long Island. On May 22, 1990, only 3 nests, all with eggs, were found on Nake.

On 22 September 1988, we saw 2 birds plunge-diving with Masked and Red-footed Boobies approximately 500 m west of South Island. On the atoll, flying Brown Boobies were observed soaring only along the windward beaches. Two birds roosted on the south-central beach of South, and another was found roosting on Kota.

<u>Numbers</u>: We counted 15 pairs during perimeter surveys in 1988, yet found none on the transects. Since we covered virtually all the windward beaches (Pt. I, Fig. 9), we are confident that fewer than 20 pairs nested on the atoll. Our population estimate for 1990 was 25 pairs.

The POBSP (Clapp & Sibley 1971a) found 3 nests on Nake in June 1965, estimating a population of 15 birds, while the Grossmans (1974) found 8 nests on Long Island, estimating a similar population. Even though our surveys triple the known population, the Brown Booby remains a rare seabird on Caroline.

<u>Phenology</u>: With the exception of one recently fledged juvenile, all nests contained eggs in September 1988 (Table 3). Clapp & Sibley (1971a) found eggs in June; the Grossmans found eggs in September. In March 1990, the 20 pairs were all on nests whose contents ranged from eggs to an older juvenile. However, 2 months later, only 3 nests, containing eggs, could be found. These data from 4 years suggest that the species may have trouble rearing young. More juveniles should have been encountered, especially in May 1990. However, cyclonic weather in February 1990 brought torrential rains and severe winds (Falconer, pers. comm.) which defoliated and uprooted the strand vegetation of Long and Nake (Pt. I, Pl. 33), deposited storm blocks on the windward reef flats and tons of sand over the existing beaches and old interislet channels of Long (AKK, pers. obs.). Brown Booby eggs and chicks would have experienced great difficulty at this time, as the region hardest hit was their sole nesting area. During February 1990, 640 mm (25.2") of rain fell in 10 days (Pt. I, App. II). Predation by Polynesian rats or coconut crabs could also limit reproduction on the atoll.

RED-FOOTED BOOBY (*Sula sula*) Figs. 6, 7

This pantropical booby numbers over 55,000 individuals in the Line Group (Clapp 1967, Perry 1980), making it one of the most important regions in the world for this species. Caroline holds the fifth largest known Red-footed Booby colony (see Nelson 1978). The largest known colony (140,000 pairs) is found on Tower Island (Galapagos): three of the 5 biggest colonies occur in the Line Group.

<u>Distribution and habitat preference</u>: In 1988, the Red-footed Booby bred on 28 islets, ranging in size from Nautonga (0.34 ha) to Nake (107.46 ha) (Fig. 6). On the Windward Islands, Red-foots occurred from Nake to Tridacna, absent only from the smallest islets (Noddy Rock, Skull Islet, Motu Atibu). The species was also widespread on the leeward islets, extending from Pandanus to Eitei. The tiny islets (Fishball, Azure, Reef-flat) were not occupied.

Red-foots are tree nesters whose distribution on Caroline closely matched that of *Tournefortia* scrub and forest. They sometimes utilized smaller *Pisonia* or *Cordia* trees where they intermingled with *Tournefortia*, and occasionally built nests in the tallest (>15 m) *Pisonia*. They nested in smaller *Tournefortia* patches within the peripheral scrublands, especially those not directly exposed to the trade winds. They clearly avoided smaller islets because of the lack of suitable *Tournefortia* in which to breed. They nested inward from the vegetated edges of the islets, generally at 3-6 m in height, and were distributed in broken rings around the smaller motus in areas of moderate winds. A higher percentage of the population occurred on perimeter surveys than on cross-island transects.

Red-foots were absent from South Island, which was primarily covered with *Cocos* (Pt. I, Figs. 50, 51). Even though *Tournefortia* occurred on all its coastlines, no boobies nested in them. Ana-Ana was also unoccupied: the presence of a family of 4 people, a cat, and a dog (all removed in 1991) undoubtedly discouraged nesting attempts. Red

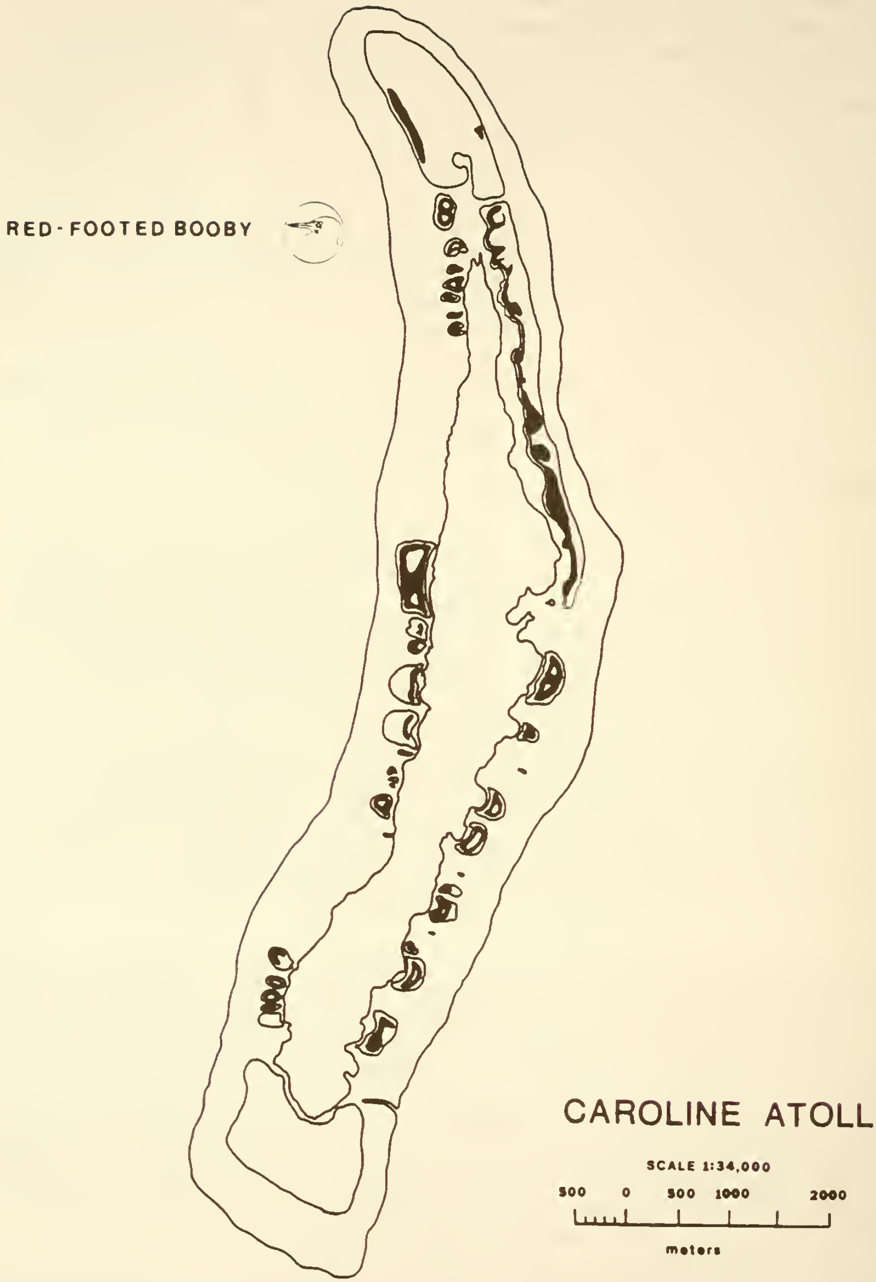


Figure 6. Distribution map of breeding Red-footed Boobies on Caroline Atoll, September 1988.

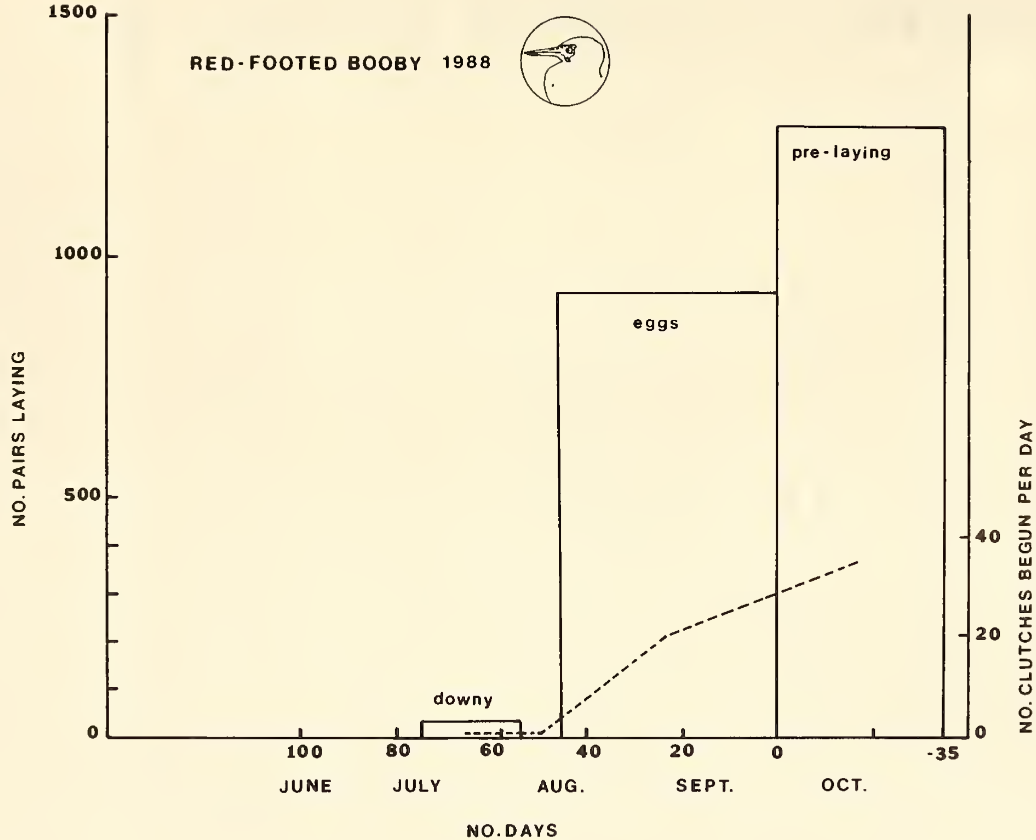


Figure 7. Approximate laying dates for Red-footed Booby nests found on Caroline Atoll in September 1988. See Fig. 3 for explanation.

foots also avoided the mixed forests of south Nake, which contained much *Cocos* and *Pandanus* (Pt. I, Fig. 37). Red-footed Boobies were thus found only in Caroline's indigenous woodlands, primarily in *Tournefortia* >2 m tall; they avoided anthropogenic plant communities and man.

Red-foots used a wider range of habitats for roosting. Nonbreeding birds were found throughout the taller indigenous trees, even in leeward situations where *Pisonia* and *Cordia* overhung the lagoon (as on Long Island).

<u>Numbers</u>: The POBSP (Clapp & Sibley 1971a) estimated 5,000 ± 25% Red-foots on Caroline in June 1965, with about 2,000 ± 25% nesting pairs. The Grossmans estimate was 3,000 ± 25% and 2,500 pairs in September 1974. In 1988 we sampled systematically more than 7% of the available habitat on all motus except Crescent (4.6% sampled) and North Arundel, and estimated that 2,221 pairs of Red-footed Boobies nested on 27 of Caroline's islets (Table 1). We found an additional 1,234 roosting, nonbreeding birds. We know (C. Kepler 1969, Nelson 1978) that fewer boobies remain in their colonies during the day than at night. Thus an unknown fraction of the population was at sea when we conducted our counts. Impressive flights of Red-footed Boobies returned each evening: 3-4 birds arrived for each one that had remained behind, many undoubtedly mates of incubating birds. To approximate the number of returning nonbreeding birds, we doubled the number of roosting adults to allow for an additional 1,234 adults and juveniles. Thus, our conservative estimate was at least 7,000 individuals.

Because Red-footed Boobies were so dependent upon *Tournefortia*, we determined the nesting population on each islet by multiplying the number of nests found on transects by the ratio of sampled to total *Tournefortia* area. Perimeter counts (Pt. I, Fig. 9) were used if the number of Red-foots observed exceeded the number calculated from the cross-island transects.

Long Island held the greatest number of nests (659), mostly in the leeward *Tournefortia* and *Tournefortia-Pisonia* edge. Bird densities were typically highest on the largest islets: Windward and Tridacna, the largest Windward Islets, held 163 and 111 nests, respectively; and Mannikiba, the biggest leeward islet, harbored the largest population (184) of the entire leeward side. There were exceptions, however: Pandanus, with 4 times the area of *Tournefortia* of any of the South Nake Islets, held fewer birds than 3 much smaller islets (Table 1).

Tournefortia scrub and forest covered approximately 125.25 ha (Pt. I, Table 9). Overall, there were 1.75 Red-footed Booby nests/1,000 m^2 of *Tournefortia* forest. Nest densities for occupied islets by island groups (Table 4) showed that Red-foots favored areas less exposed to the trade winds: most nests on the windward motus were protected by well-developed *Pisonia* forests. The exposed Central Leeward Islets held the lowest nest densities (1.2 nests/1,000 m^2), far less than on the South Nake Islets (5.3/1,000 m^2), which are protected by the northern edge of Long. The greatest densities (7.8 nests/1,000 m^2) occurred on the South Nake Islets south of Pandanus.

Table 4. Density of Red-footed Booby nests in occupied *Tournefortia* habitats on islet groups, Caroline Atoll, September 1988.

Islet Group	Number Occupied Islets	Estimated Number Nests	Area of *Tournefortia* (m^2)	Nests/1,000 m^2 of Available Habitat
Nake	1	496	300,650	1.6
Long	1	659	322,000	2.0
Windward Islets	8	434	251,900	1.7
South Nake Islets	7	319	59,800	5.3
Central Leewards	6	239	197,500	1.2
Southern Leewards	4	74	39,600	1.9
Total	27	2,221	1,170,550	1.9

Broadly speaking, Red-foots breed in well-dispersed colonies. A record density of 600 nests/1,000 m^2 on Tromelin Island (Indian Ocean) is exceptional. Elsewhere, 53 pairs/1,000 m^2 on Tower Island (Galapagos), 40/1,000 m^2 on Moku Manu (Oahu, Hawaii), and 27/1,000 m^2 on Half Moon Cay (Honduras) are more consistent high-density colonies (Nelson 1978). Only on tiny Motu Kota (Pt. I, Fig. 52), with 12 nests in 303 m^2 of *Tournefortia* (40/1,000 m^2), did we find such density, and for this reason we named the islet "Kota" (Gilbertese for Red-footed Booby).

__Phenology__: In September 1988, we located 339 nests. Of the 152 whose contents could be determined, 87 were empty, 63 contained eggs, and 2 held downy chicks. We saw dozens of flying juveniles along the windward coasts. Most pairs were building or guarding their nests during a prelaying stage that lasts from 11-35 days (Nelson 1969). Of the pairs with nests, 57.2% had yet to lay and 41.4% had laid their eggs between mid-August and late September (Fig. 7). Applied to the total breeding population, approximately 1,270 nests were in the prelaying stage and would be expected to produce eggs throughout October. An additional 919 nests had a mean laying date in early September (Fig. 7). Red-footed Boobies were synchronous with Brown Boobies but delayed relative to Masked Boobies.

In June 1965, nests containing prelaying adults, eggs, and young in all stages indicated that the birds were in the midst of a protracted breeding season extending from January to June. In September 1974, eggs and "young at nearly all stages" were present. Our data reveal that no successful nesting occurred in May-June 1988. Data from March and May 1990 indicate that nest-building began in January (or earlier), with eggs laid from January to May. However, perimeter counts and cross-island transects on 11 windward motus found virtually all Red-footed Boobies either nest-building or sitting on eggs. Chicks were found only on the leeward islands. This asynchronous breeding suggests that breeding activities were curtailed by the cyclonic weather two weeks earlier, which was particularly violent on the windward beaches harboring Brown Booby nests. Red-footed Boobies in other tropical locations have variable, opportunistic breeding seasons that depend upon food availability (Nelson 1978; F. Sibley, pers. comm.); our data suggests that similar pressures could be operating at Caroline.

Color morphs: Red-footed Boobies are polymorphic (Nelson 1978). The basic plumages are brown or white, with brown morphs having many combinations of tail, back, scapular, foot, and bill colors. A variety of brown forms and white forms occurred on Caroline, with a ratio of 9:1 (337 brown to 35 white), which contrasts sharply with Nelson's (1978) statement that "in the Line and Phoenix Islands all birds are white morphs." Most of the dark morphs were the "white-tailed" form (see Nelson 1978, pp. 660-661). The variations and proportions of plumage types show clinal change in the Line and Phoenix Islands (F. Sibley, pers. comm.), thus the question of plumage morphology needs much more study in the Central Pacific.

GREAT FRIGATEBIRD (*Fregata minor*) Figs. 8, 9 and Pt. I, Pl. 42

The Great Frigatebird breeds at widely scattered locations throughout tropical waters in the Atlantic, Pacific, and Indian Oceans. It is known to breed on all of the Line Islands except Starbuck (Perry 1980).

Distribution and habitat preference: Great Frigatebirds nested on 25 islets, including Nake, Long, and most of the larger islets (Fig. 8, Table 1), ranging in size from Azure (0.20 ha) to Nake (107.46 ha). Every occupied islet had some *Pisonia* forest, even if only a single tree (Azure). The larger islets lacking *Pisonia* forest (Arundel, 7.34 ha, Tridacna, 9.08 ha) lacked frigatebirds in 1988, although frigatebird chicks were present on Arundel in early 1989 (Anne Falconer, pers. comm).

Although Great Frigatebirds were similar in nest requirements to Red-footed Boobies, there were significant differences: the frigates tended to nest higher in, and closer to the outer edge, of the canopy (although nests were found as low as 1.3 m). Nest sites were more sheltered from the wind than those of Red-foots, and in locations where the birds could take flight easily. Such site preferences may explain the association with *Pisonia*. *Pisonia* reaches 21 m on Caroline, taller than other tree species, providing a windbreak on most islets. The largest colonies (Nake, Long, Pig, Mannikiba) were found leeward of these stands. We found nests in *Tournefortia*, *Pisonia*, and *Cordia*. They were often in the *Tournefortia-Pisonia* interface, generally in the taller *Tournefortia*. One colony on south Long overhung the lagoon in a dense *Pisonia* stand. Frigates were not found in any anthropogenic forests and were absent from then-inhabited Ana-Ana.

Numbers: The previous population estimate for Great Frigatebirds on Caroline was 10,000 birds (Clapp & Sibley 1971a, Perry 1980). The Grossmans (1974) estimated 5,000-8,000 birds, with 4,000-6,000 nests.

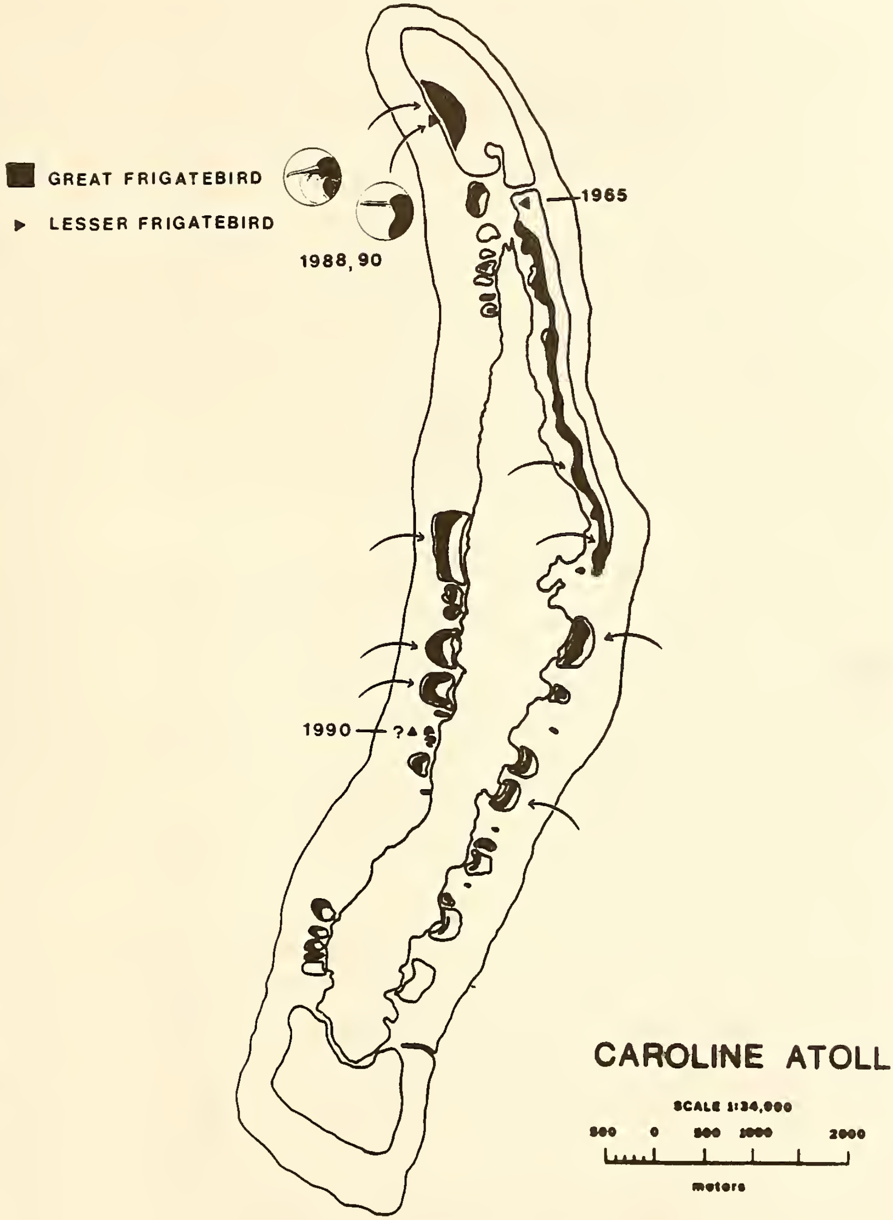


Figure 8. Distribution map of breeding Great and Lesser Frigatebirds on Caroline Atoll, September 1988.

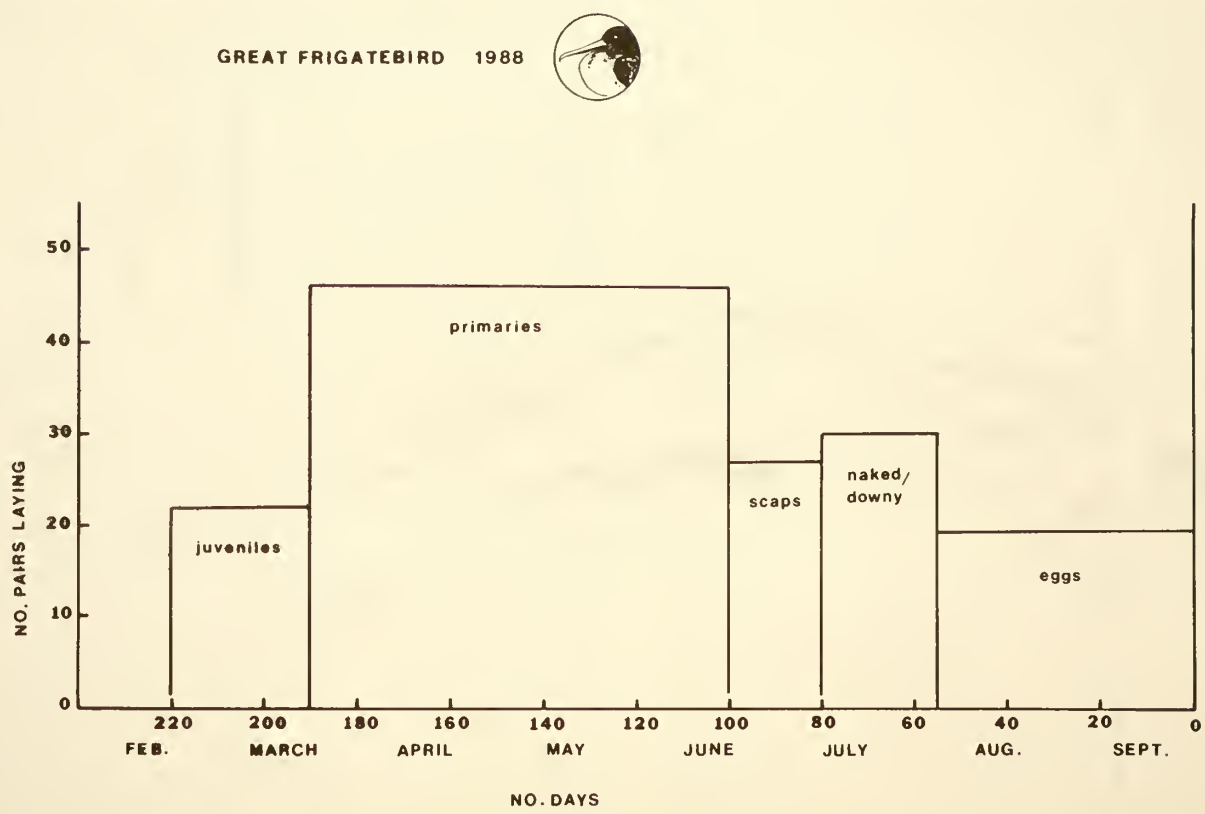


Figure 9. Approximate laying dates for Great Frigatebird nests found on Caroline Atoll in September 1988. See Fig. 3 for explanation.

We calculated that 2,427 pairs bred or attended territories. An additional 617 birds roosted, thus the entire population was approximately 5,471 individuals. A large but undetermined number of birds soared over the atoll throughout the day, and an uncountable number of birds, including fledged juveniles that would ultimately return to the island to nest (Diamond 1971), were undoubtedly at sea. Because this species is difficult to count accurately, it is unclear if the population has changed since 1965.

Phenology: In frigatebirds, the scapulars, which first appear at 81 days in *Fregata magnificens* (Diamond 1973), erupt before the primaries. Because we lack chick stage data for *F. minor* and *F. ariel*, we have modified ages from Diamond (1973) for *magnificens*, using the hatching times for *F. ariel* and *F. minor* from Nelson (1976), and fledging ages from Diamond (1975b), to construct very approximate development stages for the species on Caroline. Since they fledge at an earlier age than *F. magnificens*, we have reduced the ages for chicks with erupting primaries for *F. ariel* and *F. minor*, kept the duration of the earlier stages approximately the same, and reduced the period in juvenile plumage.

We found 214 nests in 1988. Of the 144 in which we determined contents, 49 contained eggs or young chicks, 27 held chicks with developing scapular feathers, and 68 contained older chicks (Table 5). The additional 70 adults occupied nests of unknown contents. We saw fewer than 10 displaying males and a high proportion (87%) of nests with chicks, many of them old, indicating that the breeding season was nearly over. A major laying effort had begun in March-April (Fig. 9) and continued into September. In March 1990, an abundance of flying juveniles and occasional larger chicks down to the downy stage indicated that the previous year's breeding season was ending. Of all the seabird species affected by the February 1990 storm, Great Frigatebirds suffered

Table 5. Stages in the breeding cycle of frigatebirds on Caroline Atoll, 21-29 September 1988.

	Nest stage/Approximate age in days from laying					
Species	Juv.	Primaries	Scaps.	Downy	Naked	Eggs
Great	191-220	101-190	81-100	56-80[1]		0-55
Lesser	181-210	91-180	71-90	56-70	46-55	0-45
	No. nests in each stage					
Great	22	46	27	30[1]		19
Lesser	4	13	4	5	0	0

[1] Duration of naked and downy chick stages are lumped because it was often impossible to see into canopy nests.

the most obvious mortality. We found at least 10 adults and flying immatures recently dead, either draped in partly defoliated *Tournefortia* shrubs or lying on the ground. A small number of males were beginning another courtship cycle. By May 1990, courtship and egg-laying were still underway, and nests contained eggs or small chicks up to the "remiges" stage. Peak laying on Christmas Island (Pacific Ocean) occurs from March-May (Schreiber & Ashmole 1970), the same laying cycle observed on Caroline in 1988 and 1990.

LESSER FRIGATEBIRD (*Fregata ariel*) Figs. 8, 10

The Lesser Frigatebird is a pantropical species. It breeds and disperses widely within the tropical Pacific (Sibley & Clapp 1967). One of the largest populations in the world (30,000-85,000) breeds on McKean Island, in the Phoenix Group (Garnett 1983). Lesser Frigatebirds breed on 4 of the Line Islands, with the population on Malden (7,000) the largest in the archipelago (Perry 1980).

Distribution and habitat preference: In June 1964, Lesser Frigatebirds were found nesting in one compact colony on the leeward north end of Long (Clapp & Sibley 1971a). In September 1974, adults and flying immatures were observed flying and resting (Grossman & Grossman 1974), but no nests were found, most likely because the western side of the atoll was not surveyed. A population of 200 was estimated. We found a single colony in leeward *Pisonia* forest on western Nake (Fig. 8), both in September 1988 and May 1990. The birds nested high (to 18 m) in the *Pisonia* and *Pisonia-Cordia* edge facing an open *Tournefortia* savannah. Although primarily composed of *F. ariel*, a few *F. minor* were scattered along all but the eastern edge of the colony. West of the birds, across the open forest, *F. minor* and *Sula sula* nested in a mixed colony in a denser stand of *Tournefortia*. Birds were seen soaring over Nake, Long, and the leeward islets but were not found roosting or nesting away from the colony on Nake. However, in March 1990, approximately 650 Lesser Frigatebirds were swarming above and roosting on Motu Nautonga in a tight cluster, possibly preparing for nesting.

Numbers and phenology: POBSP biologists estimated a population of 1,000 Lesser Frigatebirds on Caroline in June 1964, with 400 ± 10% breeding: only eggs were found (Clapp & Sibley 1971a). On Christmas Island, *F. ariel* laid in May and June in 1959, 1963, 1964, and 1967 (Schreiber & Ashmole 1970). Of 46 nests found in 1988, we could inspect the contents of only 26: all contained feathered chicks (Table 5). Laying dates ranged from March through July (Fig. 10), with a peak from April to June. Our limited data on Caroline's Lesser Frigates indicates, therefore, that they may be synchronous with those on Christmas. In larger Central Pacific colonies, large subpopulations of this species have differing breeding regimes (F. Sibley, pers. comm.).

Because we did not determine the colony limits, we cannot provide a population estimate. There was a minimum of 200 birds in 1988 (46 nests, plus roosting and flying individuals) and ca. 1,000 in 1990.

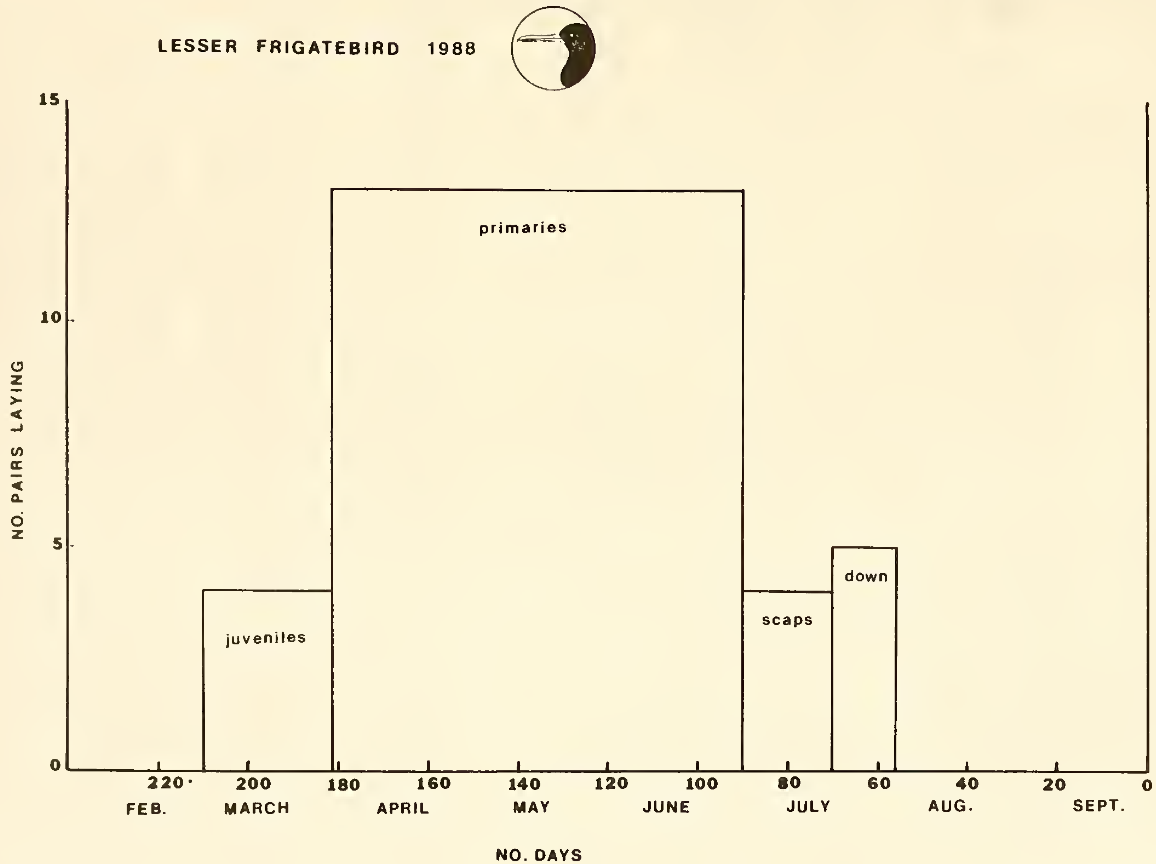


Figure 10. Approximate laying dates for Lesser Frigatebird nests found on Caroline Atoll in September 1988.

SOOTY TERN (*Sterna fuscata*) Figs. 11, 12

This tern is the most widespread and abundant tropical seabird in the world. Under favorable conditions it forms immense colonies numbering into the millions. It is known to breed on 7 of the Line Islands: the largest population in the Pacific is found on Christmas Island (15,000,000 at highest count), and 3,000,000 have been recorded on Starbuck (Perry 1980).

Distribution and habitat preference: To date, 21 colonies from 10 islets are known for the years 1965, 1974, 1988, 1989, and 1990 (Fig. 11). In September 1988, we found 3 colonies, 2 on the northern half of Long and one on Bo'sun Bird Islet; all fit the general habitat description in Clapp & Sibley (1971a). Colony A, nearly square, was 210 m on a side. Eggs were placed under a savannah-type *Tournefortia* scrub, from 1-4 m tall with approximately 60% canopy cover. The substrate was coral rubble mixed with sand, covered by *Heliotropium* (5%), *Portulaca* (1%), *Laportea* (<1%), and *Lepturus* (<1%), typical of old interisland channels. Colony 1 was located in a broad sandy corridor with 2 large "groves" of *Tournefortia*. The northern subpopulation extended 116 m along the windward beach, but 248 m along the lagoon. The southern subpopulation began 28 m further south along the beach, fronted the seaward reef for 86 m, and was shaped like a blunt triangle, its apex pointing toward the lagoon. Most chicks were under *Tournefortia*, which consisted of shrubs 2-4 m high with 80% canopy cover. The substrate was also older beach sands mixed with coral rubble, and covered with *Portulaca* (40% cover), *Lepturus* (<5%), and *Heliotropium* (<5%). The Bo'sun Bird colony, a rough oval approximately 55 m wide by 70 m long, was under 2-3 m high *Tournefortia* with 75% cover, on coral rubble/sand sparsely carpeted with *Portulaca* and *Heliotropium*.

Numbers: Populations were determined by measuring colony dimensions, then counting eggs and/or chicks in 9 m^2 sample plots located at random points along a compass line. Because juveniles moved as we approached, they were counted 6 m ahead of us in estimated 3 m x 6 m plots. The Colony 1 subcolonies (North, South) were treated separately.

Colony size (rounded) in 1988 ranged from 127,000 ± 30,000 "nests" (Colony A) to 1,500 ± 750 new eggs on Bo'sun Bird Islet (Table 6). There were an additional 6,900 ± 1,600 nearly-fledged chicks in the Bo'sun Bird colony, resulting from eggs laid 3 months earlier.

The total number of eggs and chicks was 188,000 ± 40,000. Actual numbers of adults are difficult to estimate, but in other studies have exceeded the number of eggs and young by factors of more than 2 because innumerable eggs and chicks were lost, colonies often overlapped, and many nonbreeding adults joined the prebreeding swarms or associated with breeding birds. Schreiber & Ashmole (1970), relying on POBSP data from Johnston Atoll (North-central Pacific), estimated that 4 adults were present for each egg laid. POBSP data from Johnston (Amerson & Shelton 1976) indicated that about 600,000 adults were present in a colony with 105,000 eggs, or approximately 5.7 adults/egg. If we assume that real

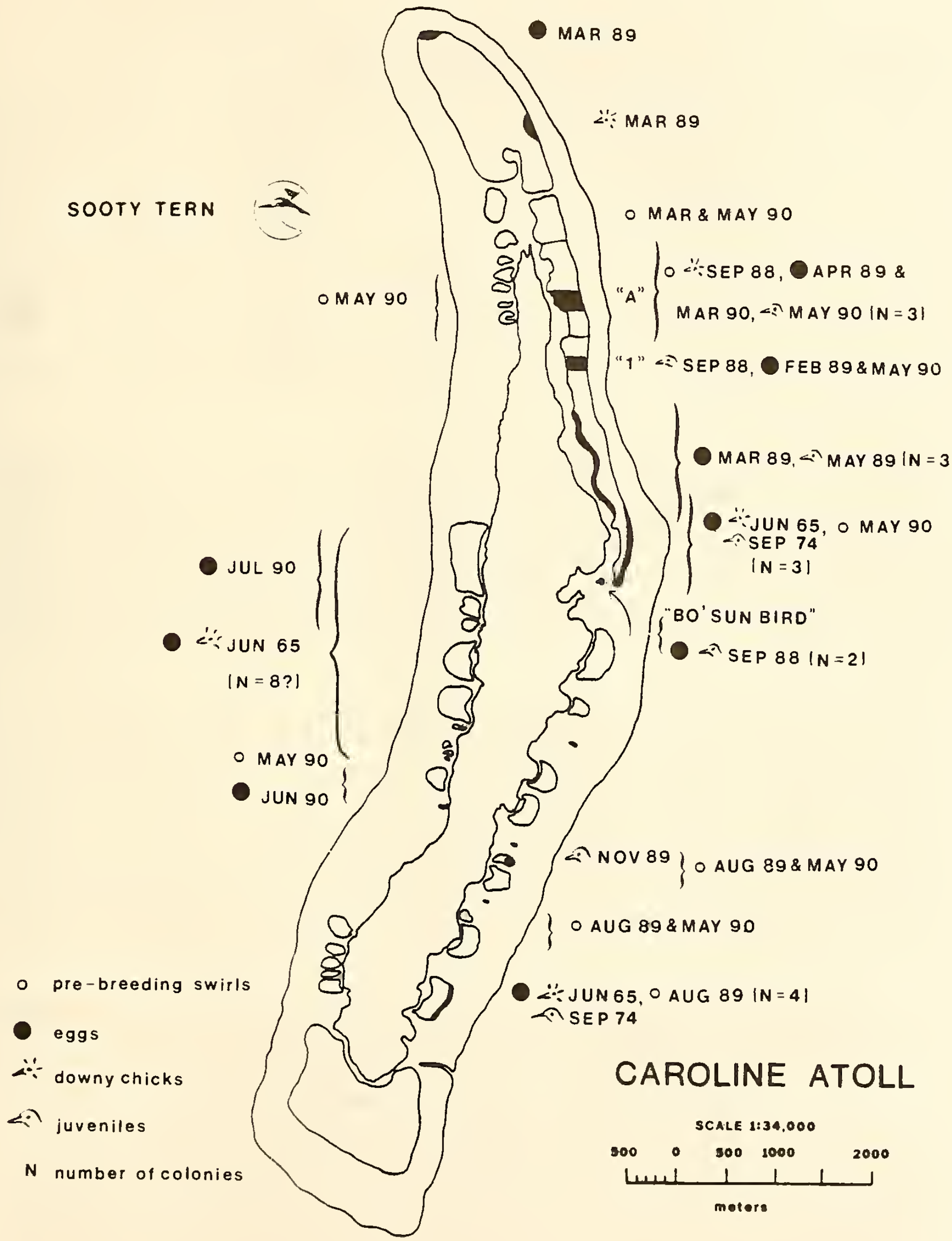


Figure 11. Distribution map of breeding Sooty Terns on Caroline Atoll, September 1988 to July 1990.

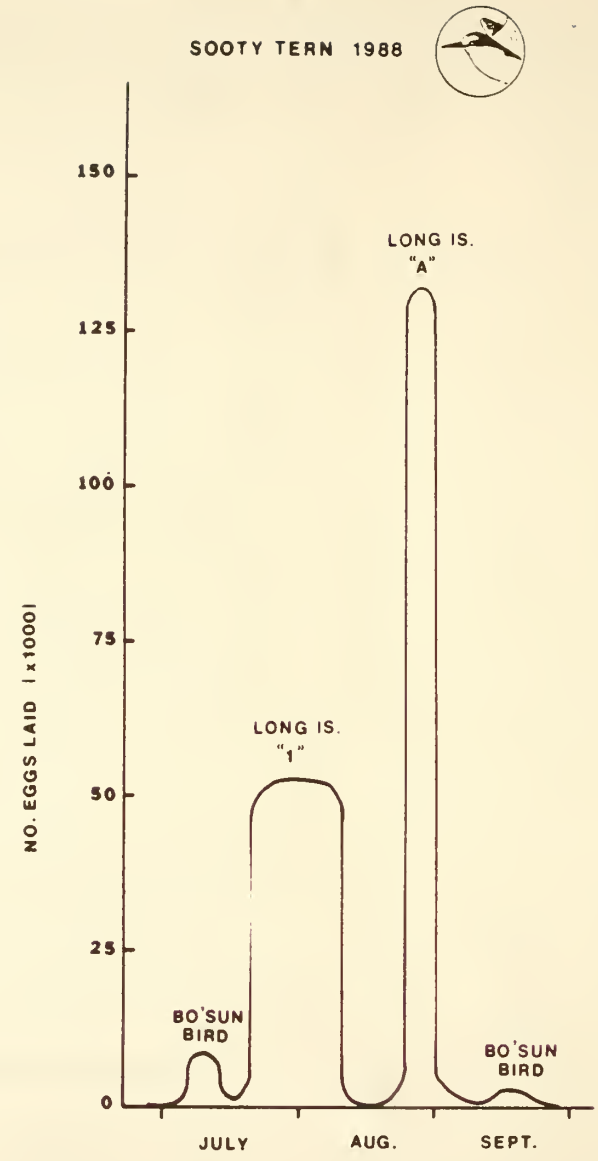


Figure 12. Approximate laying dates for Sooty Tern young found on Caroline Atoll in September 1988. See Fig. 3 for explanation.

Table 6. Sooty Tern colonies on Caroline Atoll, 27-28 September 1988.

Colony Location	Area	Calculated Population (Mean Pairs ± SE)	Nest Stage	Approx. Weeks From Laying
Long Island, A	44,100 m^2	127,449 ± 30,429	hatching eggs, downy chicks	4-5
Long Island, 1 N	24,200 m^2	41,382 ± 5,808	chicks with short tails, juv. plumage	7-10
Long Island, 1 S	6,400 m^2	10,944 ± 1,536	"	7-10
Bo'sun 8ird Islet,				
old	3,375 m^2	6,883 ± 1,575	fledglings	11-12
new	3,375 m^2	1,538 ± 758	new eggs	1-2
Total	75,075 m^2	188,196 ± 40,106		

numbers of terns in our colonies lay midway between 4 and 5.7 times the number of eggs and chicks, then the number of Sooty Terns using Caroline Atoll would have ranged between 720,000 and 1,100,000 birds (911,800 ± 21%). This is twice the estimate provided by Clapp & Sibley (1971a), even though we found fewer colonies. However, if the POBSP had used the criterion of 4 adults present for each egg laid, their total population figures would have exceeded ours, hence the 2 estimates are not strictly comparable (F. Sibley, pers. comm.).

In March 1990, laying was just beginning in 2 colonies on Long Island, (625 m x 150 - 315 m wide and 180 m long x 160 m wide). Enormous numbers of birds, both on the ground in densities up to 9 or 10 pairs/m^2 and in the air, made it impossible to calculate a reasonable population figure. According to Anne Falconer, these 2 colonies were very successful. Similarly, counting was difficult in May 1990 when 6 large prebreeding swirls hovered like huge clouds of gnats over discrete islets and islet groups (Fig. 11). Our 1988 estimate of approximately one million birds is probably a conservative count for the atoll as a whole on an annual basis.

Phenology: The incubation period in Sooty Terns is about 4 weeks (Dinsmore 1972). Young fledge 7-8 weeks after hatching, although fledging ages, dependent upon food supply (Schreiber & Ashmole 1970), are highly variable.

Four separate Sooty Tern colonies had been started over the 12-week period prior to our study in 1988 (Table 6). On Bo'sun Bird Islet a new wave of laying was just beginning in an open area immediately southwest of most of the colony, while nearly fledged chicks scurried about beneath the *Tournefortia*. Undoubtedly many young had already fledged, so many more eggs would have been laid in early July by this colony than indicated (Fig. 12). The 2 colonies on Long were established at different times: the short-tailed juveniles in Colony 1 preceded the large number of eggs, hatching eggs, and downy chicks of Colony A by 3-4 weeks.

The July-September laying period on Caroline in 1988 is very different from the bimodal breeding (May-June, December-January) reported from Christmas Island, Pacific Ocean (Schreiber & Ashmole 1970), and the May laying dates noted for Caroline by the POBSP in 1965. In September 1974, "innumerable large unfledged chicks and juveniles" were present in colonies at the tip of Long Island and on Tridacna Islet (Grossman & Grossman 1974). Additional data (Anne Falconer, pers. comm.) indicate that Sooty Terns may lay any time (Fig. 11), certainly January through September (1988 to 1990). Severe storms, which destroyed large Long Island colonies in February 1990, were likely responsible for reinitiating breeding activities on the leeward side of the atoll within the next few months. A great deal more research will be needed on Caroline before the breeding seasons for this species are fully understood. The phenomenon of several colonies on each island breeding at different times is considered the norm for the Line and Phoenix Groups (F. Sibley, pers. comm.), so the situation on Caroline is not unusual.

BROWN NODDY (*Anous stolidus*) Fig. 13

This tern, primarily a tree nester, is widely distributed throughout the warm oceans of the world. It is abundant in the Line and Phoenix Groups, with an estimated total population exceeding 40,000 birds. Brown Noddies are most abundant on Palmyra Island (10,000 birds).

<u>Distribution and habitat preference</u>: The Brown Noddy is second only to the White Tern in the number of motus (28) upon which it is known to breed (Fig. 13). It utilized the smallest (Noddy Rock, 0.02 ha) and largest (South, 104.41 ha) motus, nesting upon coral rubble and in plant communities ranging from the simplest herb mats to *Tournefortia*, *Pisonia*, *Cordia*, *Cocos*, and the mixed anthropogenic forests of South and Nake. Most pairs were well dispersed, nesting from the outer edges of *Tournefortia* to the central, inner branches of *Pisonia*, and from the ground to the crowns of 25-m *Cocos*. When nesting sympatrically with Black Noddies in *Pisonia*, the Brown Noddies typically occupied portions of branches closest to the trunk. Brown Noddies nested almost solitarily in the *Cocos* canopy on South, were found within dense colonies of Black Noddies and White Terns in tall *Pisonia* forests, with Red-footed Boobies and Great Frigatebirds in *Tournefortia*, and amidst Sooty Terns and Red-tailed Tropicbirds (Bo'sun Bird Islet). Apart from a few ground nesters on Raurau and Fishball, the only ground-nesting colony (80 nests) was located on a *Portulaca* mat on Noddy Rock--a site free of predators, although flooded during storms.

Brown Noddies often formed loose roosting "clubs" on the atoll's beaches. Aggregations of 15-20 birds were found on the west coast of South and on Sandy Inlet, south-central Nake.

<u>Numbers</u>: Clapp & Sibley (1971a) estimated a population of 1,000 birds in June 1965, with about 800 birds breeding (with eggs and young). The Grossmans estimated 400 ± 15% in September 1974. We estimated a total population of 1,491 breeding pairs (Table 1). Because nests high in

Figure 13. Distribution map of breeding Brown Noddies on Caroline Atoll, September 1988.

Cocos palms were difficult to detect, we undoubtedly overlooked many, thus our estimate of approximately 3,000 birds is conservative. Although larger than the population estimated by POBSP (Clapp & Sibley 1971a), uncertainties about the 1965 survey coverage (F. Sibley, pers. comm.) prevent us from knowing if Caroline's population has changed over the past 25 years.

Phenology: This is another species whose breeding cycle is irregular in the Central Pacific: during the 1963-1965 POBSP surveys, egg-laying was found in every month of the year somewhere in the Line and Phoenix Groups (F. Sibley, pers. comm.). On Christmas Island, which has received more attention than any other Central Pacific island, the timing of egg laying varies between colonies. In general, peak laying occurs from March to May, and from November to December. On Caroline, mating and nest-building were found in March 1990, but by May only a few eggs had been laid. Eggs and young were found in June 1965 (Clapp & Sibley 1971a) and in September 1988 (present study). Only eggs were present in September 1974. We found 246 nests in September 1988 and determined the contents of 106: 103 held eggs, 3 held downy chicks. The incubation period is 35-37 days (Dorward & Ashmole 1963), so all viable eggs had been laid within the previous 40 days--mid-August to late September. Because many nests were being built, we feel confident that laying continued into October. Clearly more research is needed to determine whether laying occurs in regular cycles.

BLACK NODDY (*Anous minutus*) Fig. 14

The Black Noddy is widely distributed in the tropical Atlantic and Pacific. It is abundant in the Line and Phoenix Groups, with populations of 16,000 estimated in the Phoenix Islands (Clapp 1967) and over 46,000 in the Line Group. Centers of abundance are Palmyra (20,000) and Christmas (14,500) (Perry 1980).

Distribution and habitat preference: The Black Noddy is a tree-nesting species that on Caroline prefers tall stands of *Pisonia*. The largest colonies (61% of the population) were found in the grand *Pisonia* forests (to 25 m) on Pig and North Pig. We found breeding birds on 18 motus, with populations exceeding 800 pairs in the *Pisonia* on Nake, Long, North Pig, and Pig (Fig. 14). The only significant colony not primarily associated with *Pisonia* was found on Tridacna, where approximately 230 pairs nested in the tallest (ca. 8 m), most central *Tournefortia-Morinda* forest. Black Noddies always nested in dense colonies near islet centers and were integral components of these plant communities: their droppings, coating the ground with a film of guano, constantly enriched the islet's meager soils.

Numbers: Clapp & Sibley (1971a) estimated that 7,000 ± 25% birds were on Caroline. The Grossmans (1974) estimated 500 ± 20%. During our visit the population was much larger: 5,122 pairs were estimated for Pig and North Pig alone (Table 1). Basing our numbers primarily on the densities of sampled colonies in *Pisonia*, we estimated that nearly 8,400 pairs were nesting during our 1988 visit. Our population estimate approached 17,000 birds, to which an unknown number of nonbreeding birds

Figure 14. Distribution map of breeding Black Noddies on Caroline Atoll, September 1988.

could be added. These values place the Caroline population far above that for Christmas, making it the largest known population in Kiribati.

Phenology: Black Noddies were just beginning a new breeding season, as was also found in September 1974. On 27 September we observed hundreds of birds gathering *Tournefortia* leaves floating along the windward shore (Long) or flying with fresh leaves to their nests (Pig, North Pig). Of the 1,085 pairs counted on transect, 536 (49%) perched as pairs, were defending nest sites, or were building nests. An additional 273 pairs were attending nearly-completed nests but were not incubating. The remaining 276 pairs were incubating, thus 75% of the pairs had not laid eggs. The contents of 230 nests were unknown, although we assumed they contained eggs because of the incubating positions of the adults. Of 46 nests whose contents were visible, 45 held a single egg, and one contained a downy chick less than 5 days old.

The breeding seasons for Black Noddies on Christmas Island and Johnston Atoll peak in April and May (Schreiber & Ashmole 1970, Amerson & Shelton 1976), where pairs are highly synchronous, laying most of their eggs within a 2-3 month period. The Caroline colony, also synchronous, but beginning egg-production in September, would be expected to peak in October/November, 6 months out of phase with the colonies further north. In 1990, however, Black Noddies were just beginning to mate and nest in March, and by May some were still sitting tightly on nests, while others had chicks in all stages. This was most likely the result of the stormy weather which affected all seabirds.

BLUE-GRAY NODDY (*Procelsterna cerulea*)

Blue-gray Noddies nest widely across the Pacific from the Kermadec Islands to Hawaii. They are scattered throughout the Line and Phoenix Groups. In the Line Islands, they were formerly known to breed only on Christmas and Malden (Perry 1980). Eggs are placed in nests minimally provided with twigs and may be on coral rubble, sheltered under vegetation, or under coral slabs to depths of one meter (Rauzon et al. 1984).

The Blue-gray Noddy was recorded as "present" on Caroline by Perry (1980). Clapp & Sibley (1971a) noted birds over the lagoon but saw none on land. When we approached Caroline, we saw 2 from the ship and later observed 3 flying across the lagoon. We also saw 3 birds perched on reef flats of the leeward motus Nautonga and Eitei. A third bird flushed repeatedly from a small clearing around a pile of bottles on Raurau, but we failed to find a nest. In March and May 1990, we observed Blue-gray Noddies on all of the Southern Leewards, plus Azure and Nautonga in the Central Leewards.

In summer 1990, Alexandre Falconer, resident on Caroline at that time, found one small chick, attended by its parents, on an open expanse of coral rubble on Motu Eitei, the first breeding record for Caroline. Eitei is adjacent to Raurau, which we predicted was the most likely breeding location for this species.

Blue-gray Noddies must breed in very small numbers on Caroline. Nests are hard to find, given their cryptic placement, the small number of birds present, and the extent of open habitat (67.7 ha of herb mats and 41.4 ha of consolidated coral rubble). F. Sibley (pers. comm.) suggests that Blue-gray Noddies are extremely vulnerable to predators, since they were observed on 12 of 20 islands visited in the Line and Phoenix Groups, but nested on only three. Where they did nest, Blue-gray Noddy colonies contained hundreds or thousands of birds.

WHITE TERN (*Gygis alba*) Fig. 15, Pl. 3

The White Tern is a widely-distributed pantropical species occurring in moderate numbers throughout the Line and Phoenix Groups. Perry (1980) estimated 17,050 birds for the Line Islands, and Clapp (1967) estimated 10,000 birds in the Phoenix Group.

Distribution and habitat preference: White Terns, the most widely distributed breeding bird on Caroline, nested on 32 of the 39 motus (Fig. 15), avoiding only those which were tiny and sparsely vegetated.

White Terns nested from one to 15 m above ground, wherever a branch or frond provided a relatively stable platform in *Tournefortia* (Pl. 3), *Pisonia*, *Cordia*, *Pandanus* (Pt. I, Pl. 35), or *Cocos*. They did not form dense colonies but were scattered throughout each motu, normally selecting sites sheltered from the prevailing trade winds. They utilized isolated trees, scrub, or forest. An unusual departure from the White Tern's usual mode of "nesting" was an egg laid in an old Black Noddy nest, 6 m up in an 8-m-tall *Tournefortia* on Tridacna Islet.

White Tern densities varied from islet to islet (Table 7). At one extreme we found only 2 nests on Raurau (0.07/1,000 m^2). Densities on

Table 7. Density of White Terns on occupied islets by islet group, Caroline Atoll, September 1988.

Islet Group	# Islets	Vegetated Area (ha)	# White Tern Pairs	Density (pairs/ 1,000 m^2)
Nake	1	66.63	1,094	1.64
Long	1	49.60	751	1.51
South	1	86.10	381	0.43
Windward Islets	9	36.09	1,164	3.23
South Nake Islets	6	8.50	122	1.44
Central Leeward Islets	9	33.56	408	1.22
Southern Leeward Islets	4	6.47	37	0.57
All Occupied Islets	31	286.88	3,957	1.38

Figure 15. Distribution map of breeding White Terns on Caroline Atoll, September 1988.

other islets ranged from 0.75/1,000 m^2 (Shark) to 6.67/1,000 m^2 (Nautonga) with a mean density of 1.38 pairs/1,000 m^2 of woodland. Overall, the lushly vegetated Windward Islets supported the highest densities. Although White Terns also nested in anthropogenic forests, their densities were low: we believe that their low densities on South Island and the Southern Leewards (Table 7) are attributable to man. Of South's 104.47 ha of vegetated land, only 4.2 ha (4.4%) was native woodland (Pt. I, Fig. 50); fully 84% was either *Cocos* (18.3 ha) or dying *Cocos-Ipomoea* (62.5 ha) forest. Although most of the Southern Leewards are covered in virgin forests, central Ana-Ana has been partly cleared (0.21 ha) to accommodate thatched huts and a garden. The activities of a family of 4, with a dog and cat (until October 1990), apparently depressed the White Tern population on Ana-Ana and, perhaps, even on nearby islets. We found no White Terns on Ana-Ana during our visit, although the Falconers, who vacated the atoll in summer 1991, assured us that they occasionally nested.

<u>Numbers</u>: We used the total woodland area of each islet, coupled with transect data, to calculate bird populations (Table 1). More birds were found on the largest islets except South Island (see above). We estimated 1,094 pairs for Nake, 751 pairs for Long, and nearly 400 pairs for Tridacna; these 3 islets accounted for over half the population (and over half the indigenous woodlands). We estimated that 3,957 pairs bred on Caroline, which doubles the numbers of Clapp & Sibley (1971a) and Perry (1980) and exceeds by 3,000 the largest population formerly known for the Line Islands.

<u>Phenology</u>: Of 569 pairs of White Terns recorded on transect, 437 were roosting without obvious signs of eggs or chicks, 107 were incubating, and 25 had chicks (often adults were not present). Of the 25 chicks recorded, 17 were downy, 7 retained extensive traces of down with remiges, and one was almost ready to fly. Incubation takes about 36 days (Ashmole 1963); young may require from 40-96 days to fledge (Gibson-Hill 1950, Ashmole 1968). Nearly all chicks were less than 4 weeks old.

On Christmas Island, Schreiber & Ashmole (1970) found that peak laying occurred in April-August each year, with some laying in each month. On Caroline, Clapp & Sibley (1971a) noted that about half of the birds had eggs, half had young in June 1965. In September 1974, White Terns had eggs only (Grossman & Grossman 1974). In March 1990, we found very few eggs and downy chicks, but in May a larger number of pairs were breeding, with eggs and chicks in all stages. Again, the February storm had most likely interrupted breeding activities, as only 2 juveniles were found on the windward side. These were in the interior *Pisonia* forests of Brothers and North Brothers Islets, which suffered less damage than motus further north. Therefore, although White Terns on Caroline do lay during the peak period on Christmas Island, laying appears to be heaviest after mid-August.

D. OTHER BIRDS ON CAROLINE ATOLL

Seven species other than seabirds have now been recorded on Caroline. Six of them are migrants (5 shorebirds and Long-tailed Cuckoo). The few shorebirds encountered (except for Bristle-thighed Curlews) and their lack of increased numbers in the fall suggest that there is only a small migration to Caroline. The Reef Heron is apparently resident, although no nest has been found.

REEF HERON (*Egretta sacra*)

We found 15 Reef Herons scattered on 8 islands: Nake (1), Long (2), Pig (1), Brothers (3), South (2), Mannikiba (2), Matawa (1), and Emerald (2), as well as on the open reef flats (1). Although birds were found on both the seaward and lagoonward sides of the islets, most were along the lagoon edge, as also found by POBSP in 1965 (Clapp & Sibley 1971a) and the Grossmans (1974). We estimated that approximately 30 birds were using the atoll. We found no signs of breeding. Of the 15 individuals we observed, 5 were dark, 8 were white, and 2 were of the pied morph.

LESSER GOLDEN-PLOVER (*Pluvialis dominica*)

This plover used the beaches and herb mats, generally to seaward. In September 1988, we found them on Nake (1), Long (4), Tridacna (4), and Mannikiba (1), estimating a total population of 20-30 birds, the same number found by POBSP (Clapp & Sibley 1971a). In March 1990, we observed 8, and in May, 3, all in winter plumage. In September 1974, 3 were seen on the windward coast (Grossman & Grossman 1974).

WANDERING/GRAY-TAILED TATTLER (*Heteroscelus incanum* or *H. brevipes*)

In September 1988, we located 18 tattlers on 6 different islets: Nake (3), Long (3), Crescent (1), Arundel (2), South (7), and Emerald (2). All birds were either alone or in pairs and generally remained in the intertidal zone, although they often foraged on herb mats close to the beach scrub. The total population was approximately 40 birds. Those few birds heard were all *H. incanum*. We saw 6 tattlers in March 1990 and several in May of the same year. The Grossmans (September 1974) observed 12 on the windward coast and around the lagoonward shore of the windward islets and South.

RUDDY TURNSTONE (*Arenaria interpres*)

One turnstone was found on the windward beach of Motu Mannikiba in September 1988, and 5 on atoll beaches in March 1990. The Caroline population probably does not exceed 15 birds.

BRISTLE-THIGHED CURLEW (*Numenius tahitiensis*) Pt. I, Pl. 22

The Bristle-thighed Curlew, common in the Line and Phoenix Groups, is a widespread migrant to atolls of the Central and South Pacific during the boreal winter (Pratt et al. 1987). The species is considered rare (Johnsgard 1981, Marks et al. 1990) and is a candidate for the U.S. Fish and Wildlife Service Endangered Species List (Gill 1990). Clapp & Sibley (1971a) estimated 20 birds for Caroline Atoll in June 1965; the Grossmans (1974) saw 4 on the windward coasts.

We counted 83 birds on 12 of Caroline's islets in 1988, including the 3 large islands (Nake, Long, South) and motus in the Windwards, Central Leewards, and Southern Leewards. In March 1990, we saw 20 curlews on 10 islets during incidental observations throughout the atoll, bringing the total number of islets on which they have been recorded to sixteen (41%). On our return trip (May 1990) we only saw 3 curlews (8 motus visited). Undoubtedly, curlews occur throughout, utilizing essentially all plant communities (for details, see Pt. I, Sect. E). Although they are most conspicuous on the beaches and reef flats, higher numbers may actually forage inland during the day. Small numbers of curlews remain all year, being least common from April to August and most abundant after September/October (R. and Anne Falconer, pers. comm.). This correlates with preliminary information from Rangiroa Atoll, Tuamotu Archipelago (Gill 1990; Gill & Redmond, in prep.).

<u>Unvegetated perimeter habitats</u>: On a complete perimeter count of South Island in 1988, we found 29 curlews. Twenty-one were foraging and loitering on the windward east coast, principally above the beach crest on coral rubble interspersed with herb mat. Similarly, 14 of 20 curlews found on Long and the Windward Islets foraged along the windward beach crest, with only 6 birds found on the lagoonward shores. Curlews were equally common on windward and leeward shores in the leeward islets, occupying habitats composed of coral rubble and sand. While the numbers indicate that curlews preferred windward shores, they may be biased because most birds were seen there in the late afternoon (13, 14, 19). Perhaps they use the relatively open areas for roosting and foraging at dusk. Our largest flock (14, Sandy Inlet, Nake) was found at 16:00, foraging on compacted, silty sand at the lagoonward end of the inlet, while single curlews dotted the interislet channels and shallow tidal reef flats (Pt. I, Pl. 22).

<u>Vegetated habitats</u>: We found Bristle-thighed Curlews on natural herb mats, in *Tournefortia* scrub, *Pisonia* forest, and in *Cocos* habitats, both in the healthy peripheral plantations and within the dying *Cocos-Ipomoea* woodlands (Pt. I, Fig. 36, Pl. 34). One was captured in a mist net under a dense *Cocos* canopy. Disintegrating plantations in the center of South (54 ha) held a large population: calculated numbers produced an estimate of 154 curlews. They foraged over the *Ipomoea*-strewn ground (interspersed with *Boerhavia* and *Phymatosorus*), frequently using broken-topped coconut trunks as lookouts. We also found 5 curlews on transects in *Pisonia* forests up to 20 m tall on Nake (calculated population, 41). They were foraging on the relatively open, although dimly lit, forest floor (Pt. I, Pl. 42).

<u>Numbers</u>: From the 1988 data we estimated a population of 300± curlews: 41 birds in *Pisonia*, 154 in *Cocos-Ipomoea*, 43 on the beaches of South,

14 at Sandy Inlet, Nake, and 62 scattered over the remaining motus. Because 154 were calculated from a single flock of 7 curlews on one transect on South, there may be a bias in our population estimate. However, this habitat covers 80 ha, 77% of South's total area, and incidental observations made off-transect indicated that curlews commonly foraged in *Cocos-Ipomoea* woodlands. We believe that our estimated density, about 1.5 birds/ha, is reasonably correct.

Bill length: Bristle-thighed Curlews show great variation in bill length immediately after the breeding season. Because birds of the year migrate south before their bills reach adult length (R. Gill, pers. comm.), the ratio of "long" to "short" bills provides a rough estimate of juvenile survival. Of 31 curlews seen in September, 20 were clearly adult length, 7 were conspicuously shorter, and 4 were "intermediate" (probably young birds). All March and May birds had long, adult-sized bills.

Some subadults remain on their Pacific wintering grounds for up to 3 years, during which time they pass through a flightless phase (Gill 1990, Marks et al. 1990). No flightless birds were seen.

Foraging: We saw one curlew chase and capture a small Polynesian rat at dusk on the south shore of South Island. The bird bashed the rat on the coral rubble, then ran rapidly about with the rat dangling from its bill. After about 5 minutes, the bird swallowed the rat with vigorous gulps.

Polynesian rats, abundant on Caroline (especially in *Pisonia* and *Cocos*-dominated habitats), remain within the forest during the day, but many move to the beach crest and tide line at dusk. They provide abundant potential prey for curlews, which can easily capture them on the open rubble. The synchronous appearance of rats and curlews at the beach-woodland interface at dusk may be part of the foraging strategy of this large shorebird. The presence of curlews beneath the forest canopy may also be partly associated with this source of food.

SANDERLING (*Crocethia alba*)

One Sanderling in winter plumage was seen at water's edge on the windward beach of Long Island on 27 September 1988. Although Sanderlings are well-known fall migrants in the Line and Phoenix Islands (Clapp & Sibley 1967, 1968), this is the first record for Caroline Atoll.

LONG-TAILED CUCKOO (*Eudynamis taitensis*) Fig. 16

The Long-tailed Cuckoo breeds in New Zealand and winters in the southwest Pacific. The center of its winter range lies in central Polynesia, but birds have been recorded as far as Palau in the northwest and Pitcairn Island in the southeast. Although occurring throughout French Polynesia and the Cook Islands, it had not been recorded from the Line Islands prior to our expedition (Bogert 1937; Clapp & Sibley 1971a, 1971b; Pratt et al. 1987; Ellis et al. 1990).

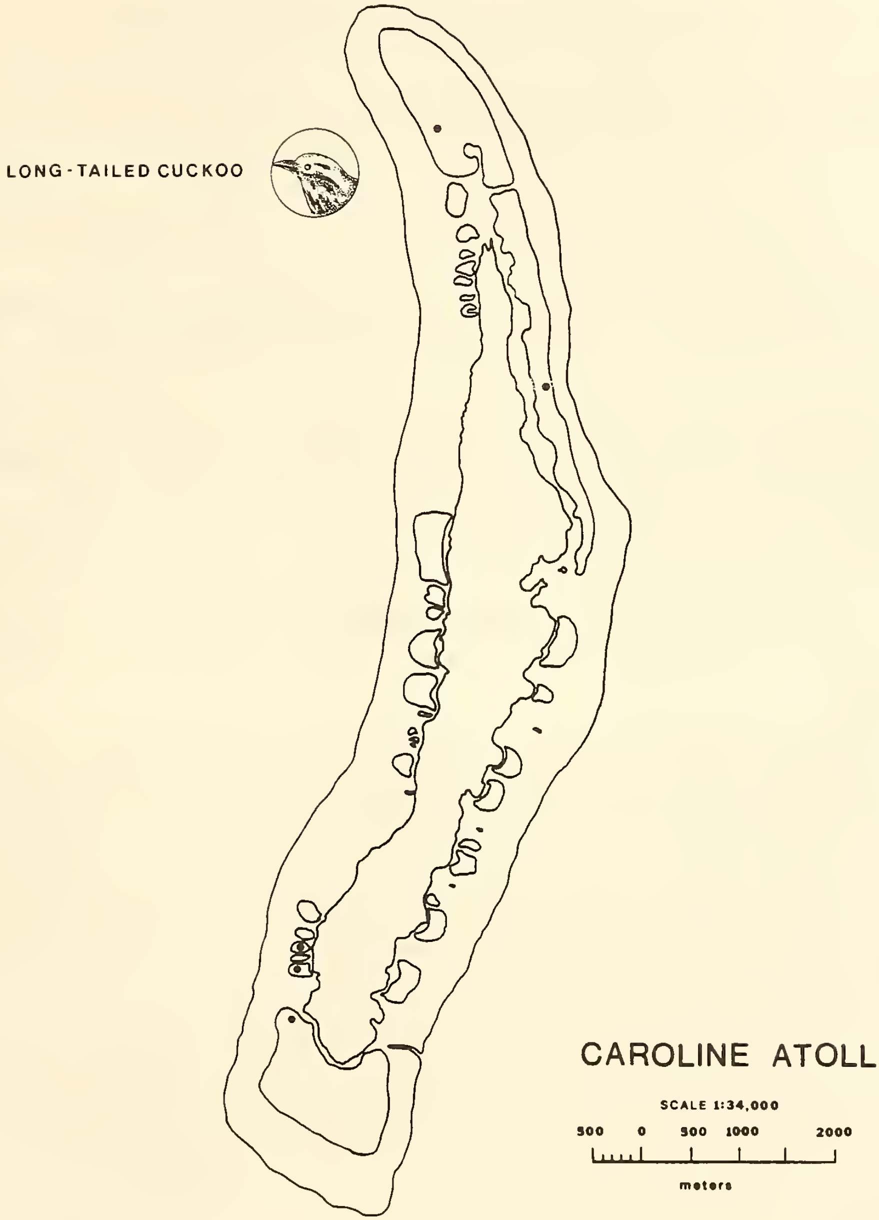


Figure 16. Preliminary distribution map of the Long-tailed Cuckoo on Caroline Atoll. The species most likely utilizes all well-wooded motus.

We found Long-tailed Cuckoos on 4 of Caroline's 39 motus (Fig. 16). We heard its distinctive mono- and disyllabic call notes on South, Long, and Pisonia, identified one on Nake, and on 28 September collected a male in a mist net on Transect 4, Long Island (USNM 607191). Soon after our return home we sent a description and photograph of this species to the Falconers: they, and AKK, have since seen them several times on Motu Ana-Ana in March, April, and May 1989-90.

All the cuckoo sightings were at canopy or subcanopy level, and 3 of the 4 1988 birds were in *Pisonia* forests. The individual on South foraged in a *Cocos* canopy 21 m tall. The netted male flitted secretively within an undisturbed, tangled low-canopy (4-6 m) *Pisonia-Tournefortia* interface. We suspect that this elusive migrant occurs throughout the mid-to-upper levels of Caroline's forest canopy.

These records establish the Long-tailed Cuckoo as a winter visitor to Caroline Atoll. Our observations on 4 motus in 8 days, including the southernmost, northernmost, windwards, and leewards, indicate that many individuals were present. A March 1990 first sighting on Vostok (J. Phillips, pers. comm.) further suggests that the species disperses regularly to the Southern Line Group.

E. OTHER VERTEBRATES

Lizards

Although "small lizards" were observed on Caroline in 1825 (Paulding 1931), it wasn't until 1965 that the first collections were made (Clapp & Sibley 1971a). We collected 4 lizard species, increasing the known terrestrial herpetofauna from 3 to 6 (Table 8). Although all are indigenous, the azure-tailed skink (*Emoia cyanura*) is particularly widespread in Oceania, and is suspected of being partly dispersed by man (Brown 1956, Crombie & Steadman 1986). Recent data from Flint suggest that *E. cyanura* may have been introduced by Tahitian copra laborers this century (Kepler, in prep.). The same situation may be true on Caroline, especially since this easily-indentifiable species was not seen or collected by POBSP personnel in 1965 (Table 8). All but 2 of the lizard species known from the Line Islands (Crombie 1990) have now been found on Caroline. It is perhaps noteworthy that we added 3 species to the atoll list but failed to find 2 species collected in 1965. Since both groups collected lizards opportunistically, rather than systematically, there is evidently much need for further study in this area.

Turtles

We found 3 Pacific green sea turtles (*Chelonia mydas*), a threatened species (McKeown 1978), at Caroline in 1988. Two were swimming over the lagoon reef flats, one west of Arundel, the second east of Ana-Ana. The third was in the open sea about 100 m west of South Island near the "boat entrance." Ron Falconer has seen up to 7

Table 8. Lizards collected on Caroline Atoll, 1965-1988.

Species	Specimens: Clapp & Sibley 1971a	Present Study
Mourning gecko _Lepidodactylus lugubris_	USNM 158355-57	USNM 299773
Polynesian gecko _Gehyra oceanica_	USNM 158353-54	--
Snake-eyed skink _Cryptoblepharus poecilopleurus_	--	USNM 299772
Moth skink _Lipinia noctua_[1]	USNM 158358	
-- _Emoia impar_		USNM 299768-70
Azure-tailed skink _Emoia cyanura_	--	USNM 299771

[1] USNM 158358 has recently been reidentified by R. I. Crombie as _Lipinia noctua_, not _Emoia nigra_, as reported in Clapp & Sibley (1971a).

turtles in the lagoon in a single day. In April and May 1990, AKK saw workers from Tahiti capture and kill a minimum of 4 green turtles in the lagoon, and 2 more were in fishtraps on our departure. Two others entered the lagoon during the following 4 months (R. Falconer, pers. comm.).

In March 1990, AKK and G. Wragg found 3 old nests, presumably of this species, on the northwest coast of Nake within 100 m of the northern tip of the islet. These are the first known turtle breeding records for the atoll. Young (ca. 1922) notes that the copra plantation laborers ate green turtles from September to December each year, and members of the Line Islands Expedition (Grossman & Grossman 1974, Vickers 1974) saw fresh turtle tracks either on South or Nake. The February 1990 storm added large amounts of sand to Caroline's shorelines, providing potential new habitat for turtle nesting.

Terrestrial Mammals

None of the terriers (see Pt. I) that were introduced to control rats on South Island early this century (Young ca. 1922) have survived (F. Sibley, pers. comm.; R. Falconer, pers. comm; pers. obs.). In May 1990 the Falconers kept a dog and cat on Motu Ana-Ana. The dog regularly visited all the Southern Leewards and accompanied the family in their sailing canoe throughout the atoll. As a result of our recommendations, the cat was removed from Caroline in October 1990. The dog, with the family, vacated Caroline in summer 1991.

Bennett (1840) noted "rats of a red-brown color," the first reference to rodents on Caroline. Dixon (1884) found that rats were "not numerous" and that they nested "just at the base of the fronds" of the coconuts. Two specimens collected by the POBSP proved to be *Rattus exulans* (Clapp & Sibley 1971a), an uncommon mammal restricted to South Island.

The 19th and 20th century settlers found rats (presumably *R. exulans*) to be extremely abundant and very destructive to the coconut plantations; they contributing greatly to the twice-abandonment of copra enterprises on Caroline (Young ca. 1922, Maude ca. 1938). They voraciously devoured both growing and fallen nuts, as well as dried copra. Being arboreal, they also lapped the juices of the flower stalks, preventing nut development. In 1920 alone, over 4,600 were trapped on South (Maude ca. 1938). Thousands more were killed by terriers introduced in a vain attempt to control them.

We found rats on almost every islet, especially in or near coconut palms and *Pisonia* trees. We recorded them during daylight hours on most transects. Each night at our campsites on Long and South we noticed groups of 10-20, so tame as to approach within one meter while we were eating. Rats evidently undergo wide population fluctuations, as they were less abundant in March and May 1990 than in September 1988.

We suspect that rats periodically reach most motus, and that those apparently lacking rats (such as Noddy Rock) are too small and/or depauperate to support a resident population. Because *R. exulans* is a known seabird predator (C. Kepler 1967, Fleet 1972, Norman 1975), the restriction of some species (i.e. Red-tailed Tropicbird) to small islets may be due to rat populations on larger islets.

Rats were an abundant nuisance on Ana-Ana; the Falconers trapped over 1,300 animals in 2 years and, like the pioneers before them, relied upon a dog to help keep them at bay.

Marine Mammals

On March 14, 1990, members of the Line and Phoenix Islands Expedition observed a minimum of 10 Pacific bottlenose dolphins (*Tursiops gilli*) in the open sea about 500 m off the southeast corner of South Island.

F. COCONUT CRABS

The coconut crab (*Birgus latro*, Coenobitidae), the largest terrestrial invertebrate on earth, ranges throughout the tropical Indo-Pacific (Pt. I, Pl. 21). It is highly esteemed as a source of food throughout its range, and for this reason is rare or absent on or near most inhabited islands. Because it is heavily exploited by man, it is under consideration for endangered species status (E. Reese, pers. comm.).

Since March 1990, dozens of Caroline's coconut crabs have been killed for food and for preservation in formalin as curios for the Tahiti tourist market. Because of the increasing numbers of visitors to Caroline, it is important that Caroline's coconut crabs receive protection.

History: A Californian malacologist, C. D. Voy, was the first to collect coconut crabs (*Birgus latro*) on Caroline in 1875 (Pilsbry & Vanatta 1905). They are not mentioned again until 1910, when Young (ca. 1922) wrote that "hundreds of great Coconut Crabs were seen: 40 large ones were caught by the crew of the schooner in an hour" on South Island. Young also noted that coconut crabs were considered a great nuisance by plantation laborers, who killed them mercilessly. Evidently they dug up newly planted nuts and snipped off emerging shoots. On smaller motus, visited less frequently than South, Nake, and Long, these depredations were difficult to control. Thus the small motu plantations were abandoned soon after initial planting, resulting in a remarkably rapid recovery of the original vegetation (see Pt. I, Sect. G). Today large crabs once again burrow beneath the boles of well-maturing *Pisonia* forests which their ancestors helped recreate less than 70 years ago.

It is hardly credible that these enormous crabs, the dominant terrestrial animal of the atoll environment, could have been overlooked by almost all visitors prior to the 20th century. The only plausible explanation is that coconut crab populations were reduced drastically each time Caroline was inhabited: 1846 to at least 1852, 1885 to 1901, and 1916 to 1929. Voy collected them in 1875, 10 years before initial land clearing began; Young noted them in a 1910 visit 9 years after the first abandonment of the plantations, and again from 1916 on when copra enterprises were begun anew. From 1916 to 1920 land clearing was far more extensive, involving most of the area of the Windward Islets and Nake (Pt. I, Table 13), and thus a very large number of homeless coconut crabs would have been evident at that time. Again, mass slaughter reduced their numbers until the main group of copra-cutters left in 1929. Since then, occasional Polynesian and other visitors have taken crabs, but since the island was basically uninhabited for 60 years, their numbers have recovered substantially. "Great numbers" were seen in 1974 (Gilbert and Elllice Is. Govt. 1974). However, activities since 1990 do not bode well for the species (see Sect. G). It is of interest in this regard that members of the 1934 Mangarevan Expedition saw no coconut crabs on nearby Flint Island (R. Fosberg, pers. comm.), nor were they mentioned in an historical summary paper on Flint by Maude (ca. 1942), but some were found at the southern tip of the island in 1906, which at that time was covered in virgin mixed broadleaf forest, including large *Pisonia grandis* trees, within whose boles the crabs burrowed (E. Campbell 1908; A. Kepler, in prep.). Today Flint has perhaps the greatest density of coconut crabs in the world (A. Kepler

1990b). Human pressures have likely operated on Flint as on Caroline (A. Kepler, in prep.).

Distribution and habitat preference: In 1988 and 1990, coconut crabs were abundant in the *Cocos* plantations of South and Nake, and present, in varying densities, on 12 other motus (Fig. 17). Although generally associated with *Cocos*, we found them in woodlands of *Pisonia, Cordia*, and *Tournefortia*, as well as on rubble beaches (especially after dusk). Although capable of surviving without coconut palms, these crabs appear to seek them out. In the open understory of the tall plantations, or in groves of only one or 2 palms, telltale piles of shredded coconut husk fibers (Pt. I, Pl. 53) disclosed the crab's presence.

Because the prevalent coarse rubble substrates on Caroline are hard to burrow into, coconut crabs occupied a variety of shelters: mounds of fallen coconuts and rotting palm fronds (to 1.5 m high), piles of rubble pushed against tree roots, sand burrows, tunnels within the *feo* (Pt. I, Pl. 21), or large cavities in the boles of mature *Pisonia* trees. Coconut crabs also use a variety of shelters on the Tokelau Islands (Yaldwyn & Wodzicki 1979), Flint, and Palau (AKK, pers. obs.).

Numbers: Though conspicuous and slow-moving, coconut crabs are very difficult to count. Environmental variables such as rainfall, tide, lunar cycle, and population size and age classes all affect their activity (Reese 1965; Helfman 1977a, b). Although unable to conduct mark-recapture studies, we did make incidental observations on the numbers of individuals seen during transect and perimeter surveys. Coconut crabs are generally nocturnal, but we often found them during daylight, at times exposed on coral gravel beaches close to the waterline. E. Reese (pers. comm.) suggests that the abundance of rats occupying the same habitat may "force" the crabs to be more diurnal, as has been reported from the Indian Ocean. Our estimate of the population on Caroline is approximately 2,200 individuals, based on the number of daytime observations, the area covered, and the fact that only one out of every 3 or 4 individuals may be present on any given night (Helfman 1977b, Reese 1987).

Foraging: Since the first detailed description of coconut crabs in 1705, their shy, curious habits have been the subject of folklore, speculation, and misinformation (see Reyne 1939). No scientist has yet published a documented account of a coconut crab actually opening a coconut (Helfman 1979), which is widely held to be their consummate foraging behavior. Helfman is convinced that they do so, as he has found piles of coconut fiber and observed crabs walking with husked, opened nuts in places where he was the only other possible coconut husker. We repeat Helfman's (1979) assertion that coconut crabs *do* husk fallen coconuts. The piles of finely separated fibers (Pt. I, Pl. 53) we encountered are totally different from those produced by stick or machete husking, the 2 methods commonly employed by Pacific peoples. The crab tears virtually every fiber off individually, a process so painstakingly slow it probably takes days. We did not observe this on Caroline, but in March 1990 AKK, on uninhabited Flint Island, observed a large male coconut crab that had just husked a coconut and was enlarging

Figure 17. Distribution map of coconut crabs on Caroline Atoll.

a small crack in the center of the smooth nut in a manner similar to that described by Gardiner (1907) in Reyne (1939, p. 297). In June 1992, AKK also encountered large males eating coconut meat and husking fibers in the Southwest Palau Islands, Micronesia.

On Caroline we observed the aftermath of coconut crab-Sooty Tern predation or scavenging. On Brothers Islet, several entrances and pathways leading to coconut crab holes were strewn with the feathered skeleta of adult Sooty Terns (and possibly Brown Noddies), along with numerous, freshly snipped branches of *Pisonia* up to 0.7 m long (Pt. I, Sect. H). This was also recorded on Tridacna Islet by Clapp & Sibley (1971a) for Sooty Tern eggs and chicks, and by Helfman (1979) and Reese (1987) on Enewetak, Micronesia.

<u>Sizes</u>: Living in a rich environment free of predators, coconut crabs attain huge sizes on Caroline. The bodies of the largest males were as wide as a full-sized, unhusked coconut, giving them weights of at least 4 kg (G. Helfman, pers. comm.). Thorax widths for 10 crabs (2 females with eggs, 8 males) averaged 129 mm. The thorax of the largest male measured 200 mm across, making it, along with many measured on Flint in 1990 (A. Kepler 1990b), one of the largest recorded coconut crabs in the world (the previous record was 178 mm in Helfman 1977a), with an age estimated to exceed 40 years (E. Reese, pers. comm.).

G. CONSERVATION: ATTRIBUTES OF INTERNATIONAL SIGNIFICANCE

Caroline's exceptional attributes need to be elucidated, for the atoll has remained essentially unknown, even to some who have evaluated its worth (King 1973; Stoddart 1976; Garnett 1983, 1984). There are few, if any, islands remaining in the Pacific that can claim the impressive array of natural features exhibited by Caroline (Nicholson & Douglas 1969). We believe that it is imperative that this atoll, which has managed to escape large-scale, permanent human disturbance, should remain undeveloped.

Currently Caroline is uninhabited and has been since ca. 1930 except for a single family from 1987-1991. There are no roads, vehicles, stores, jetties, or services (water, sewage, or food), and no communication. There is no passage into the lagoon or safe sea anchorage.

<u>Lack of Major Disturbances</u>

Man's presence anywhere--especially on pristine or near-pristine islands--generally brings rapid, often irreversible, changes. One of the most important of Caroline's attributes is its relative lack of disturbance and very few exotic plant species. Aside from obvious human impacts on South, Nake, and Ana-Ana, the majority of its motus are dominated by indigenous vegetation and its reefs are basically pristine. There is no obvious pollution to alter the chemistry of the lagoon, beyond the flotsam and jetsam that litter the beaches. It is thus an exceptionally clear and clean ecological laboratory that presents a lagoon ecosystem before extensive disturbance by man, providing marine biologists with opportunities to study undisturbed natural communities; for example, the maze of patch reefs in the lower half of the lagoon has the highest recorded density of living *Tridacna* (20/.25 m^2) ever recorded (Sirenko & Koltun 1992). This is one of the few undisturbed world populations of this species (Pt. I, Pl. 25). In addition to conventional ecological studies, biomedical research could investigate the causes and treatment of ciguatoxicity of fishes and crabs. Such topics are increasingly important as more islands are subjected to disturbance and pollution. For example, the abundant red snapper (*Lutjanus vaigiensis*) and red spotted crab (*Carpilius maculatus*), both notoriously poisonous, are safe to eat on Caroline. Caroline, lacking the problems and pollution that beset many other Pacific islands, could serve as a "control island."

Terrestrial Ecosystems

Caroline's motus of varied age and size classes provide excellent examples of substrate and vegetation development, accompanied by an increasing diversity of bird life. On account of its relatively low human disturbance and rapid forest recovery, especially since 1920, Caroline is thus also an outdoor laboratory for terrestrial ecosystems: many motus have recovered so remarkably they are almost indistinguishable from those which have remained pristine, while others are in different stages of recovery resulting from varied management (or non-management) practices.

Caroline's concentric pattern of plant community development and the relationships of these communities to motu size, shape, and location on the atoll rim could continue to provide insight into evolutionary processes on atolls that are left undisturbed.

Physiography

Caroline offers many opportunities for geological research, under reasonably unmodified conditions. Valuable clues as to the nature of underground water supplies may lead to a better understanding of the regulation of water supplies on inhabited islands. Notable physiographic features include inland upraised reefs (*feo*) and deep sand deposits, coalesced islets, exposed older reefs, lithified beachrock, a conglomerate platform, a "perched lagoon," patch reefs, a nonfunctional *hoa*, and changes in motu size and shape during the past century.

Flora

Caroline's insular flora, typical of central equatorial islands in their natural state and covering 70% of the atoll's land area, is of both national and international importance. The 26 extant plant species are 89% indigenous (possibly 92%), an extremely high figure for anywhere in the world. Six of the 7 plant communities are natural. Lushly wooded, Caroline possesses tall *Pisonia grandis*) forests (Pt. I, Pl. 43), reaching 21 m and occurring on 29 islets. Although less majestic than the prime forests of Washington and Fanning (Northern Line Group)[1], which enjoy a heavier rainfall, those on Caroline are notable: Caroline's 62 ha of *Pisonia* forest may well cover a larger area than on any other Pacific atoll.

Caroline also possesses significant stands of the hardwood *kou* (*Cordia subcordata*), which ranges from Africa to Polynesia, but is now rare in the Pacific. Caroline's groves (Pt. I, Pl. 26), although small and often mixed with other indigenous trees, total 26 ha, possibly the greatest area on any Pacific atoll. The extensive presence of tree heliotrope (*Tournefortia argentea*) is also notable: scrub and forests of this species form 40% of the atoll woodlands (Pt. I, Pl. 47). Caroline's large groves are some of the most unmodified in the Pacific, as elsewhere *Tournefortia* is typically restricted to coastal fringes surrounding anthropogenic plantations (personal observations; Wiens 1962; R. Fosberg, pers. comm.).

Caroline, and its neighbor Flint, are also ideal islands in which to monitor the transition from *Cocos* plantations to a more natural state: rainfall regimes, intensity of management, underground water reserves, slightly differing plant communities, and a wide range of island/islet sizes have resulted in marked differences in revegetation pattern only 60 years after the atoll was abandoned.

Seabirds

Associated with Caroline's plant communities are 11 species of breeding seabirds numbering well in excess of 1,000,000 individuals. Almost every islet harbors nesting populations of up to 9 species (Fig. 18). The populations of most of these species are of national importance (Table 9). For example, Caroline has the fifth largest Red-footed Booby colony in the world. Its Black Noddy and White Tern (Pl. 3) populations are the largest in Kiribati. Under the 1975 Republic of Kiribati Wildlife Conservation Ordinance (amended in 1979), all known seabirds, migrant shorebirds, and endemic land birds are "fully protected throughout the Gilbert Islands" (Garnett 1983, p. 128). However, their protected status is in doubt on Caroline, due to attempts to commercially develop the island. Caroline deserves protection similar to the 5 closed areas on Christmas Island and the 7 island sanctuaries in the Line and Phoenix Groups (Garnett 1983), preferably accompanied by on-site enforcement.

---

[1]In 1992, these forests were evidently altered considerably by immigrant Gilbertese and cyclonic weather.

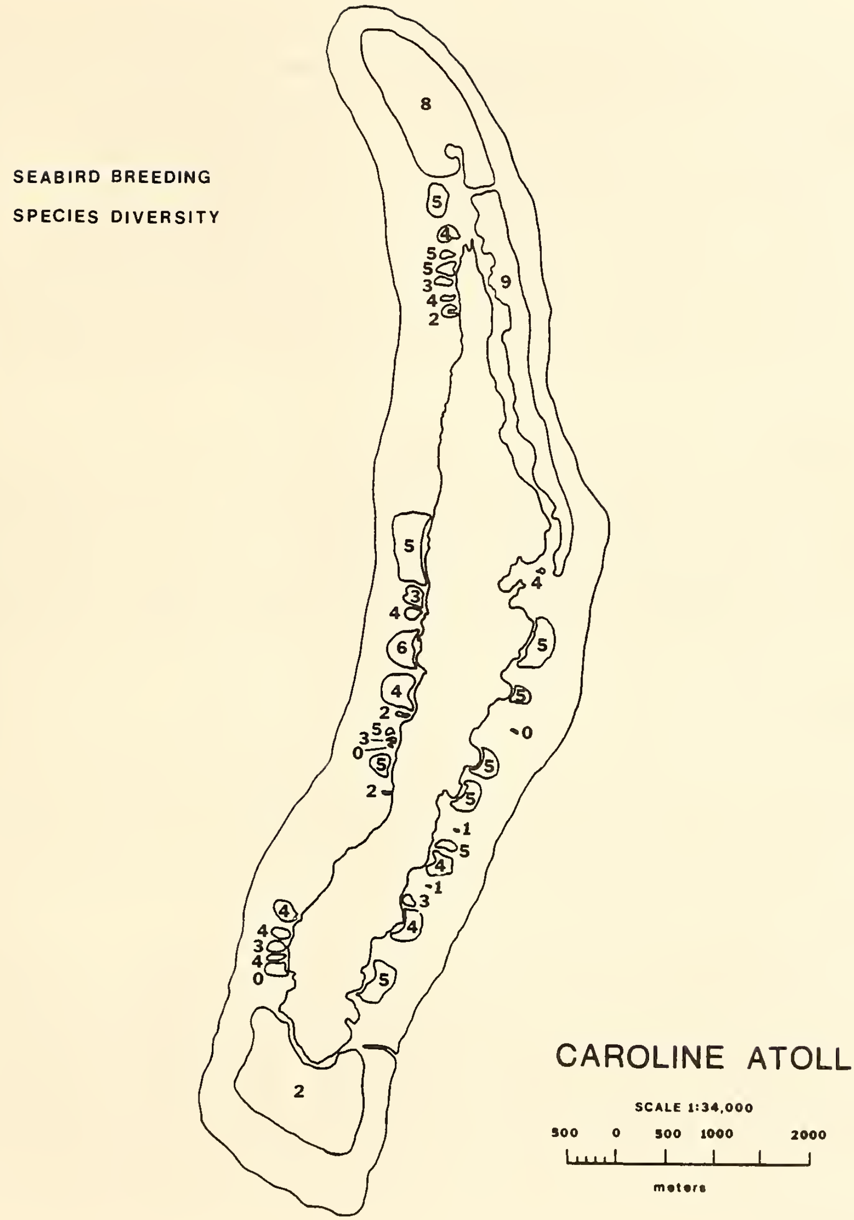


Figure 18. Seabird breeding species diversity by islet, Caroline Atoll.

Table 9. Comparative abundance of Caroline's breeding seabirds in the Line Group.

Species	Estimated Population	Comparative Abundance in the Line Group
Red-tailed Tropicbird	300[a]	Second largest population
Masked Booby	400	Fourth largest population
Brown Booby	40	Third largest population
Red-footed Booby	7,000	Third largest population
Great Frigatebird	6,100	Third largest population
Lesser Frigatebird	200+	--
Sooty Tern	912,000	Third largest population
Brown Noddy	3,000	Third largest population
Black Noddy	17,000	Largest population (largest in Kiribati)
Blue-gray Noddy	<10	--
White Tern	8,000	Largest population (largest in Kiribati)

[a] Based upon nest count in 1990.

Shorebirds

Caroline is an important wintering ground for the Bristle-thighed Curlew, a rare shorebird and candidate for the U.S. Fish and Wildlife Service Endangered Species list. Some subadults remain all year on the atoll. As adult curlews pass through a flightless phase on their Pacific wintering grounds, islands such as Caroline provide a predator-free environment for this vulnerable phase of their life history.

Coconut Crabs

Caroline is exceptional in harboring a robust population of coconut crabs (Fig. 17; Pt. I, Pl. 21). These large invertebrates are abundant in the *Cocos* plantations of South and Nake and are found in good numbers in the indigenous *Pisonia* forests on most larger motus.

Turtles

Although green turtles are not abundant on the atoll, worldwide populations of these marine reptiles have suffered so greatly from overexploitation that remote, predator-free islands such as Caroline provide important, though small, sanctuaries. Since 1978 the Pacific green sea turtle has been reclassified by the United States Department of the Interior as threatened and the Pacific hawksbill sea turtle as endangered.

Archaeology

From an archaeological point of view, Caroline houses one intact Tuamotuan *marae* (ancient religious site) and another smaller site, partly destroyed by storms. The main site (Pt. I, Fig. 3, Pl. 36), basically undisturbed since the 1870s, is a relic of prehistoric occupation worthy of protection and study, being the only one of its kind in the Line and Phoenix Islands.

Current Conservation Status

Caroline Atoll is owned by the government of the Republic of Kiribati and does not enjoy any legal protection (Garnett 1983, Ministry of the Line and Phoenix Islands, pers. comm.). Over the last 50 years it has been leased to private individuals who have scarcely altered the atoll. The benign management of the past is no guarantee for the future, and from October 1989 to the present, pressures to develop the atoll have mounted rapidly. Proposed schemes included an airstrip, a blasted channel through the reef, a hotel, a casino, logging, and commercial harvest of fish and lobsters. In March 1990, commercial harvesting of fish, the taking of coconut crabs, and illegal killing of green turtles began, emphasizing that no island, however remote, is guaranteed protection through isolation.

In addition, during the past 3 years Caroline has become more visited than ever before, mostly without the knowledge or consent of the Kiribati government. During 1990 yachts were present almost the entire year, and in 1989 a cruise ship landed tourists who visited several seabird colonies during midday heat. At this time Polynesian crewmen presented some passengers with fresh tail feathers from Red-tailed Tropicbirds (B. Danielsson, pers. comm.). There are many reasons why Caroline is inappropriate for resident tourists or development (remoteness, distance from medical aid, no regular water supply, no passage into the lagoon, mosquitos, etc.; see A. Kepler 1990a). Caroline could support a limited number of ship-based ecotourists each year, but indiscriminate visitation by yachts or other craft, such as developed into an increasing problem at Suvarov, in the Cook Islands (G. MacCormack, pers. comm.), should be discouraged.

Recommendations for an international preserve began in January 1989. During the 1990 ICBP expedition to the Line Islands, team leaders discussed conservation matters with Kiribati government officials and key scientists in French Polynesia. We obtained photodocumentation of illegal land clearing and wildlife disturbance during the last 2 visits to Caroline (A. Kepler 1990a, b, c). As a result, the Kiribati government considered altering their plans for the development of Caroline in favor of wildlife preservation.

In 1990 and 1991, The Nature Conservancy of Hawaii attempted to establish a triple-island preserve on Caroline, Vostok, and Flint through negotiations with Kiribati officials on Tarawa. These negotiations failed, and the Kiribati government leased Caroline (and Flint) for 55 years to the person responsible for the schemes and illegal activities noted above.

H. LITERATURE CITED

Amerson, A. B., Jr. & P. S. Shelton. 1976. The natural history of Johnston Atoll, Central Pacific Ocean. Atoll Res. Bull. 192:1-479.

Ashmole, N. P. 1963. The Fairy Tern *Gygis alba* on Ascension Island. Ibis 103b:365-378.

______. 1968. Breeding and molt in the White Tern (*Gygis alba*) on Christmas Island, Pacific Ocean. Condor 70:35-55.

Bennett, F. D. 1840. Narrative of a whaling voyage round the globe from the year 1833-36, Vol. I. Bibliotheca Australiana 46:1-402.

Bogert, C. 1937. Birds collected during the Whitney South Sea Expedition. XXXIV. The distribution and migration of the Long-tailed Cuckoo (*Eudynamis taitensis* Sparrman). Am. Mus. Novit. 933:1-12.

Brown, W. C. 1956. The distribution of terrestrial reptiles in the islands of the Pacific Basin. Proc. 5th Pac. Sci. Conf. 3A:1479-1491.

Campbell, E. 1908. Flint Island Eclipse Expedition, Jan. 3, 1908. Selected pages from an unpublished diary by the wife of Director W. W. Campbell, Lick Observatory, California, 51 pp.

Clapp, R. B. 1967. Line Islands. Unpubl. report, 32 pp.

______ & F. C. Sibley. 1967. New records of birds from the Phoenix and Line Islands. Ibis 109:122-125.

______. 1968. Additional new records of birds from the Phoenix and Line Islands. Ibis 110:573-575.

______. 1971a. Notes on the vascular flora and terrestrial vertebrates of Caroline Atoll, Southern Line Islands. Atoll Res. Bull. 145:1-18.

______. 1971b. The vascular flora and terrestrial vertebrates of Vostok Island, South-central Pacific. Atoll Res. Bull. 144:1-10.

Clark, L., R. E. Ricklefs & R. W. Schreiber. 1983. Nest-site selection by the Red-tailed Tropicbird. Auk 100:953-959.

Crombie, R. I. 1990. Herpetofauna of Oceania: Island lists and species distributions. In prep.

______ & D. W. Steadman. 1986. The lizards of Rarotonga and Mangaia, Cook Island Group, Oceania. Pac. Sci. 40:44-57.

Diamond, A. W. 1971. The ecology of the sea birds of Aldabra. Phil. Trans. Roy. Soc. Land. B260:561-571.

______. 1973. Notes on the breeding biology and behavior of the Magnificent Frigatebird. Condor 75:200-209.

______. 1975a. The biology of tropicbirds at Aldabra Atoll, Indian Ocean. Auk 92:16-39.

______. 1975b. Biology and behaviour of frigatebirds *Fregata* spp. on Aldabra Atoll. Ibis 117:302-323.

Dinsmore, J. J. 1972. Sooty Tern behavior. Bull. Fla. St. Mus. Biol. Sci. 16(3):129-179.

Dixon, W. S. 1884. Notes on the zoology of Caroline Island, *in* Report of the operations of the American expedition to...Caroline Island.... Nat. Acad. Sci. Mem. 2:90-92.

Dorward, D. F. & N. P. Ashmole. 1963. Notes on the biology of the Brown Noddy (*Anous stolidus*) on Ascension Island. Ibis 103b:447-457.

Ellis, D. H., C. B. Kepler, A. K. Kepler & K. Teeb'aki. 1990. Occurrence of the Long-tailed Cuckoo (*Eudynamis taitensis*) on Caroline Atoll, Kiribati. Emu 90:202.

Fleet, R. R. 1972. Nesting success of the Red-tailed Tropicbird on Kure Atoll. Auk 89:651-659.

______. 1974. The Red-tailed Tropicbird on Kure Atoll. A.O.U. Monogr. 16:1-64.

Garnett, M. C. 1983. A management plan for nature conservation in the Line and Phoenix Islands. Pt. I: Description, 318 pp; Pts. II, III: Policy and recommendations, 131 pp.

______. 1984. Conservation of seabirds in the South Pacific region: A review. ICBP Technical Publication 2:547-557.

Gibson-Hill, C. A. 1950. Notes on the birds of the Cocos-Keeling Islands. Bull. Raffles Mus. 22:212-270.

Gilbert and Ellice Islands Government. 1974. Line Islands expedition report. Reports by the Minister and Secretary of Natural Resources, Director of Agriculture, and Fisheries Officer. 71 pp. See also Grossman & Grossman (1974), Vickers (1974), and Ward (1974), Pt. I, this vol.

Gill, R. E. 1990. Ecology of curlews in French Polynesia during spring, *in* Summary of the proceedings from the workshop on Bristle-thighed Curlews, Anchorage, Alaska. R. E. Gill and C. M. Handel, eds. 22 pp.

Gill, R. E. & R. L. Redmond. In press. Distribution and habitat associations of Bristle-thighed Curlews on Rangiroa Atoll. 15 pp.

Grossman, H. & H. Grossman. 1974. Preliminary report (land vertebrates), *in* Line Islands expedition report, Gilbert and Ellice Islands Government. P. 72-89.

Helfman, G. S. No date. Ecological considerations for the management of the coconut crab, *Birgus latro* (L.). Unpub. ms., 8 pp.

______. 1977a. Ecology and behavior of the coconut crab, *Birgus latro* (L.). M.S. Thesis, Univ. of Hawaii, Part I, 109 pp.

______. 1977b. Temporal distribution of crabs. M.S. Thesis, Univ. of Hawaii, Part II, 158 pp.

______. 1979. Coconut crabs and cannibalism. Nat. Hist. 88(9):76-83.

Johnsgard, P. A. 1981. The plovers, sandpipers, and snipes of the world. Lincoln, Univ. Nebraska Press.

Kepler, A. K. 1990a. Caroline Atoll: Fact sheet, including conservation attributes and recommendations. Unpublished ms., 12 pp.

______. 1990b. Flint Island: Fact sheet. Unpublished ms., 6 pp.

______. 1990c. Vostok Island: Fact sheet. Unpublished ms., 6 pp.

______. (In prep.). Flint Island, South-central Pacific Ocean: Its history and biota.

Kepler, C. B. 1967. Polynesian rat predation on Laysan Albatrosses and other Pacific seabirds. Auk 84:426-429.

______. 1969. Breeding biology of the Blue-faced Booby on Green Island, Kure Atoll. Publ. Nuttall Orn. Club 8:1-97.

______. 1978. The breeding ecology of sea birds on Monito Island, Puerto Rico. Condor 80:72-87.

______ & A. K. Kepler. 1978. The sea birds of Culebra and its adjacent islands, Puerto Rico. The Living Bird 16:21-50.

King, W. B. 1973. Conservation status of birds of Central Pacific islands. Wilson Bull. 85:89-103.

Markham, Sir Clements. 1904. The voyages of Pedro Fernandez de Quiros, 1595-1606, 2 Vols., Hakluyt Society, Series II, Nos. 14-15. The Hakluyt Society, London.

Marks, J. S., R. L. Redmond, P. Hendricks, R. B. Clapp & R. E. Gill. 1990. Notes on longevity and flightlessness in Bristle-thighed Curlews. Auk 107(4):779-781.

Maude, H. E. ca. 1938. Caroline Island. Unpublished ms., 8 pp.

______. ca. 1942. Flint Island: Part N. Author's ms., of unknown origin, 4 pp. (printed but not published).

McKeown, S. 1978. Hawaiian reptiles and amphibians. The Oriental Publishing Company, Honolulu, Hawaii, 80 pp.

Nelson, J. B. 1969. The breeding ecology of the Red-footed Booby in the Galapagos. J. Anim. Ecol. 38:181-198.

Nelson, J. B. 1976. The breeding biology of frigatebirds--a comparative review. The Living Bird 14:113-155.

______. 1978. The Sulidae: Gannets and boobies. Oxford Univ. Press, Oxford, England, 1,012 pp.

Nicholson, E. M. & G. Douglas. 1969. Draft check list of Pacific oceanic islands. Micronesica 5(2):327-463.

Norman, F. I. 1975. The Murine rodents *Rattus rattus*, *exulans*, and *norvegicus* as avian predators. Atoll Res. Bull. 182:1-13.

Paulding, H. 1931. Journal of a cruise of the United States Schooner *Dolphin*. G. & C. & H. Carvill, New York, 258 pp.

Perry, R. 1978. Visit to the Southern Line Islands. Atoll Pioneer 4:6-7, 6 Jan., 1978.

Perry, R. 1980. Wildlife conservation in the Line Islands, Republic of Kiribati (formerly Gilbert Islands). Envir. Cons. 7:311-318.

Pratt, H. D., P. L. Bruner & D. G. Berrett. 1987. A field guide to the birds of Hawaii and the tropical Pacific. Princeton Univ. Press: Princeton, New Jersey, 409 pp.

Rauzon, M. J., C. S. Harrison & R. B. Clapp. 1984. Breeding biology of the Blue-gray Noddy. J. Field Ornithology 55:309-321.

Reese, E. S. 1965. The ecology of the coconut crab, *Birgus latro* (L.). Bull. Ecol. Soc. America 46(4):191-192. Abstract.

______. 1987. Terrestrial environments and ecology of Enewetak Atoll, *in* The natural history of Enewetak Atoll, Vol. I. Pp. 187-202.

Reyne, A. 1939. On the food habits of the coconut crab (*Birgus latro* L.), with notes on its distribution. Archives néerlandaises de zoologie 3:283-320.

Schreiber, R. W. & N. P. Ashmole. 1970. Seabird breeding seasons on Christmas Island, Pacific Ocean. Ibis 112:363-394.

Sibley, F. C. & R. B. Clapp. 1967. Distribution and dispersal of Central Pacific Lesser Frigatebirds, *Fregata ariel*. Ibis 109:328-337.

Sirenko, B. I. & V. M. Koltun. 1992. A study of the benthic communities of Caroline Atoll (Line Islands, Pacific Ocean), *in* Results of the First Joint US-USSR Central Pacific Expedition (BERPAC), Autumn 1988. P. A. Nagel, ed. U.S. Fish and Wildlife Service, Washington, D.C. Chapter 1.4, pp. 166-169.

Stonehouse, B. 1962. The tropic birds (genus *Phaethon*) of Ascension Island. Ibis 103b:124-161.

Vickers, E. H. 1974. Report on a tour of all the Line Islands and some Phoenix Islands by the Director of Agriculture, G.E.I.C., *in* Line Islands expedition report, 1974, Gilbert and Ellice Islands Government. Pp. 39-66.

Yaldwyn, J. C. & K. Wodzicki. 1979. Systematics and ecology of the land crabs (Decapoda: Coenobitidae, Grapsidae and Gecarcinidae) of the Tokelau Islands, Central Pacific. Atoll Res. Bull. 235:1-53.

APPENDIX

Preliminary List of Arthropods

The knowledge of Arthropods on Caroline is limited to 15 Lepidopterans collected by Dr. Palisa during the Solar Eclipse Expedition (Dixon 1884), a scant list of common insects (beetle, gnat, etc.) in the same paper, and a preliminary collection of 82 specimens made by Graham Wragg and AKK in 1990. The latter, identified by David Preston and Scott Miller (B. P. Bishop Museum, Honolulu, Hawaii), contained no endemics, consisting primarily of widespread Pacific species and immatures identifiable only to family level.

Although our collection is also scant, it is the second collection of Arthropods from Caroline and the only one containing species other than Lepidoptera: *Isometrus maculatus* (scorpion), *Scolopendra subspinipes* (centipede), *Anoplolepis longipes* (long-legged ant), Isopoda, lepidopterans (larvae and pupa), dermestid beetles (larvae and adults), cockroaches (Dictyoptera), Hibboboscidae adult (Diptera), Isopoda, Nitidulidae (immature and adults, Coleoptera), Curculionidae (Coleoptera), immature Hemiptera (Lygaeidae), Scolopendriidae immature, spiders (Arachnida).

Plate 1. Incubating Red-tailed Tropicbird, Bo'sun Bird Islet, Caroline Atoll, 25 September 1988. The nest scrape is in fine coral rubble under a *Tournefortia* shrub.

Plate 2. Masked Booby adult with egg on coarse coral rubble substrate with *Portulaca* mat, Nake Island, Caroline Atoll, 26 September 1988.

Plate 3. White Tern adult with egg in typical nest site, a dead *Tournefortia* branch, South Island, Caroline Atoll, 23 September 1988.

ATOLL RESEARCH BULLETIN

NOS. 397-398

NO. 397. PART I. HISTORY, PHYSIOGRAPHY, BOTANY, AND ISLET DESCRIPTIONS
BY ANGELA K. KEPLER AND CAMERON B. KEPLER

NO. 398. PART II. SEABIRDS, OTHER TERRESTRIAL ANIMALS, AND CONSERVATION
BY CAMERON B. KEPLER, ANGELA K. KEPLER, AND DAVID H. ELLIS