PLANT BIOGEOGRAPHY OF GUAM

Edited by

Lynn Raulerson

Contributing Authors

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With an Introduction

by

F. R. Fosberg

UNIVERSITY OF GUAM

MARINE LABORATORY

Technical Report No. 69

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INTRODUCTION

F. R. Fosberg

Under sponsorship of the University of Guam Marine Laboratory a course entitled "Island Phytogeography" was offered in the Biology Department of the University during the 1980 Summer Session. A part of the work in this course was a project involving study and mapping of the areal aspects of a botanical feature on Guam. The nature and extent of the phenonmenon were left up to each student.

A serious constraint was the short duration of the course, six weeks, of which at least the first week was used in orientation and choice of a subject. The students were at various levels of maturity and experience, as well as having different interests. Since no strictures were placed on sources of information and no requirements of originality were imposed nothing of much interest was expected.

Hence it was a gratifying surprise, when the papers and maps were turned in at the end of the course, to find that, with very few exceptions, not only new but interesting information was presented. Much of this was of a nature that it seemed a pity to have it go to waste and be forgotten, as it would surely be of interest as base-line data for future ecological and distributional work.

The suggestion was made that if the authors cared to polish up their papers to a shape fit for publication, a means be sought to get them printed, to form part of the permanent data-base for the ecology and geography of Guam.

Dr. Lynn Raulerson agreed to serve as editor, and the Marine Laboratory offered to provide funds for duplication and distribution of the lot as a number or volume of their Technical Report series. The accompanying papers are the result. It is hoped that this may serve as an example and stimulus to comparable accomplishments by students in other courses dealing with the ecology and geography of Guam.

THE VEGETATION OF AN ISLET IN TUMON BAY, GUAM

David R. Gardner

ABSTRACT

Plants of 15 species and 11 families were inventoried and mapped. The islet vegetation resembled the vegetation of undisturbed areas of the Tumon Bay shoreline. A variety of dispersal mechanisms faciliated plant colonization and the islet vegetation has varied from year to year. Weather variables such as extended dry seasons and typhoons have had considerable impact on the islet vegetation, which has also been influenced by proximity to the reef margin, salt spray and oceanic waves.

INTRODUCTION

Scientific interest in the small, unconsolidated islet on the outer reef flat of south Tumon Bay, Guam, has been mildly active since the mid-1960's (Randall, pers. comm.). However, research on the islet's biota has not been formally pursued or published.

The islet, which was without vegetation in 1968-1969, has undergone several colonizations. It gradually acquired plant and animal life, but in 1976 Supertyphoon Pamela, with winds in excess of 200 mph, completely destroyed it. Again, regrowth has occurred.

This paper presents an inventory and mapping of existing vegetation on the islet and a comparison of this vegetation with that of the Tumon Bay shoreline. Possible colonization patterns were discussed, with reference to dispersal mechanisms, reef currents, and biogeographical relationships. The study site is shown in Figs. 1, 2, and 3.

MATERIALS AND METHODS

Initial Investigations

This study was conducted using methods presented by Cain and Castro (1959), and Gates (1949). United States Geological Survey topographic maps and aerial photographic rectified mylar-based maps were first studied to clarify the location, shape and general dimensions of the Tumon Bay study area.

Plant specimens were placed in plastic bags and taken to the University of Guam for identification. Stone (1970), Moore and McMakin (1979) and assistance from F. R. Fosberg aided in the identification of the plant species.

Islet side-profile photographs taken with a 600 mm telephoto lens, 400 ASA 135-36 film, from the Tumon View Apartments at the north end of Tumon Bay provided additional information. These photographs were later used to produce a side-profile islet vegetation diagram (Fig. 4).

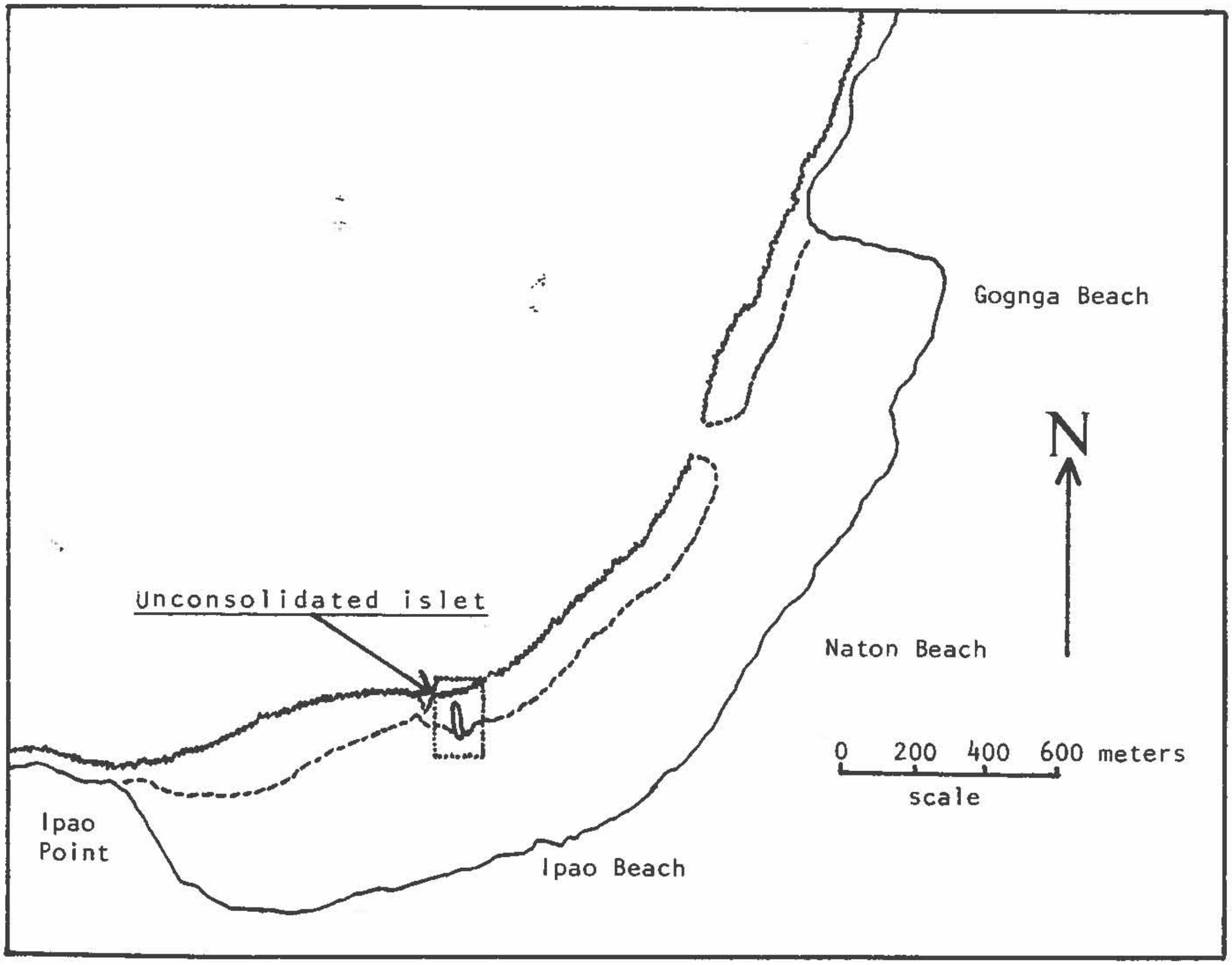

Fig. 2. Map of Tumon Bay, Guam, showing islet study site and Tumon Bay shoreline. Map is after FitzGerald, 1976.

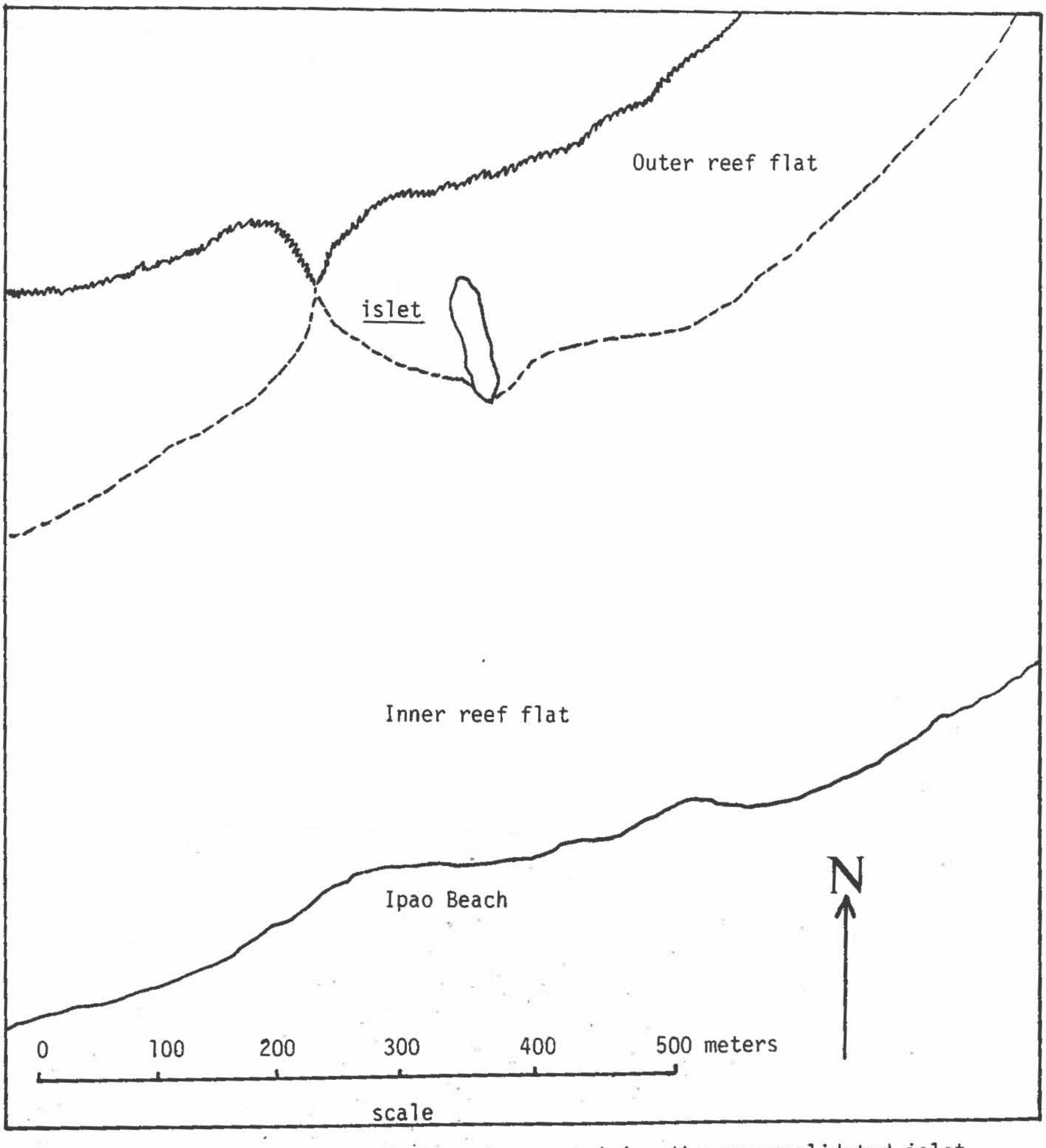

Fig. 3. Map of the portion of Tumon Bay containing the unconsolidated islet that is the primary study site. Map is after USGS rectified aerial photographic maps, 1977.

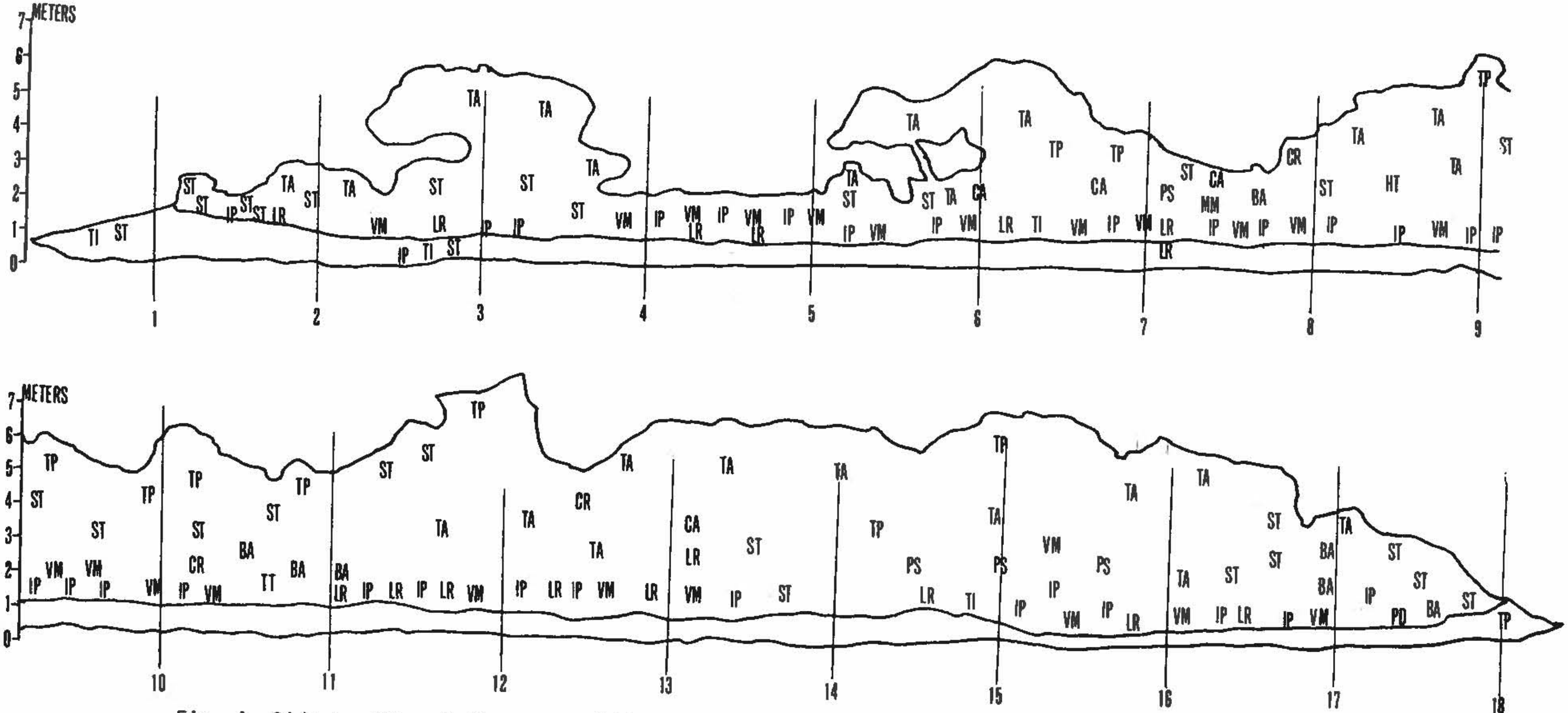

Fig. 4. Side profile of the unconsolidated islet, Tumon Bay, Guam. Height scale and transect numbers are indicated. The lower strip of the diagram is a continuation of the upper strip. See Table 2 for key to species abbreviations.

Study Area Description: Physiography

The islet was 100 m long from north-northwest to south-southeast (Figs. 2 and 3). Originally one of the boulder zones on the southern outer reef flat of Tumon Bay, the islet has accumulated on the reef-rock pavements, storm-wave deposited boulders, coral-algal-mollusk rubble, gravel and bioclastic beach sand (Randall et al., 1976) to an altitude of 2 m above mean sea level. The islet seaward tip was 85 m from the reef margin; its landward tip was 375 m from the nearest Tumon Bay shoreline.

Tumon Bay (Figs. 2 and 5) is crescent-shaped, faces northwest and extends over a distance of 3 km (FitzGerald, 1976). Randall et al., (1976) noted that Tumon Bay reef was lined with 2666 m of beach shoreline. They defined a beach as an "accumulation of unconsolidated deposits along the shoreline, with their seaward boundary being the low tide or reef-flat platform level and extending in a landward direction to the strand vegetation or first change in physiographic relief or topographic structure". The sand along this bay was bioclastic except for two sites of artificially maintained beaches (Randall et al., 1976).

Rocky shorelines separated the beach shoreline at two places. Gognga Beach was separated from Naton Beach by a 170 m long stretch of rocky shoreline at the northern part of the bay. This moderate-to-steep terrace of Mariana Limestone was edged with numerous limestone blocks and boulders which buttressed onto the reef flat. The Reef Hotel was built upon this rocky terrace.

The second section of rocky shoreline separated Naton Beach from Ipao Beach. This rocky shoreline, again a terrace of Mariana Limestone, extended 220 m between the Dai-Ichi Hotel beach area and the Continental Hotel. The Continental Hotel was built upon the southern, lower portion of this limestone terrace; its beach is man-made, under constant maintenance, and covers a beach-rock pavement. A more coarse beach extended from the Continental Hotel to the Hilton Hotel at the southern end of Tumon Bay. This beach area was also constantly groomed and dredged to keep the lighter and finer sand present. During the time of this project, the beach area in front of the Pacific Islands Resort adjacent to the public park beach was bulldozed. Coral-algal-mollusk rubble was removed and excavated sand was put in its place. Pioneer plants were also uprooted and removed.

Both ends of Tumon Bay were rocky shoreline lined by raised terraces of Mariana Limestone. These shorelines were high, with numerous cliffs, and they edged narrow reef flats which were buttressed by large limestone blocks and boulders.

Study Site Mapping and Vegetational Analysis

Data collection and treatment were modified somewhat from techniques listed by Gates (1949) and by Fosberg (1953). A metric surveyor's tape was set on the islet from the landward tip to the seaward tip. At 5 m intervals, starting with the station 5 m above the high-tide level, cross-sectioned transects of the islet were taken. These transects were angled so that one end was pointed towards the seaward end of the old Guam Memorial Hospital and the other end was aimed towards the southern end of

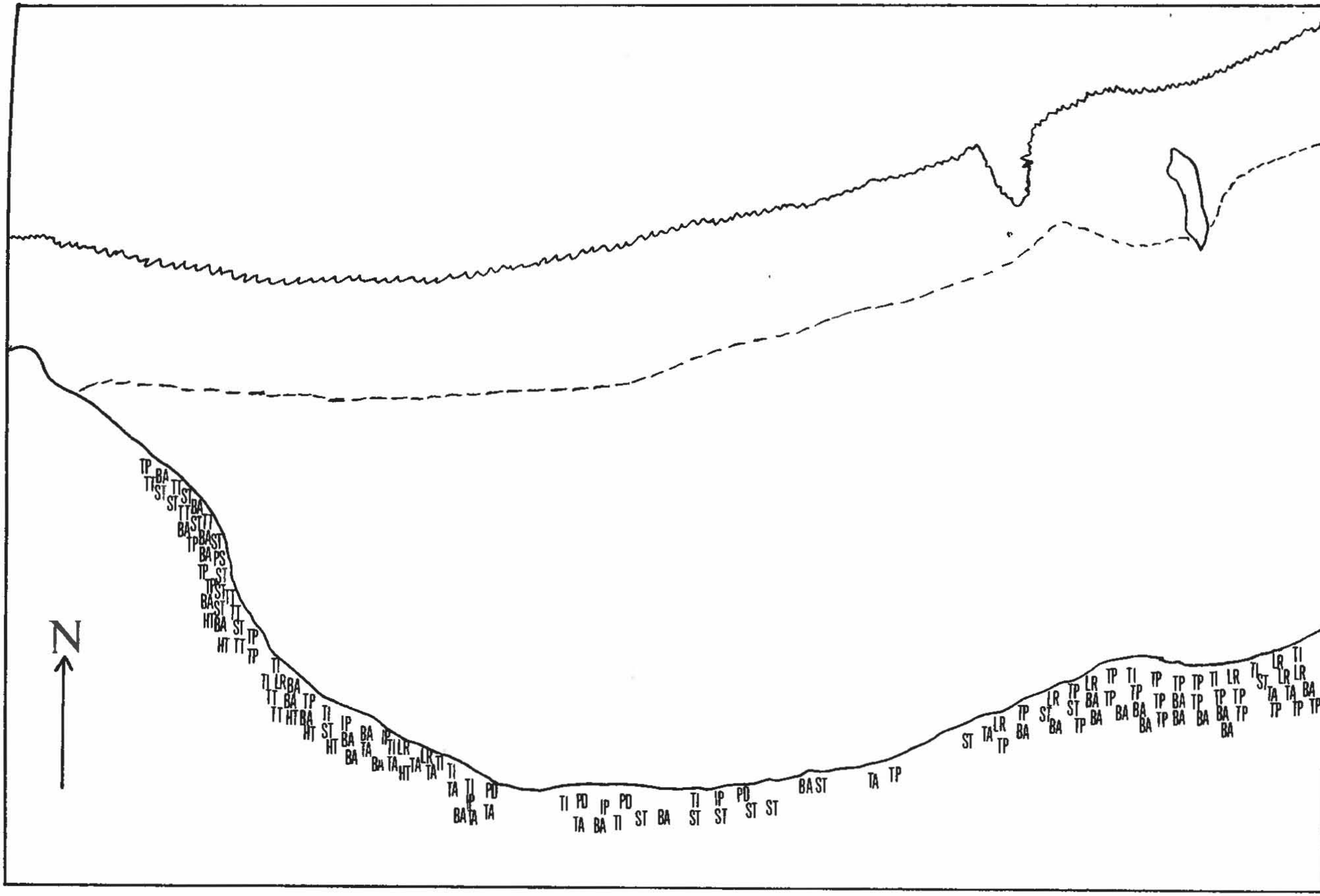

Fig. 5A. Outline map of Tumon Bay shoreline, south end, showing species sites. See Table 2 for abbreviations.

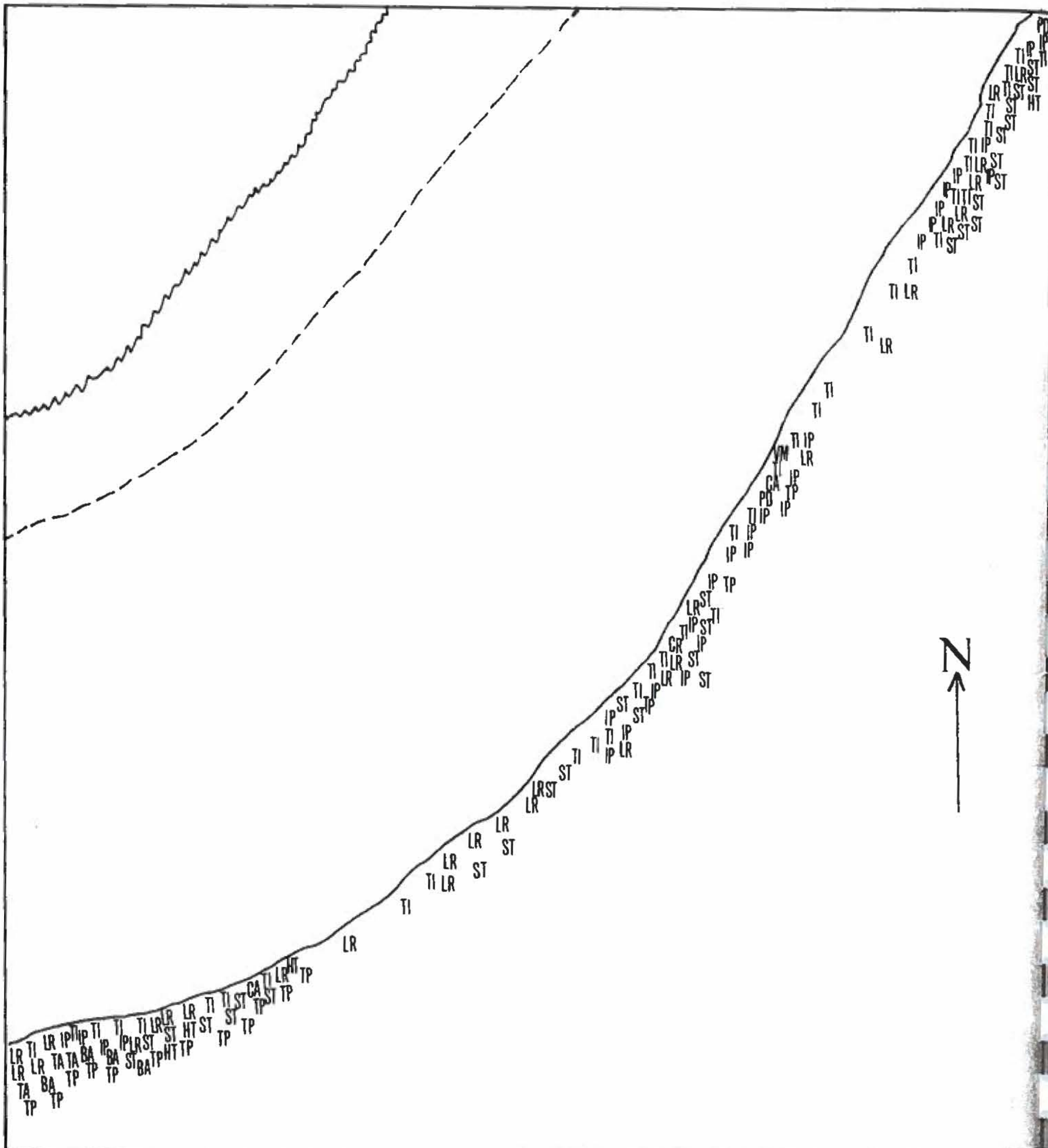

Fig. 5B. Outline map of Tumon Bay shoreline, central (east) section, showing species sites. See Table 2 for species abbreviations.

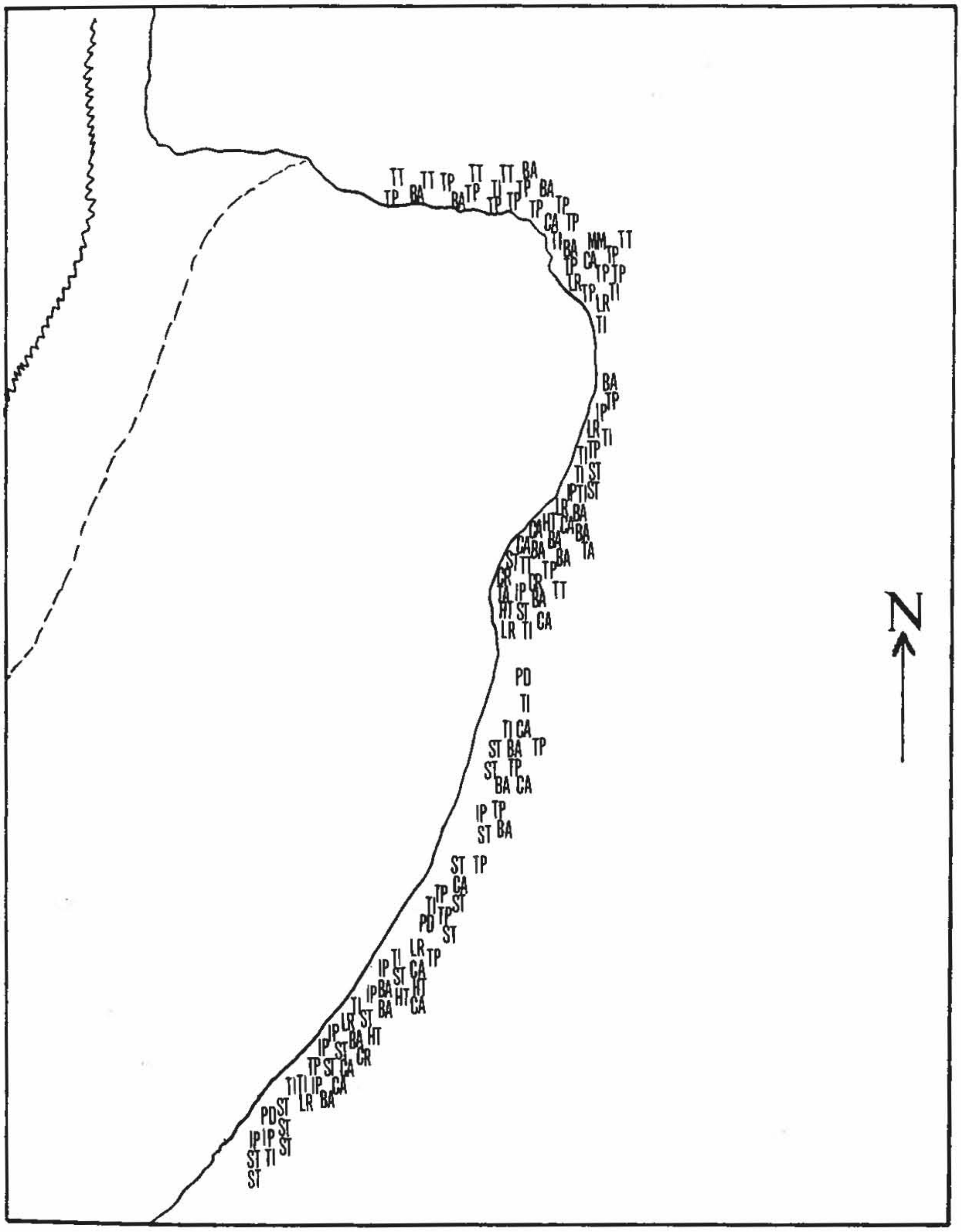

Fig. 5C. Outline map of Tumon Bay shoreline, north end, showing species sites. See Table 2 for species abbreviations.

the Tumon View Apartments. All plant types observed within a 2.5 m distance from either side of a transect line were noted. A list of all islet plants was compiled (Table 1). Plant positions were indicated on a sketch map of the islet (Fig. 6), after which their occurrences were tallied and tabulated (Table 2).

Islet species occurring on the Tumon Bay shore were noted during three walks along the entire length of the bay. Their locations were plotted on photocopies of aerial photographic maps. These plottings were then transferred to an outline diagram of Tumon Bay (Fig. 5) and were tabulated in Table 2.

DISCUSSION

Islet Vegetation

Fifteen species of plants grew on the small islet on the south Tumon Bay outer reef flat (Table 1). The islet plants were primarily those of strand vegetation as defined by Fosberg (1953), Moore and McMakin (1979), Muniappan (1976), Stone (1970), Walter (1971) and Wiens (1962); species included, in order from the beach to the islet's center, Ipomoea pes-caprae, Vigna marina, Scaevola taccada, Tournefortia argentea, Thespesia populnea, Hibiscus tiliaceus, Barringtonia asiatica, and Canavalia rosea. Three pioneering grasses occurred on disturbed or otherwise barren areas of the islet.

Non-strand plants were also found on the islet. The weedy Passiflora suberosa formed a thin mat over much of the clear areas under overhanging Tournefortia, Thespesia and Scaevola. Although Triphasia trifolia, Colubrina asiatica and Melanolepis multiglandulosa var. glabrata were typical limestone forest plants (Stone, 1970), specimens of the first 2 species on the islet seemed to endure the harsh conditions on the islet quite well, but those of Melanolepis did not; most appeared to be desiccated, with brown and yellow leaves.

During the last few weeks in July the vegetation on the islet became exceedingly lush and almost succulent looking, which may have resulted from increasing amounts of rainfall. Although some of the pioneer plants may rely on soil water held by capillary action near the substrate surface, the larger and more deeply rooted plants must utilize a small basal ground water (Ghyben-Herzberg lens) formation (Wiens, 1962). A major indication that this freshwater reservoir existed was the thick mat of Enteromorpha clathrata (Roth) which grew on the islet's landward intertidal zone. According to FitzGerald (1976), this filamentous green algae has an optimum growth at 30‰ salinity. This is less than the average oceanic salinity of 35-36°/₀₀, and indicates an influx of fresh water.

Comparison of Islet Vegetation with Tumon Shore Vegetation

The Tumon Bay shore vegetation was typical strand vegetation, altered by human impact. There were numerous residential or hotel-public beach front areas where the native vegetation was cleared away (Fig. 5). Along most of the beach, however, strand vegetation could be found, and zonation was

Table 1. A checklist of the plants on the unconsolidated islet, Tumon Bay, Guam.

Scientific Name	Common Name
MONOCOTYLEDONAE	
GRAMINEAE	
Lepturus repens (G. Forster) R. Brown	Lasaga
Paspalum distichum L.	Salt grass
Thuarea involuta (G. Forster) R. Brown ex Roemer and Schultes	Lasaga
DICOTYLEDONAE	
BORAGINACEAE	
Tournefortia argentea L. f.	Hunig
CONVOLVULACEAE	
Ipomoea pes-caprae (L.) R. Brown	Alalag-Tasi; Beach Morning Glory
EUPHORBIACEAE	
Melanolepis multiglandulosa var. *glabrata* (Muell.-Arg.) Fosberg	Alom
GOODENIACEAE	
Scaevola taccada (Gaertner) Roxburgh	Nanaso
LECYTHIDACEAE	
Barringtonia asiatica (L.) Kurz	Puting
MALVACEAE	
Hibiscus tiliaceus L.	Pago; Hau; Sea-Hibiscus
Thespesia populnea (L.) Solander ex Correa	Binalo; Kilulu
PAPILIONOIDEAE	
Canavalia rosea (Sio.) De.	Akangkang-Tasi; Seabean
Vigna marina (Burm.) Merrill	Akangkang-Manulasa
PASSIFLORACEAE	
Passiflora suberosa L.	Passionfruit
RHAMNACEAE	
Colubrina asiatica (L.) Brongniart	Gasoso
RUTACEAE	
Triphasia trifolia (Burm. f.) P. Wils.	Limon-China; Limoncito Limeberry

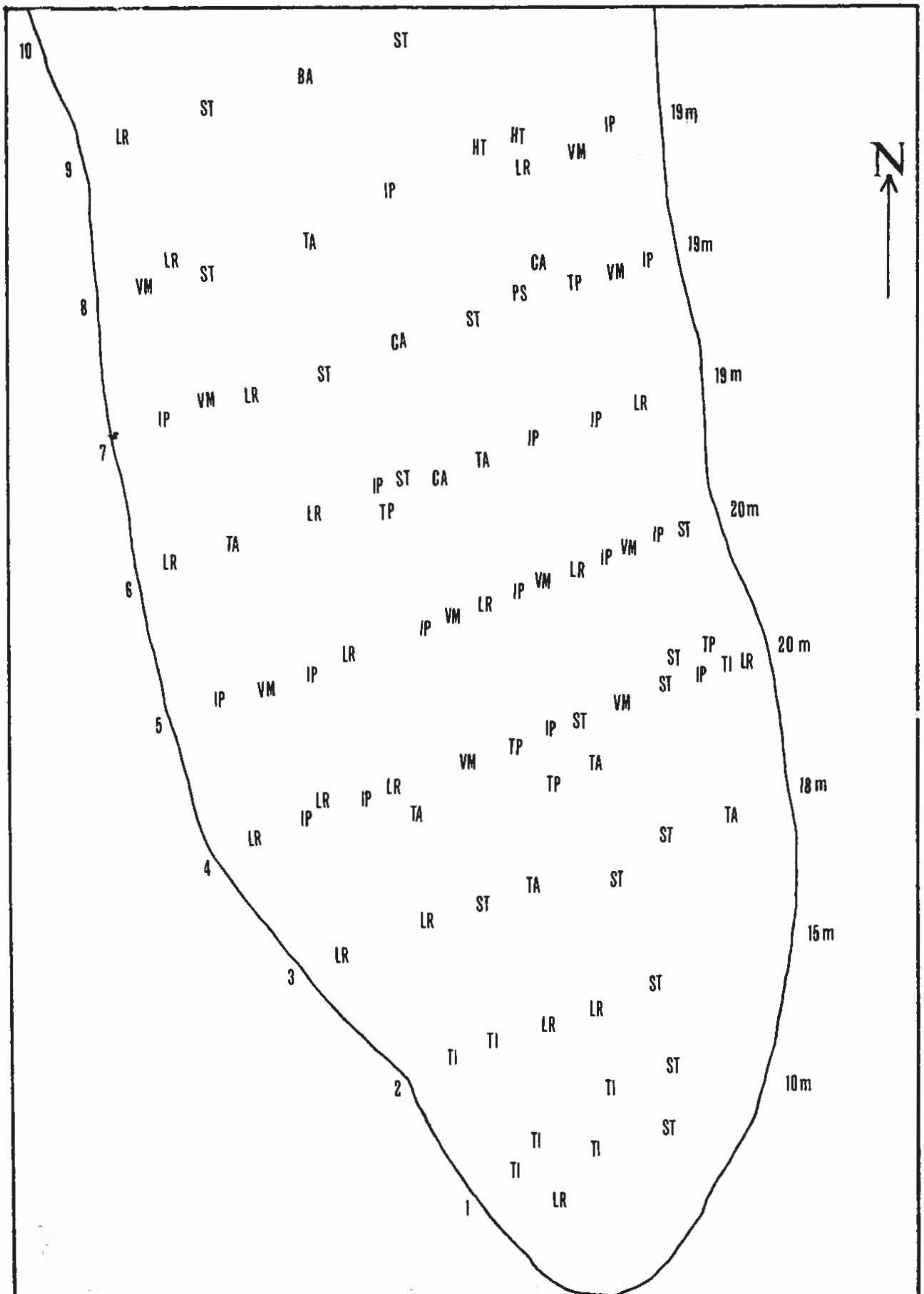

Fig. 6A. Tumon Bay islet, south end, showing plant species on numbered transects of variable lengths. See Table 2 for species abbreviations.

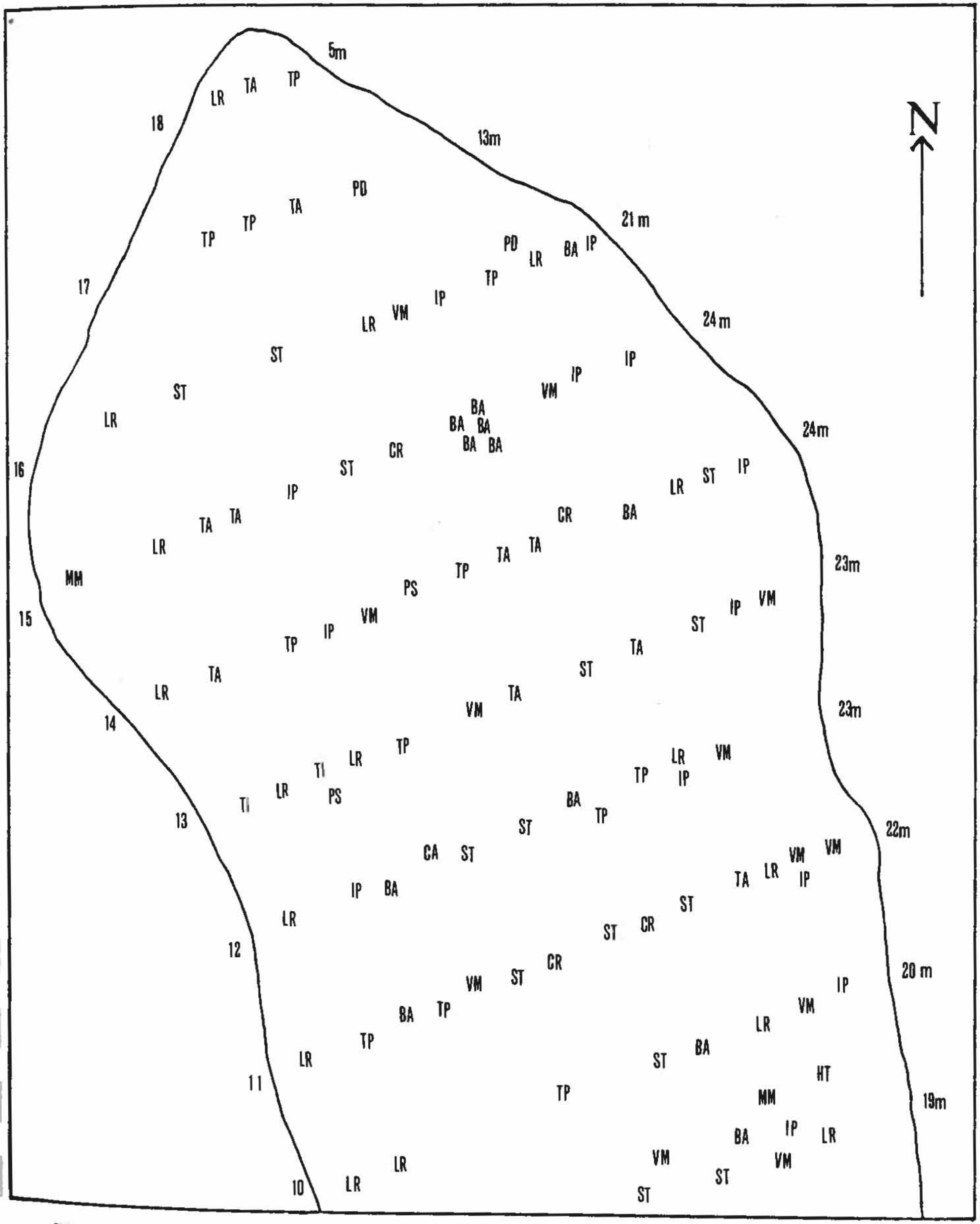

Fig. 6B. Tumon Bay islet, north end, showing plant species on numbered transects of variable lengths. See Table 2 for species abbreviations.

Table 2. Number and percent of total, of plant species occurrence sites for the islet vegetation and Tumon Bay shoreline vegetation.

Scientific Name	Species Abbr.	Islet Sites	%	Shore Sites	%
Lepturus repens	Lr	35	18.22	45	10.71
Paspalum distichum	Pd	1	0.52	8	1.90
Thuarea involuta	Ti	9	4.69	65	15.48
Tournefortia argentea	Ta	20	10.42	17	4.05
Ipomoea pes-caprae	Ip	31	16.15	49	11.67
Melanolepis multiglandulos var. *glabrata*	Mm	2	1.04	1	0.24
Scaevola taccada	St	28	14.58	66	15.71
Barringtonia asiatica	Ba	13	6.77	53	12.62
Hibiscus tiliaceus	Ht	1	0.52	15	3.57
Thespesia populnea	Tp	16	8.33	62	14.76
Canavalia rosea	Cr	5	2.60	4	0.95
Vigna marina	Vm	23	11.98	3	0.71
Passiflora suberosa	Ps	3	1.56	1	0.24
Colubrina asiatica	Ca	4	2.08	14	3.33
Triphasia trifolia	Tt	1	0.52	17	4.05
TOTALS: 15 species		192	99.98	420	99.99

also noticeable. A gradation between sandy shoreline and rocky shoreline existed in a number of places along Tumon Bay. This geological gradation was accompanied by a biological gradation of strand plants.

In the sandy areas, the predominant tree-shrub type was Scaevola taccada. Pioneer and secondary ground cover plants such as Lepturus repens, Thuarea involuta, Ipomoea pes-caprae, Vigna marina, and Canavalia rosea were dense and occasionally sent tendrils and creepers over the beach sand past the high tide level. However, ground cover was absent along rocky shorelines where huge Thespesia populnea and Barringtonia asiatica, which contained numerous epiphytic ferns and mosses, towered over the intertidal zone. Saplings of Barringtonia and Thespesia were the only strand vegetation present under the shady canopy of the adults. On the higher ridges landward, limestone forest vegetation, including Triphasia trifolia, Colubrina asiatica, and Passiflora suberosa, prevailed. Tournefortia argentea were most common in the transition zones between the sandy shore and the rocky shore. On some of the limestone blocks and boulders that buttressed out onto the reef flat and were not shaded by overhanging shoreline canopy, pioneer plants such as Lepturus repens and Thuarea involuta managed to gain a foothold and grew in dense clumps. Scaevola was the most common shrub on both the islet and the Tumon shore.

Possible Dispersal Mechanisms of Islet Vegetation

Colinvaux (1973), Fosberg (1953), Odum (1971), Stone (1970), and Wiens (1962) suggested six methods or mechanisms of plant dispersal and colonization: 1) floating on currents in the bay and the ocean; 2) traveling by wind; 3) carried to the islet by birds--either as undigested seeds having been egested or regurgitated, or through attachment to bird's feet and feathers; 4) coming in on other floating objects; 5) accidental transportation by humans; and 6) intentional introduction by humans.

The Barringtonia and Tournefortia could have arrived on the islet by floating. The buoyant fruiting bodies of both types of plants were found along the edges of the islet near the high-tide level. Scaevola, Passiflora, Triphasia and Lepturus have seeds and fruits that may be eaten by birds, and Lepturus seeds also have a type of clamp mechanism that may attach to a bird's feathers. This clamp opens when dry and releases the seed from the feathers. Scaevola, Lepturus, Thespesia and Canavalia seeds also can float.

Accidental introduction of plants by humans is also a factor. People who place their towels on Tumon shoreline grasses or shrubs and then take the towels with them to the island, serve as mechanisms for seed dispersal. This could account for the excess occurrence of the ground cover plants on the islets in contrast to their relatively sparse occurrence along Tumon Bay (Table 2).

CONCLUSIONS

Fifteen species of plants existed on the islet during the time of this project.

Vegetation of the islet has recovered rapidly from catastrophes, several times.

Islet plants are quite similar to Tumon Bay shoreline plants; both are strand vegetation.

A variety of dispersal mechanisms has facilitated the colonization of the islet.

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THE VEGETATION OF UPPER TOGCHA VALLEY

James Kodama

The Upper Togcha Valley (Fig. 1) is a geologically complex area containing three different geologic members (Fig. 2). A narrow ridge of volcanic Bolanos pyroclastic material is surrounded by Bonya argillaceous limestone and Alifan limestone (Tracey et al. 1964). The Togcha River separates the volcanic member from the limestone members; the east slope of the valley is limestone and the west slope is volcanic. The angles of the slopes vary from vertical to 60 degrees.

The Bolanos deposit, a conglomerate of rocks and boulders in a hard matrix, lay at the base of the valley and made up much of the river bed. Above this on the west slope were layers of weathered clay and sandstone; the east slope was rounded and not as rugged as the hard limestone of northern Guam. The valley bottom was about 30 m below the west slope and 60 m below the east slope.

Because of this geological difference the plants of the east and west slopes were entirely different. At first glance the vegetation seemed to consist of two types of formations, a limestone forest and a savanna (Fosberg, 1960). The east slope was covered with typical limestone forest plants: Intsia bijuga, Hibiscus tiliaceus, Artocarpus mariannensis, Ficus prolixa, Pandanus fragrans, Pandanus dubius, Mammea odorata, Hernandia sonora, Neisosperma oppositifolia, Morinda citrifolia, Flagellaria indica, Piper guahamense and Cycas circinalis.

The west slope was a savanna dominated by Miscanthus floridulus with a scattering of Scaevola taccada, Cerbera dilatata, some planted Casuarina, and Muntingia calabura.

A closer study showed that the base of the western, volcanic slope contained species of the ravine forest formation; they included Areca catechu, Angiopteris durvilleana, Freycinetia reineckei, and Barringtonia racemosa This ravine forest was restricted to areas near the river and thus was not so well developed as the ravine forests of south central Guam.

A weed community was found at the top of each slope. The top was of the west ridge was bulldozed for construction of a townhouse condominium community. Three years ago when the aerial photograph (Fig. 3) was taken there were only a few Leucaena leucocephala (tangantangen) growing on the edges of the disturbed land. At the time of this study Leucaena encircled the whole ridge and had moved down the slope; in some areas it was found almost to the bottom of the valley. Tangantangen is a weedy species that spreads rapidly on disturbed land, and especially well on limestone aggregate which was used as landfill.

The top of the east slope, which has been occasionally farmed and therefore greatly disturbed, also showed some areas of quarrying for gravel; a weed community also occurred here. Leucaena and Carica papaya covered large patches. In addition, a small coconut grove was located at the top edge of the ridge.

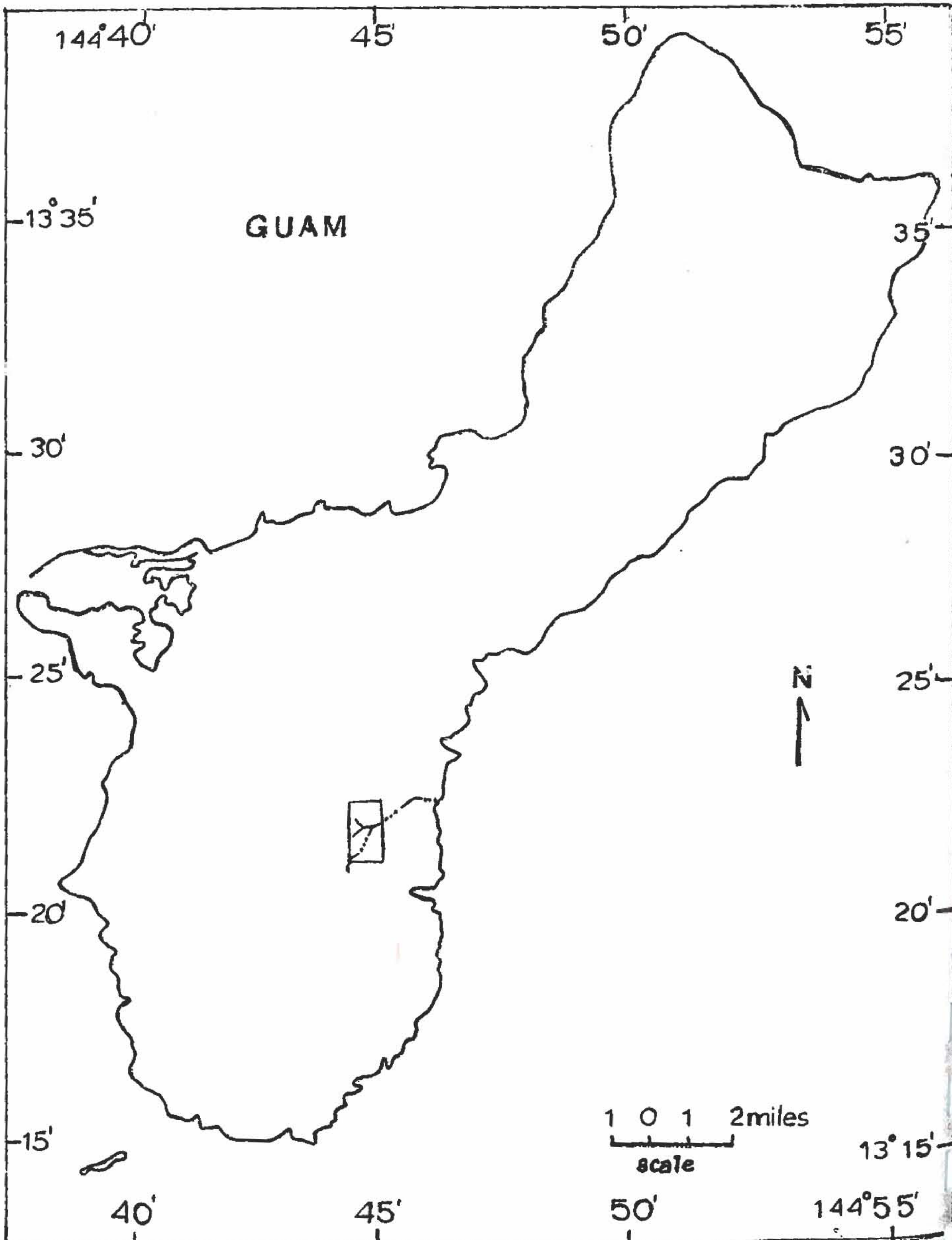

Fig. 1. Upper Togcha Valley. Rectangle is area which is enlarged in Figure 2.

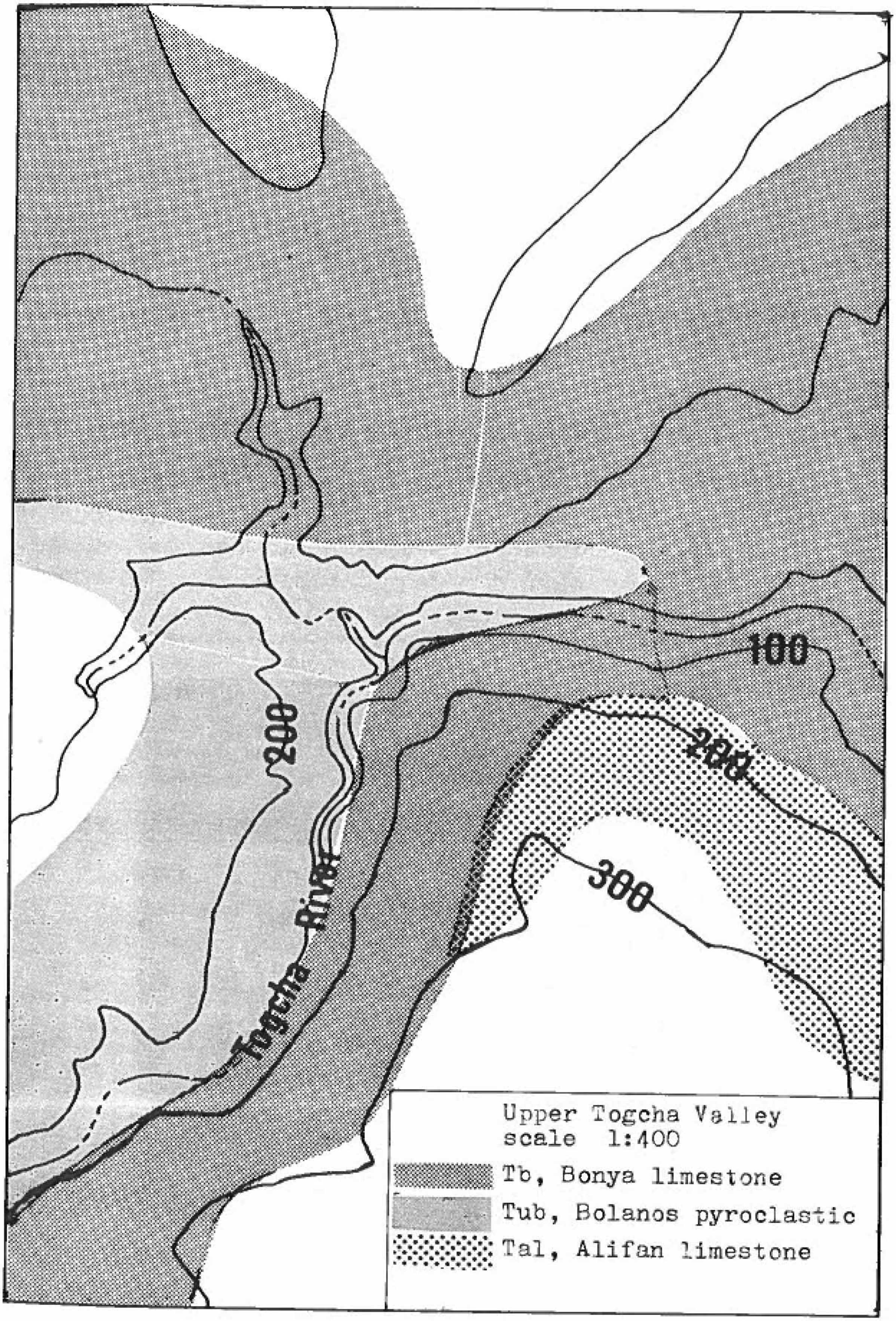

Fig. 2. Geology of Upper Togcha Valley

Throughout the area, especially on the east slope, were many introduced plants such as Annona reticulata, Mangifera indica, Artocarpus altilis and Musa sp.; these were either planted on farms that no longer exist, or escaped from upstream farms.

It is likely that drastic changes will continue to occur in the future. The savanna slope with its limestone fill will probably have more Leucaena; exotic trees will probably be planted by the homeowners to deter erosion. The limestone-slope already has many introduced species, including Vitex, and this means that more native plants will be crowded out and the character of the vegetation will continue to change.

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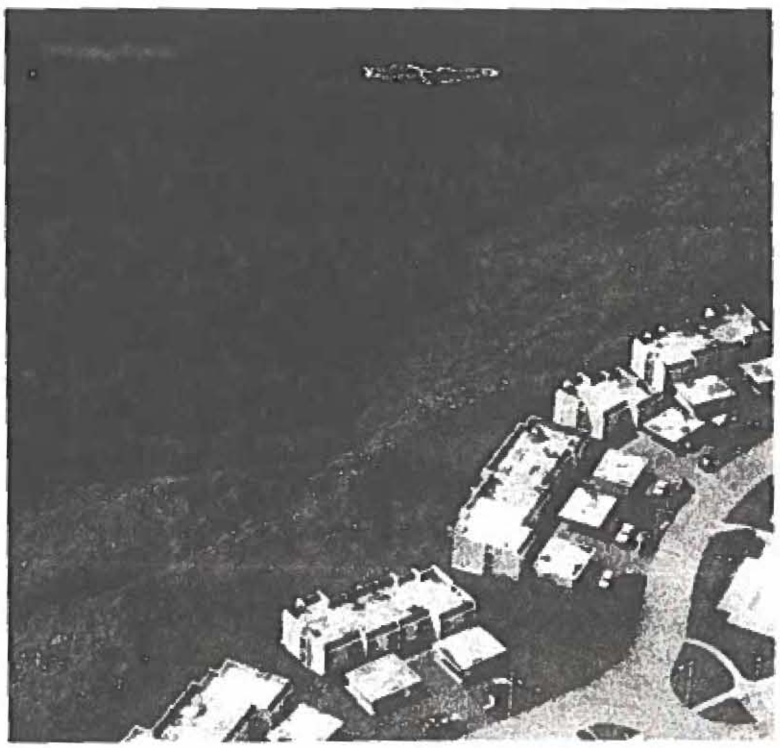


Fig. 3. Upper Togcha Valley: aerial view. Buildings are part of Cas as de Serenidad Condominium.

THE VEGETATION OF COCOS ISLAND, GUAM (MARIANA ISLANDS)

Clifford P. Neubauer and Debie R. Neubauer

ABSTRACT

The strand vegetation of Cocos Island is similar in species and numbers of species to that of other barrier reef islands of Micronesia. Several high island species do appear on Cocos, probably because Cocos is only 1.5 km from the high island of Guam.

Changes may occur in the future. Commercial development projects will bring exotic weeds and ornamentals. Leucaena leucocephala may continue to increase its population area on Cocos, and may eventually out compete the endemic Leucaena insularum. Mangrove areas now occupied by young Rhizophora mucronata may mature, enlarge, and become more diverse with other mangrove species.

INTRODUCTION

A coral island is defined as the portion of a coral reef exposed above sea level at high tide. Coral reefs develop underwater in the tropics and subtropics. Coral limestone may become exposed by a fall in sea level or a tectonic or elastic rise in the sea bottom; sediments may accumulate by wind-driven waves. In-depth discusssions of island formation can be found in Fosberg (1974) and Thomas (1963). Generally, coral islands are classified as either low, or elevated islands. The latter usually possess a more diverse flora than the former because elevated islands have more habitats available and were probably not totally submerged during past elevations in sea level. The number of species comprising an island flora is dependent upon several factors: salinity, rainfall (moisture), island area, isolation, geographic gradient (east to west), and elevation, or any combintation of the above (Fosberg, 1974). Variables such as temperature, elevation, substratum and hydrologic complexities are reduced in coral atolls because of the nature of atolls (Thomas, 1963).

The number of vascular species present on an atoll range from zero on Kingman Reef in the Line Islands and Motu-one in the Marquesas, to approximately 70 on atolls in the Caroline Islands (Fosberg, 1974). Small coral islands which are near high islands generally have a rich flora with many species derived from the nearby high island (Fosberg, 1960).

Small low coral islets are found around the high islands of the Carolines. These low islets correspond almost exactly to atoll islets in their vegetation and environmental conditions. The only difference is that some wet high island species may be found on the low islets (Fosberg, 1960).

Cocos Island (Figs 1 & 2) is a barrier islet approximately four kilometers south of Merizo, Guam (Beaty, 1967). The length and width of the island are 1800 meters and 250 meters, respectively (Elkins et al., 1977). The Cocos atoll-lagoon formation was built by coral polyps from an underwater

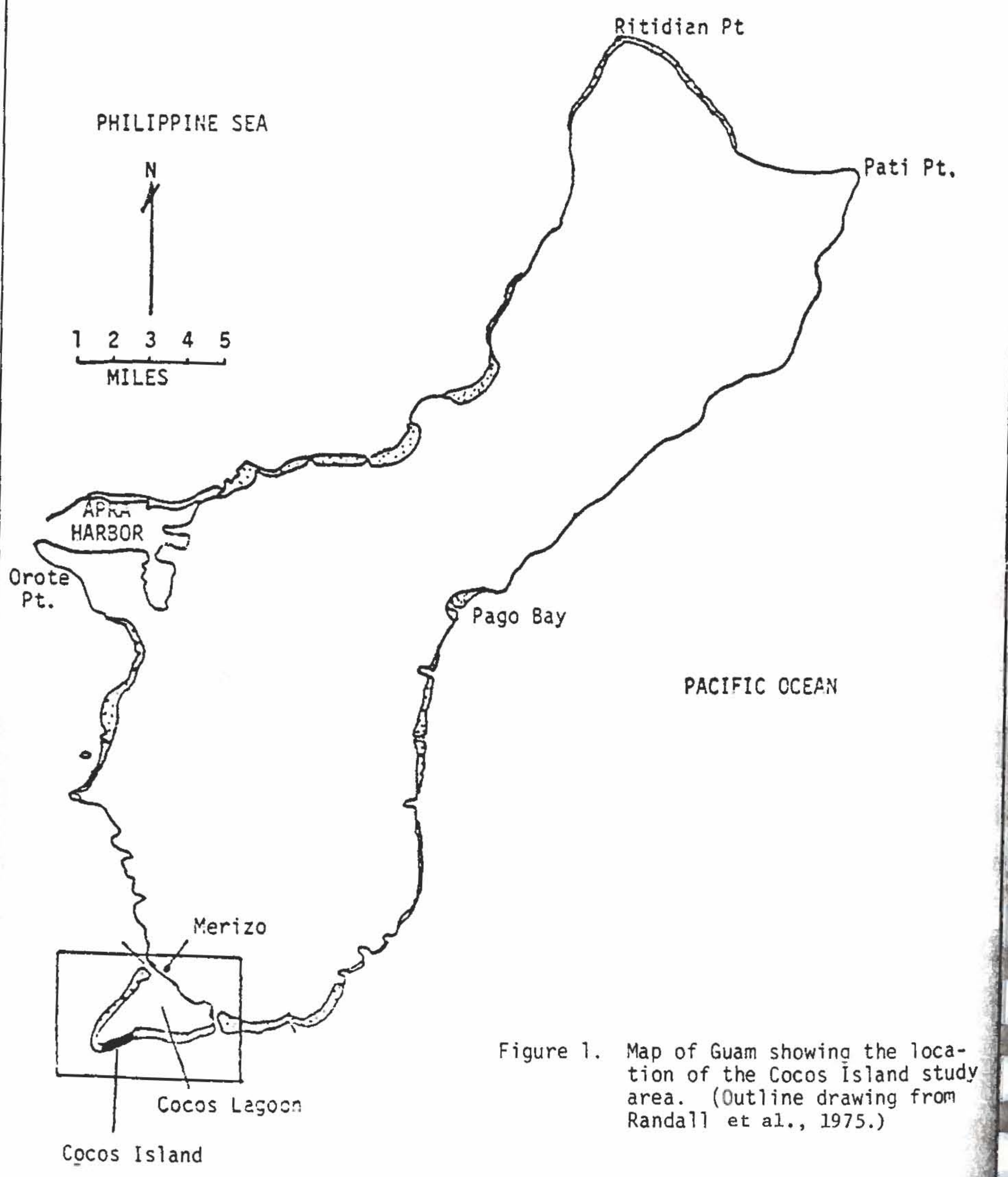


Figure 1. Map of Guam showing the location of the Cocos Island study area. (Outline drawing from Randall et al., 1975.)

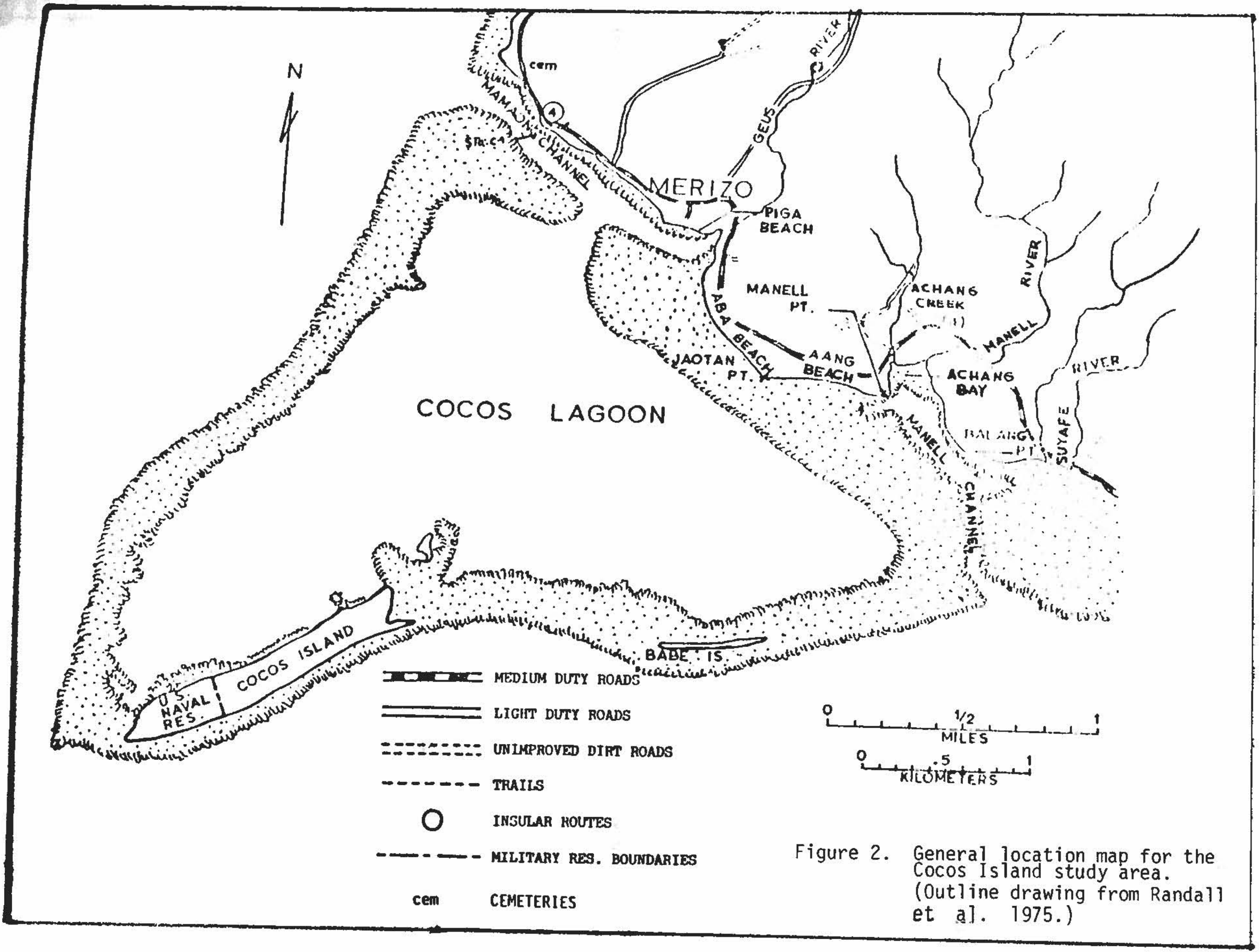


Figure 2. General location map for the Cocos Island study area. (Outline drawing from Randall et al. 1975.)

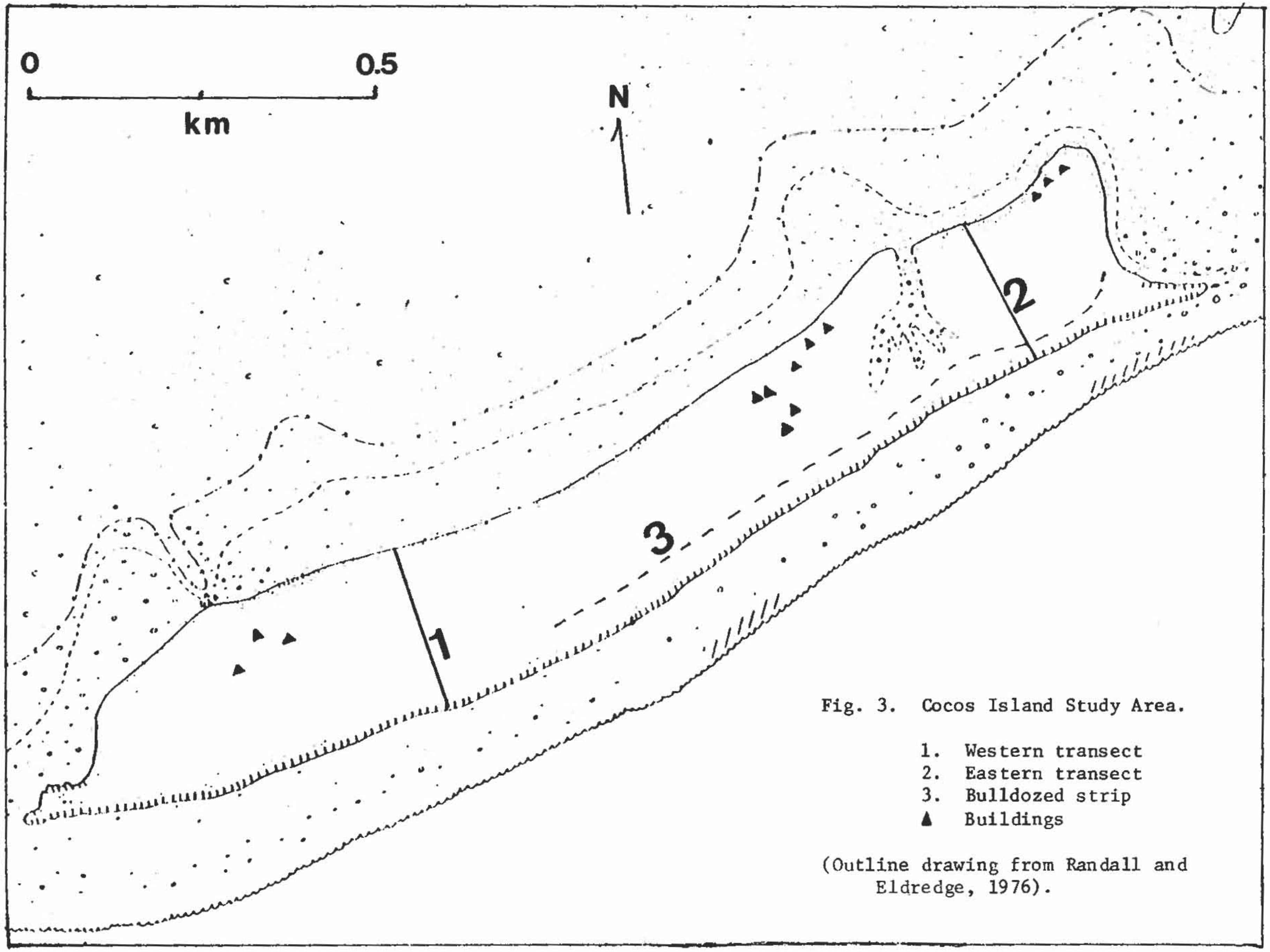


Fig. 3. Cocos Island Study Area.

1. Western transect
2. Eastern transect
3. Bulldozed strip
▲ Buildings

(Outline drawing from Randall and Eldredge, 1976).

block of volcanic rock that broke away from Guam along a fault during ancient earthquake activity (Tracey et al., 1964). Cocos Island is composed of the remains of reef organisms that were broken down into fine particles by storm driven waves. Water currents collected the pieces in an eddy and eventually piled the rubble high enough to break the surface and finally deep enough to support land plants (Elkins et al., 1977).

Tracey et al., 1964) suggest that Cocos Island is composed of beach sand and gravel (beach rock in the intertidal zone and patches of emerged detrital limestone), and has an elevation of less than three meters. The island is adjusted to moderate or calm surf and is easily altered by large swells from the west or southwest directions during typhoons.

Ibanez (1886) briefly describes Cocos Island as having a sandy northern coast and madreporic rock southern coast. At that time, the island was untilled and a few trees were present. The Ignacio Cruz family owned Cocos Island and operated a copra plantation there prior to World War II. The Rothchilds eventually bought the island from the Cruz family (Hutton, 1962). Tracey et al., (1964) stated that Typhoon Allyn (17 November 1949) carried away part of the eastern quarter mile of the island. Fosberg (pers. comm.) said most of the vegetation was destroyed by the typhoon. The U.S. Coast Guard acquired, by condemnation, 8.9 hectares (22 acres) of the west side of the island in 1950 for a LORAN station. Buildings were constructed and the vegetation was continually disturbed until 1966 when the station was abandoned. The Gottwald family bought the remaining 21.9 hectares (54 acres) in 1958.

Fosberg (1954) categorized the vegetation of Cocos as a mixed forest complex, and later classified Cocos Island as a coconut plantation (Fosberg, 1959). Beaty (1967) described the vegetation of Cocos as a thick undergrowth covering most of the interior of the island, with ironwood (*Casuarina equisitifolia*) and coconut palms (*Cocos nucifera*) as the most prominent plants. Randall et al., (1975) briefly mentioned Cocos as a wooded barrier islet approximately one mile long.

MATERIALS AND METHODS

Plants were collected from representative areas of Cocos Island between 30 June and 20 July 1980, pressed, and dried in an electric plant dryer at the University of Guam. Stone (1970), Moore and McMakin (1979), Raulerson (pers. comm.) and Fosberg (pers. comm.) were utilized to identify plant specimens; and voucher specimens are deposited in the University of Guam Herbarium. Two random line transects, perpendicular to the shore and completely traversing the island, were run (Fig. 3). Representative plant specimens were collected and identified along the transects to determine if species zonation occurred.

RESULTS AND DISCUSSION

The vegetation of Cocos Island is presented in Figure 4; the species are listed in Table 1. The western half of the island can be divided into two areas, the undisturbed central and southwestern portion of the island and the disturbed northwestern Coast Guard LORAN Station (Area 7). The vegetation of the undisturbed areas appears to inhabit distinct zones typical of

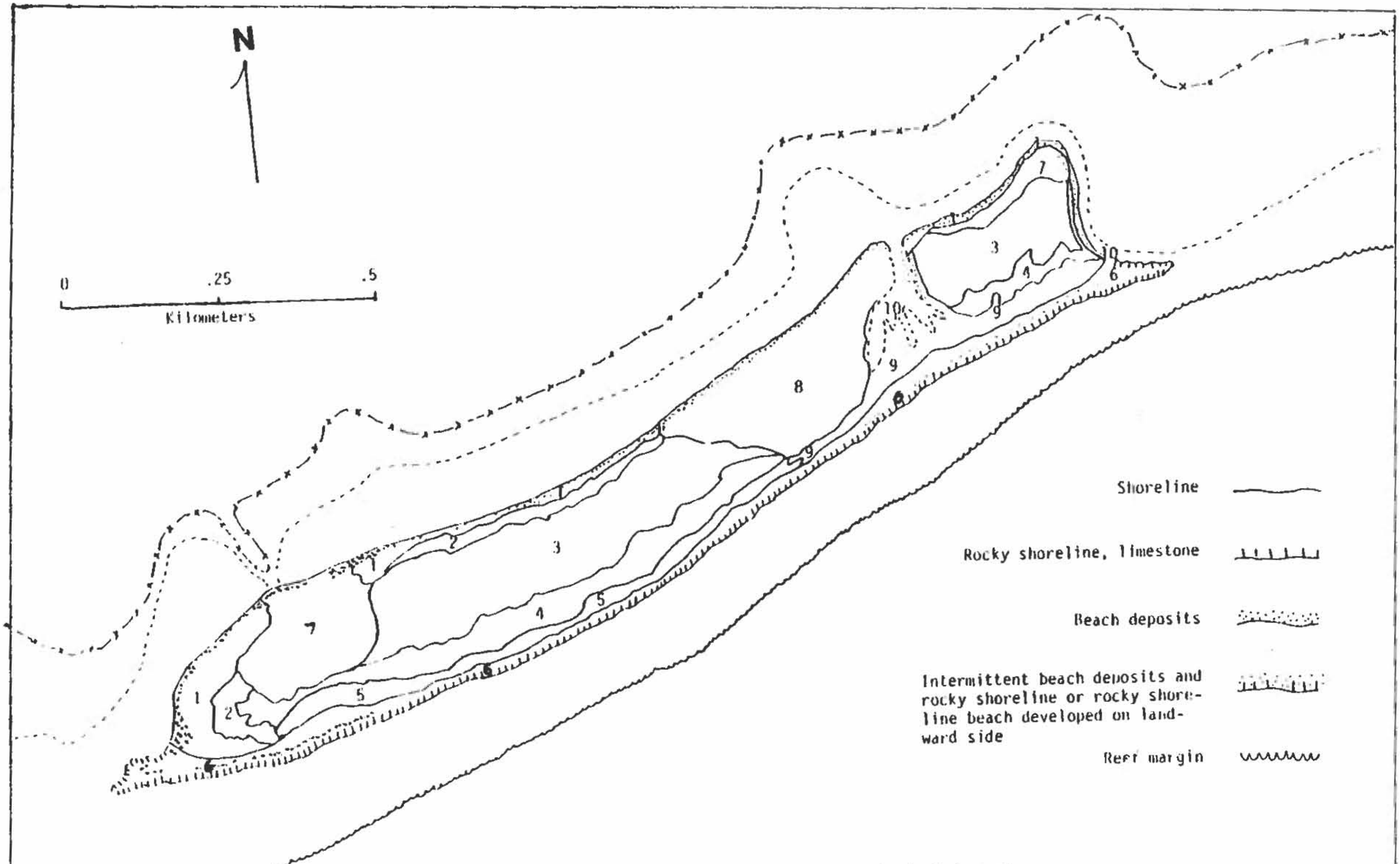


Figure 4. Vegetation map for the Cocos Island study area. A legend explanation for the numbered vegetation units is given on the following page. (Outline drawing from Randall and Eldredge, 1976.)

Vegetation Map
Explanation of Units

1. Beach Ridge Strand - vegetation dominated by: Ipomoea pes-caprae and Thuarea involuta growing on sandy beach.

2. Forest Edge - dominated by: Cocos nucifera, Thespesia populnea, and Morinda citrifolia with an undergrowth of various grasses.

3. Mixed Forest - dominated by: Hernandia sonora, Cocos nucifera, Carica papaya, Guettarda speciosa, Morinda citrifolia. Undergrowth generally dense where disturbance has been recent.

4. Casuarina Forest - dominated by: Casuarina equisetifolia with understory of Carica papaya, Morinda citrifolia. Varying from sparse to fairly dense. Large trees common.

5. Lower Brushy Fringe - dominated by: Tournefortia argentea, Scaevola taccada, Wollastonia biflora, Lepturus repens. Varies from fairly dense to sparse.

6. Beach Scrub - dominated by Pemphis acidula (< 0.5 m) growing on coral rock platforms.

7. Abandoned Area - with secondary growth of Ipomoea pes-caprae, Bidens alba, Leucaena leucocephala, Wollastonia biflora, tall grass, weed patches.

8. Resort Area - with cultivated species, Cocos nucifera, Thespesia populnea, Thuarea involuta, Paspalum conjugatum.

9. Windward Forest Edge - Pemphis acidula and Casuarina equisetifolia with Lepturus repens.

10. Mangrove Area - Rhizophora mucronata.

Table 1. Plant species of the Cocos Island Study Area.

Scientific Name
Polypodiaceae
Polypodium scolopendria L.
Araucariaceae
Araucaria heterophylla (Salisb.) Franco
Agavaceae
Agave americana L.
Amaryllidaceae
Hymenocallis littoralis (Jacquin) Salisbury
Commelinaceae
Rhoeo spathacea (SW.) Stearn
Cyperaceae
Fimbristylis cymosa R. Brown
Fimbristilis cymosa var. pycnocephala (HBD) Kick
Gramineae
Cenchrus echinatus L.
Cynodon dactylon (L.) Persoon
Eustachys petraea (Fw.) Desu.
Lepturus repens (G. Forster) R. Brown
Panicum maximum Jacquin
Paspalum conjugatum Bergius
Paspalum paniculatum L.
Paspalum setaceam Michn
Porobolus virginicus (L.) Kunth
Thuarea involuta (G. Forster) R. Brown
Palmae
Cocos nucifera L.
Pandanaceae
Pandanus dubius Sprengel
Pandanus tectorius Parkinson
Aizoaceae
Sesuvium portulacastrum L.
Boraginaceae
Tournefortia argentea L.
Capparidaceae
Capparis cordifolia Lamarck

Table 1. Continued

Scientific Name - continued
Caricaceae
Carica papaya L.
Casuarinaceae
Casuarina equisetifolia L.
Combretaceae
Terminalia samoensis Rechinger
Compositae
Bidens alba (L.) DC
Conyza canadensis (L.) Cronquist
Wollastonia biflora var. *canescens* (Gaud.) Fosberg
Convolvulaceae
Ipomoea tuba (Schlechtendahl) G. Don
Ipomoea pes-caprae spp. *brasiliensis* (L.) V. Oostroom
Euphorbiaceae
Codiaeum variegatum L.
Euphorbia chamissonis (Klotsch & Garcke) Boissier
Goodeniaceae
Scaevola taccada (Gaertner) Roxburgh
Hernandiaceae
Hernandia sonora L.
Lauraceae
Cassytha filiformis L.
Lecythidaceae
Barringtonia asiatica (L.) Kurz
Leguminosae
Canavalia cathartica Thouars
Intsia bijuga (Colebr) O. Kuntze
Leucaena insularum var. *guamensis* Fosberg & Stone
Leucaena leucocephala (Lam.) DeWit
Pithecellobium dulce (Roxb.) Bentham
Sophora tomentosa L.
Lythraceae
Pemphis acidula Forst.
Malvaceae
Hibiscus rosa-sinensis L.
Hibiscus tiliaceus L.
Thespesia polpulnea (L.) Solander ex Correa

Table 1. Continued

Scientific Name - continued
Nyctaginaceae
Bougainvillea glabra Chrisy
Passifloraceae
Passiflora foetida var. *hispida* (DC.) Killip
Rhamnaceae
Colubrina asiatica (L.) Brongniart
Rhizophoraceae
Rhizophora mucronata Lamarck
Rubiaceae
Guettarda speciosa L.
Hedyotis strigulosa (Bartl. ex DC.) Fosb.
Morinda citrifolia L.
Sapinaceae
Allophylus timorensis (DC.) Blume
Tiliaceae
Triumfetta procumbens G. Forster
Verbenaceae
Stachytarpheta indica (L.) Vahl

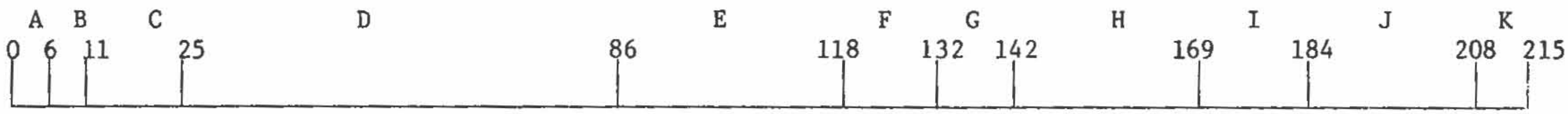
coral atolls. These zones are well illustrated along the vegetational transects (Figs. 3, 5 & 6). Five percent of the cross-sectional distance on the lagoon side of the island was covered by beach sand, Ipomoea pes-caprae, Sporobolus virginicus and Thurarea involuta. Inland was a forested area dominated by Cocos nucifera, Hernandia sonora, Guettarda speciosa, Morinda citrifolia and Carica papaya. This area did not appear to be a remnant of the coconut plantation because the few coconut trees present were not uniformly dispersed. This mixed forest area accounted for 35% of the transect (Areas 2 and 3). Casuarina equisetifolia with an understory of Carica and Morinda followed the mixed forest area seaward along the transect. This vegetation corresponds with Area 4 (Fig. 4) and was 21% of the transect. This area and those discussed below were probably under the influence of salt spray even when surf conditions were moderate to calm. A complex of Wollastonia biflora, Tournefortia argentea, and Scaevola taccada is immediately seaward of the Casuarina forest (Area 5). These species formed distinct monoculture belts in the following order (land to sea): Wollastonia, Tournefortia, and Scaevola (Plate 1). The former two species were approximately 2 m tall. Scaevola was approximately 1.7 m tall adjacent to the Tournefortia stand and rapidly decreased in height, seaward, to less than 0.5 m. This complex was 24% of the length of the transect. Pemphis acidula, which was short and shrublike, dominated the pitted coral rock beach (Area 6). No tall specimens of this species grew along the shore. Pemphis and solid coral rock accounted for approximately 15% of the transect length. A cleared. bulldozed strip approximately 3 m wide was cut through the Pemphis area approximately one year prior to this study (Plate 2). Little or no vegetation had grown back on this disturbed ground, which extended approximately one-half of the length of the island.

The zonation of vegetation was probably directly related to salt spray and the salinity of the soil and ground water. Salinity decreased from the shore toward the interior of the island. Zones four, five and six were not exactly parallel to the shore, but followed a pattern of undulations which probably reflected microclimate differences.

The recently disturbed Area 7 on the northwest side of the island was dominated by Leucaena leucocephala, Ipomoea, Bidens alba, Passiflora foetida, and Wollastonia. This appeared to be the only area on Cocos Island where "tangantangan" (Leucaena leucocephala), introduced to Guam, had become established. The area was becoming overgrown with herbs and in time may revert to a mixed forest situation.

The eastern half of the island was like the western half, except that a portion was being developed as a tourist resort area (Fig. 4, Area 8). The resort area was cleared of almost all previous vegetation except for some large trees of Thespesia populnea, Cocos, Casuarina, and Guettarda. Numerous cultivated species were introduced for ornamental purposes: Codiaeum variegatum, Hibiscus rosa-sinensis, Bougainvillea glabra, Araucaria heterophylla, Rhoeo spathacea, Pandanus dubius, Hymenocallis littoralis, and Agave americana (Plate 3). Their ability to tolerate salt spray, brackish soil water and high light intensities will determine if these species can become established on Cocos Island. More species of grass appeared to be present in this area than in undeveloped areas; they were probably accidentally introduced by employees and the numerous tourists entering the resort area. Also, herbaceous plants were trimmed constantly and this may have increased the number of available sites for these grass species.

Figure 5. Vegetational Transect 1



A = Sandy beach area

B = Beach ridge dominated by Ipomoea pes-caprae, Thuarea involuta, Sporobolus virginicus

C = Forest edge dominated by Carica papaya, Cocos nucifera, Thespesia polpulnea

D = Mixed forest area dominated by Hernandia sonora, Cocos nucifera, Morinda citrifolia, Guettarda speciosa - dense vegetation

E = Casuarina forest dominated by Casuarina equisetifolia with understory of Carica papaya, Morinda citrifolia; few Guettarda speciosa

F = Outer edge of Casuarina forest; Cocos, Carica present with understory of Wollastonia biflora

G = Area dominated by Wollastonia greater than 1.5 m tall (very dense)

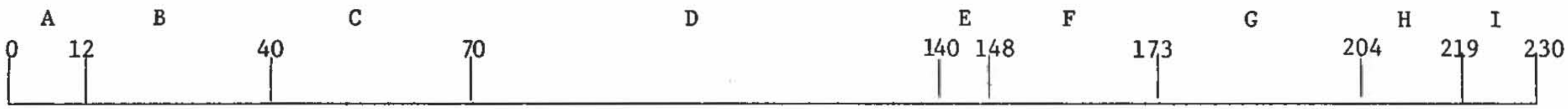
H = Dominated by Tournefortia (1.5-1.8 m tall) and Wollastonia (very dense)

I = Scaevola taccada and Tournefortia argentea

J = Pemphis acidula, tufts of Fimbristylis cymosa

K = Coral rock

Figure 6. Vegetational Transect 2



A = Sandy beach area

B = Beach ridge dominated by *Ipomoea pes-caprae*, *Thuarea involuta*, some *Pemphis acidula*

C = Forest edge dominated by *Cocos nucifera*, *Bidens alba*, *Thespesia populnea*, *Guettarda speciosa*

D = Mixed forest area dominated by *Cocos*, *Carica papaya*, *Casuarina equisetifolia*; dense in some areas; heavy growth of grasses

E = Casuarina forest dominated by *Casuarina equisetifolia* with understory of *Carica*, *Morinda citrifolia*, *Cocos*, presence of *Bidens alba*, *Leucaena insularum*; not very dense

F = Outer edge of *Casuarina* forest with strays of *Cocos*, *Wollastonia*, *Pemphis* and *Casuarina*

G = Area dominated by *Pemphis* and *Casuarina*

H = *Pemphis acidula* with tufts of *Fimbristylis cymosa*

I = Coral rock

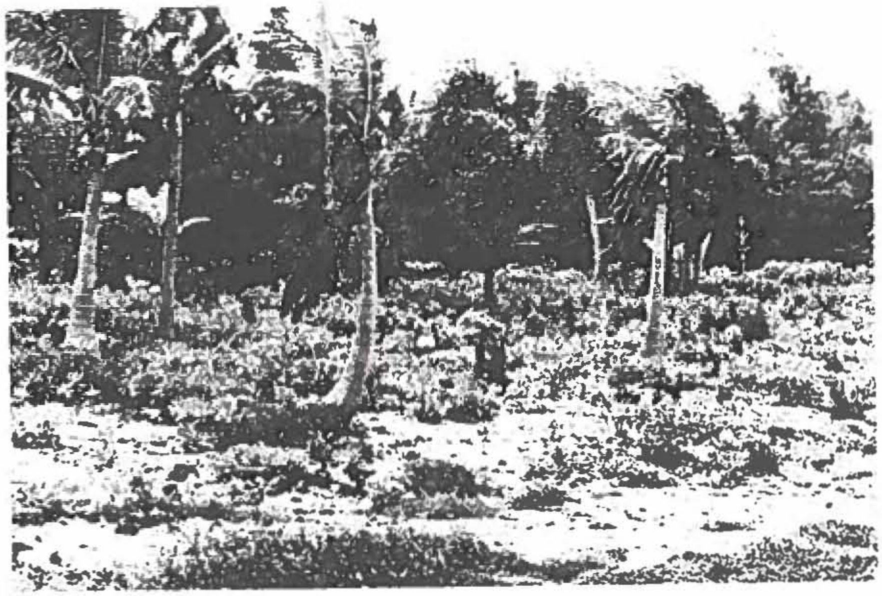


Plate 1. Conspicuous zonation on seaward s ide of Cocos. Pemphis in foreground, Scaevola among Cocos, Tournefortia surrounding Pandanus and Casuarina forest in background.

Plate 2. Bulldozed strip through Pemphis on seaward side of the island, showing little vegetation growing back.

Plate 3. Codiaeum variegatum and Hibiscus rosa-sinensis along stone wall with Bougainvillea glabra on left.

Plate 4. Intertidal area bordered by Casuarina and Pemphis, with Rhizophora indicated by arrow.

An abandoned resort area with picnic huts and buildings occupied the northeastern corner of the island. Most of the vegetation was removed; only selected tall trees of Casuarina and Cocos remained. This area was overgrown with various conspicuous weed species, most of which, including Bidens, Cenchrus echinatus, Cynodon dactylon, Paspalum conjugatum, and Eustachys petraea, were introduced.

Vegetational transect two is presented in Figure 6. Seventeen percent of the cross-sectional distance on the lagoon side of the island was covered by beach sand, Ipomoea pes-caprae, Thuarea involuta and Pemphis acidula. The interior of the eastern half of the island contained remnants of the Cruz's coconut plantation and a strip of Casuarina forest. The plantation had an undergrowth of aggressive weedy species (Wollastonia and Bidens) and varying proportions of Carica, Guettarda, Morinda, Allophylus timorensis, Scaevola, Tournefortia, Casuarina, Intsia bijuga, and other trees and large shrubs. The forest vegetation in certain areas was extremely dense. The taller, more mature coconut trees were regularly spaced, but young coconut seedlings filled the areas between the trees and a mat of grasses covered the ground. The presence of the grasses and weeds indicated recent disturbances either from man or storms. This mixed forest area occupied 44% of the transect (Fig. 4, Area 3). The mixed forest eventually merged into the Casuarina forest. The forest had a thick cushion of "needles", lacked dense undergrowth, and was easy to penetrate. Many of the Casuarina trees were taller than 20 m. The undergrowth was sparse and included a few Wollastonia, Bidens and Leucaena insularum. This vegetation corresponds with Area 4 (Fig. 4) and occupied 14% of the transect.

Mixed stands of Casuarina and Pemphis bordered the top of the sandy outer beach flats and accounted for 14% of the transect (Plate 4). Pemphis, which in this area was approximately 1.5 m tall, was the dominant species of the pitted coral rock platform adjacent to the sea. In that area it was short (< 0.5 m) and shrubby, and tufts of Fimbristylis cymosa were occasionally interspersed. Coral rock and Pemphis accounted for 11% of the transect.

A series of small channels on the north, lagoon-side of Cocos Island may have resulted from storm or typhoon wave action. One plant and several Rhizophora mucronata seedlings occurred in these channels. More than 75 seedlings of Rhizophora were located on the northeastern tip of the island (Fig. 4, Area 10). These seedlings were sheltered, not exposed to waves, and their abundance made it almost certain the habitat will become populated by a stand of mangroves (Fosberg, 1960).

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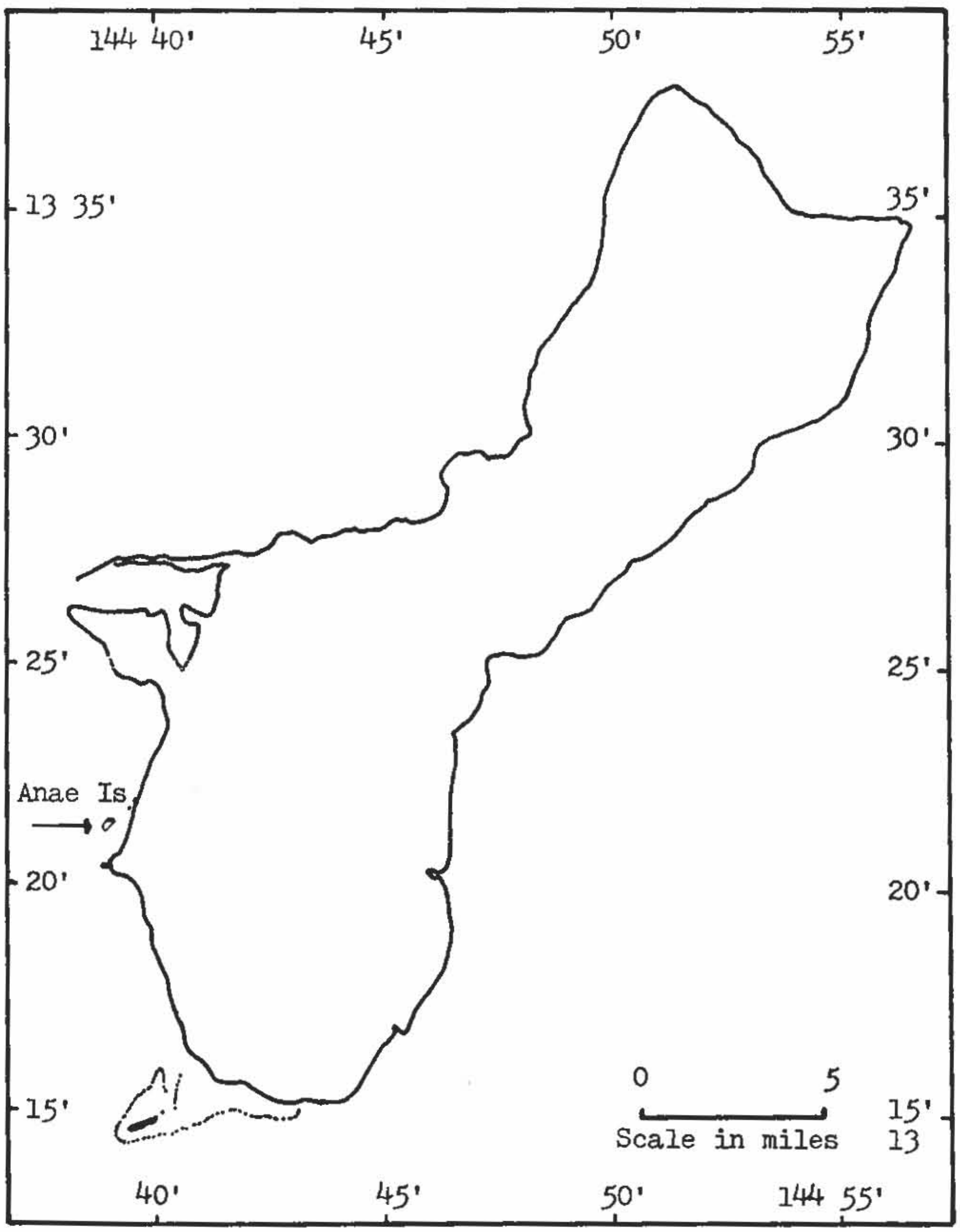


Fig. 1. Map of Guam (Stone, 1970).

SURVEY OF PLANT SPECIES AND THE QUALITATIVE ASSESSMENT OF THE DISTRIBUTION OF VEGETATION ON ANAE ISLAND

Roy N. Tsutsui

ABSTRACT

The plant species of Anae Island, a small raised coral islet on the southwest reef of Guam, were identified and the vegetation mapped. Anae is characterized by Halophytic-Xerophytic Scrub. Future development of a climax vegetation seems unlikely because Anae is tiny and exposed to extremes of wind and wave action, water and light.

INTRODUCTION

Anae Island is a small, rectangular, raised coral islet of Mariana Limestone (Randall and Eldredge, 1976). It is situated about 1000 m off of Taelayog Beach, Agat, and is separated from Guam by a deep channel (Fig. 1). It is about 320 m long, 150 m wide, and 14.74 m high at its highest point, with steep slopes and cliffs on the windward side (facing Guam) and wave-pounded benches on its leeward side facing the Philippine Sea (Fig. 2). About 150 common noddy terns have a nesting site at its southern end.

Very little information exists concerning the vegetation of islets on Guam. Fosberg (1960) noted that raised coral islets have an integrated community of both strand and limestone forest, and classified this type of community as the Halophytic-Xerophytic Scrub. Anae Island appears to fit this description, but no research has been done specifically describing its flora and vegetation.

This report provides base-line data of Anae Island vegetation, including a checklist of plant species, their estimated percent coverage, and vegetation patterns. Such data should be useful for comparison if the island is surveyed at a later time.

METHODS

A three-man zodiac, courtesy of the U.O.G. Marine Laboratory, was used to reach Anae. On calm days it was possible to anchor off the reef nearest the island and swim to the island, but on rough days the zodiac was surfed in and anchored in the middle of the reef flat.

The only materials needed were a 50 m transect tape, a compass, a notepad and pencil, a map, a plastic bag, and a knife.

The data were obtained in three phases; a trip to the island was necessary to accomplish each. First, all of the kinds of plants on Anae were collected and identified. Some plants were kept in plastic bags until they could be pressed at the U.O.G. Herbarium, but others withered before they were pressed and were later collected and pressed on the island. Notes were taken on the locations and abundances of each species.

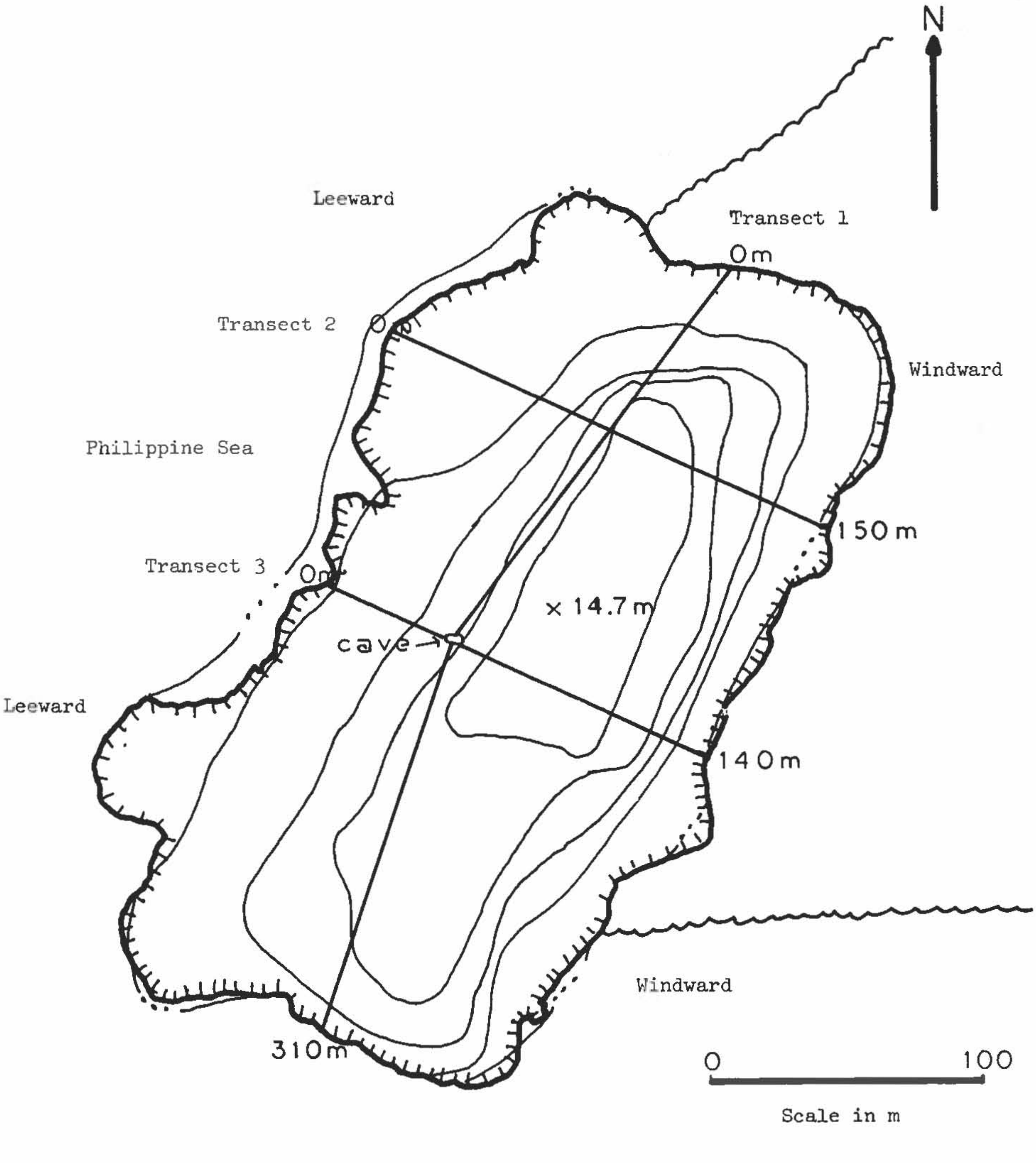


Figure 2. Map of Anae Island showing elevation and transects.

Following this, three transects were chosen (Fig. 2). Transect 1 bisected the island longitudinally to the large cave; it bisected the southern portion into two equal parts. Transect 2 extended across the island half way between the cave and the northern end of the island. Transect 3 extended across the island at the cave.

A qualitative method by Braun-Blanqet (1964) was used to assess plant species quantity and gregariousness at each five meter interval of the transect and one meter to each side. This method uses scales of % cover and sociability, which are explained in Table 1. After the transects were chosen the vegetation was mapped using the transects as reference lines.

RESULTS AND DISCUSSION

Anae Island had thirty different species of plants; their names and their cover/sociability values in terms of the whole island are shown on Table 1. The most abundant species were Casuarina equisetifolia, Leucaena leucocephala, Wollastonia biflora, and Polypodium scolopendria. Species from both beach strand and limestone forest systems (Fosberg, 1960) were present, and included twelve young trees of Heritiera longipetiola, a rare species on Guam. The location of this group, and the vegetation patterns of dominant plant species are pictured in Figure 3; the number code and survey of the patterns of Figure 3 are noted in Table 2.

The Casuarina forest, with large trees (some 15 m tall with 1.5 m diameters) was distinctive, as was the Leucaena forest. However, community intergradation was the rule, and single-species patches of either tree were uncommon.

Windward and leeward sides of the island differed; the windward cliff area had thirteen plant species while the outskirts of the leeward area had only two. The substrate of this leeward area was exposed, eroded limestone which was probably wave-scoured during storms and thus not suitable for soil or plant development. Most of the weeds and other fast settling plants with shallow roots were located in open, inland areas with little soil at the southern end of the island.

The transect profiles (Figs. 4 & 5), which are not drawn to scale, show species diversity and distribution along the three transects. The profile of longitudinal Transect 1 shows the Casuarina forest blending with the Leucaena forest, and the limited vegetation on the southern end of the island. Both transverse section profiles demonstrate community integration and differences between the windward and leeward sides of the island. Triphasia is an important marker species for the cliffline. Polypodium, which was not shown in Figure 3 because it is an understory forest species, is abundant. Beach strand vegetation occurs thoughout, is concentrated on the sides of the island especially the windward cliff area. The windward cliff area probably had more wind-blown seeds from Guam. The windward side is also higher than the leeward and cover/sociability values for the transects and profiles are noted on Table 3. Minor species of Transect 1 are not recorded in the Transect 1 profile, to prevent overcrowding.

Table 1. Checklist and cover/sociability values of the plants of Anae Island, Guam. The cover/sociability values, developed by Braun-Blanquet (1964), represent quantity and gregariousness of the plant species. Abundance and dominance are combined in the measurement of species quantity according to the following seven step scale: r a few isolated specimens, cover negligible

- \- sparsely present, cover low;
- 1 more frequently present, though covering less than 5% of the sample plot (whole island), or only isolated with the same cover;
- 2 abundant, or covering 5-25% of the sample plot;
- 3 any number of specimens, covering 25-50% of the sample plot;
- 4 any number, covering 50-75%; and
- 5 any number, covering 75-100%.

Sociability is given after the value for the quantity, separated by a full stop, on a scale of five steps: (1) singly growing; (2) growing in groups; (3) growing in small patches or cushions; (4) growing in small colonies or forming extensive patches or carpets; and (5) growing in large herds.

Family and plant species	cover . sociability
Aizoaceae	
Sesuvium portulacastrum L.	2 . 3
Caricaceae	
Carica papaya L.	- . 1
Casuarinaceae	
Casuarina equisetifolia L.	4 . 5
Compositae	
Blumea sinuata (Lour.) Merr.	r . 1
Emilia javanica (Burm.) C. B. Robinson	r . 1
Mikania scandens (L.) Willd.	1 . 4
Vernonia cinerea (L.) Lessing	- . 1
Wollastonia biflora (L.) Fosberg	4 . 4
Cycadaceae	
Cycas circinalis L.	r . 1
Cyperaceae	
Fimbristylis cymosa ssp. *umbellato-capitata* (Hillebrand) Koyama	2 . 3
Euphorbiaceae	
Melanolepis multiglandulosa var. *glabrata* (Muell.-Arg.) Fosberg	r . 1
Phyllanthus amarus Schum. & Thonn.	- . 1
Phyllanthus marianus Mueller-Argoviensis	- . 1
Goodeniaceae	
Scaevola taccada (Gaertner) Roxburgh	2 . 2

Table 1. Continued

Family and plant species	cover . sociability
Gramineae	
Lepturus repens (G. Forster) R. Brown	3 . 4
Pennisetum polystachion (L.) Shultes	1 . 3
Lecythidaceae	
Barringtonia asiatica (L.) Kurz	- . 1
Leguminosae	
Leucaena leucocephala (Lam.) deWit	4 . 5
Lythraceae	
Pemphis acidula Forst.	2 . 4
Moraceae	
Ficus prolixa var. *carolinensis* (Warburg) Fosberg	r . 1
Ficus prolixa var. *subcordata* Corner	r . 1
Nyctaginaceae	
Pisonia grandis R. Brown	r . 1
Polypodiaceae	
Polypodium scolopendria (Burm. f.) Ching	4 . 4
Portulacaceae	
Portulaca australis (L.) Fosberg	- . 3
Rubiaceae	
Hedyotis foetida var. *mariannensis* (Merill) Fosberg	1 . 2
Hedyotis strigulosa (Bartl. ex DC.) Fosb.	r . 1
Morinda citrifolia L.	2 . 2
Rutaceae	
Triphasia trifolia (Burm. f.) P. Wils.	2 . 4
Sterculiaceae	
Heritiera longipetiolata Kanehira	- . 2
Urticaceae	
Pilea microphylla (L.) Liebmann	- . 3
Verbenaceae	
Callicarpa candicans (Burm. f.) Hochr.	3 . 2

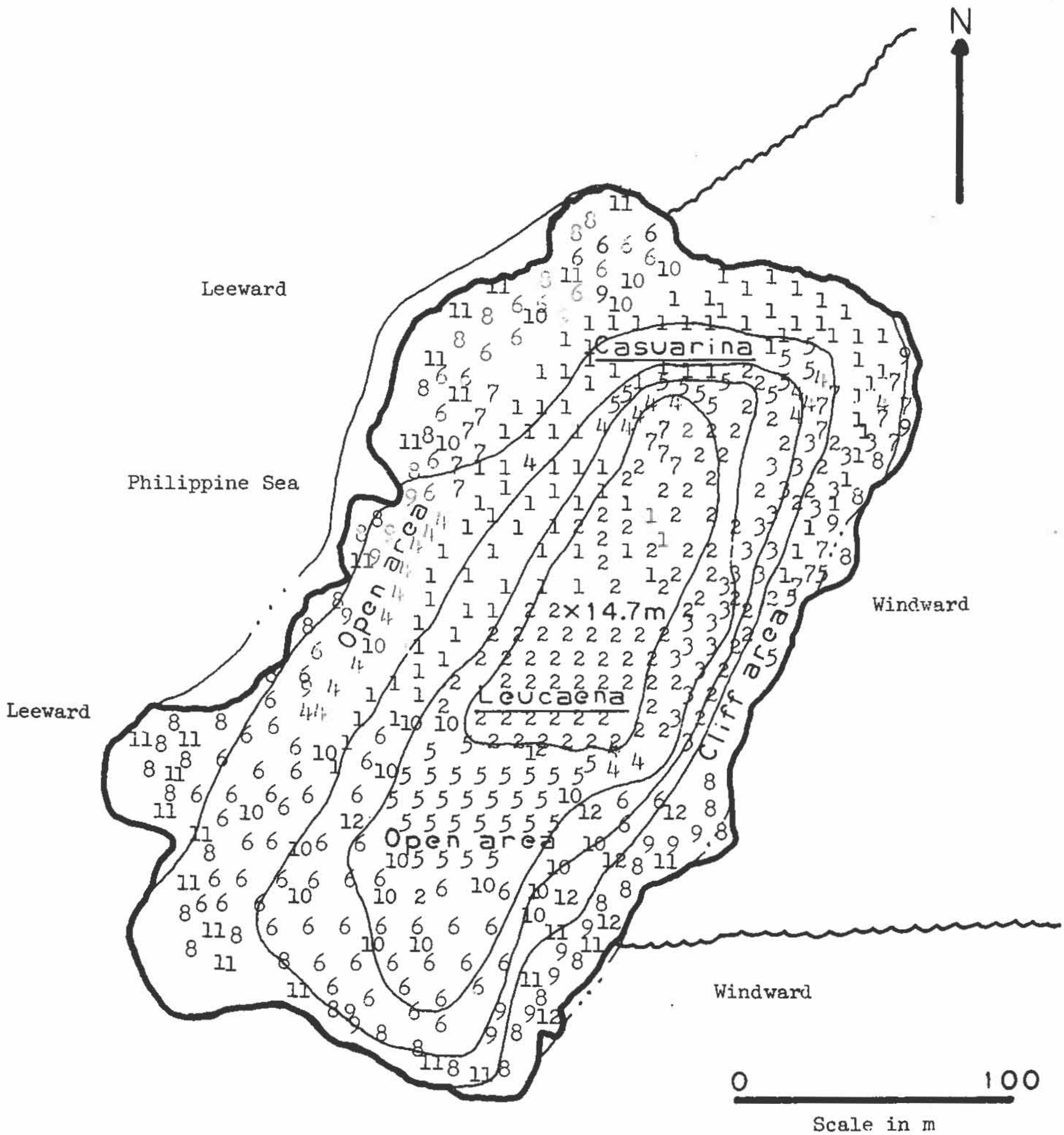


Figure 3. Map of Anae Island showing elevation and vegetation patterns. Refer to Table 2 for the number code of the vegetation.

Table 2. Identification of vegetation patterns and the plants in them on Anae Island. The patterns are estimations drawn from ground observations and are shown in Figure 3.

Zone	Dominant species	Other species	Number
Casuarina forest (mixed with limestone vegetation)	*Casuarina equisetifolia*		1
		Callicarpa candicans	
		Carica papaya	
		Hedyotis foetida	
		Hedyotis strigulosa	
		Lepturus repens	
		Leucaena leucocephala	
		Morinda citrifolia	
		Phyllanthus marianus	
		Polypodium scolopendria	
		Scaevola taccada	
		Vernonia cinerea	
		Wollastonia biflora	
Leucaena forest	*Leucaena leucocephala*		2
		Callicarpa candicans	
		Cycas circinalis	
		Ficus prolixa	
		Hedyotis foetida	
		Heritiera longipetiolata	
		Lepturus repens	
		Melanolepis multiglandulosa	
		Morinda citrifolia	
		Phyllanthus amarus	
		Phyllanthus marianus	
		Polypodium scolopendria	
		Pilea microphylla	
		Triphasia trifolia	
		Wollastonia biflora	
Windward cliff area	*Triphasia trifolia*		3
	Casuarina equisetifolia		1
	Leucaena leucocephala		2
	Scaevola taccada		7
	Pemphis acidula		9
	Sesuvium portulacastrum		8
		Callicarpa candicans	
		Cycas circinalis	
		Hedyotis foetida	
		Morinda citrifolia	
		Pennisetum polystachion	
		Phyllanthus marianus	
		Wollastonia biflora	

Table 2. Continued

Zone	Dominant species	Other Species	Number
Open area (inland)	Callicarpa candicans		4
	Wollastonia biflora		5
	Fimbristylis cymosa spp. umbellato-capitata		6
	Pemphis acidula		9
	Lepturus repens		10
	Pennisetum polystachion		12
		Blumea sinuata	
		Emilia javanica	
		Hedyotis strigulosa	
		Leucaena leucocephala	
		Vernonia cinerea	
Open area (leeward outskirts)	Sesuvium portulacastrum		8
	Portulaca australis		11

Transect 1 (longitudinal section)

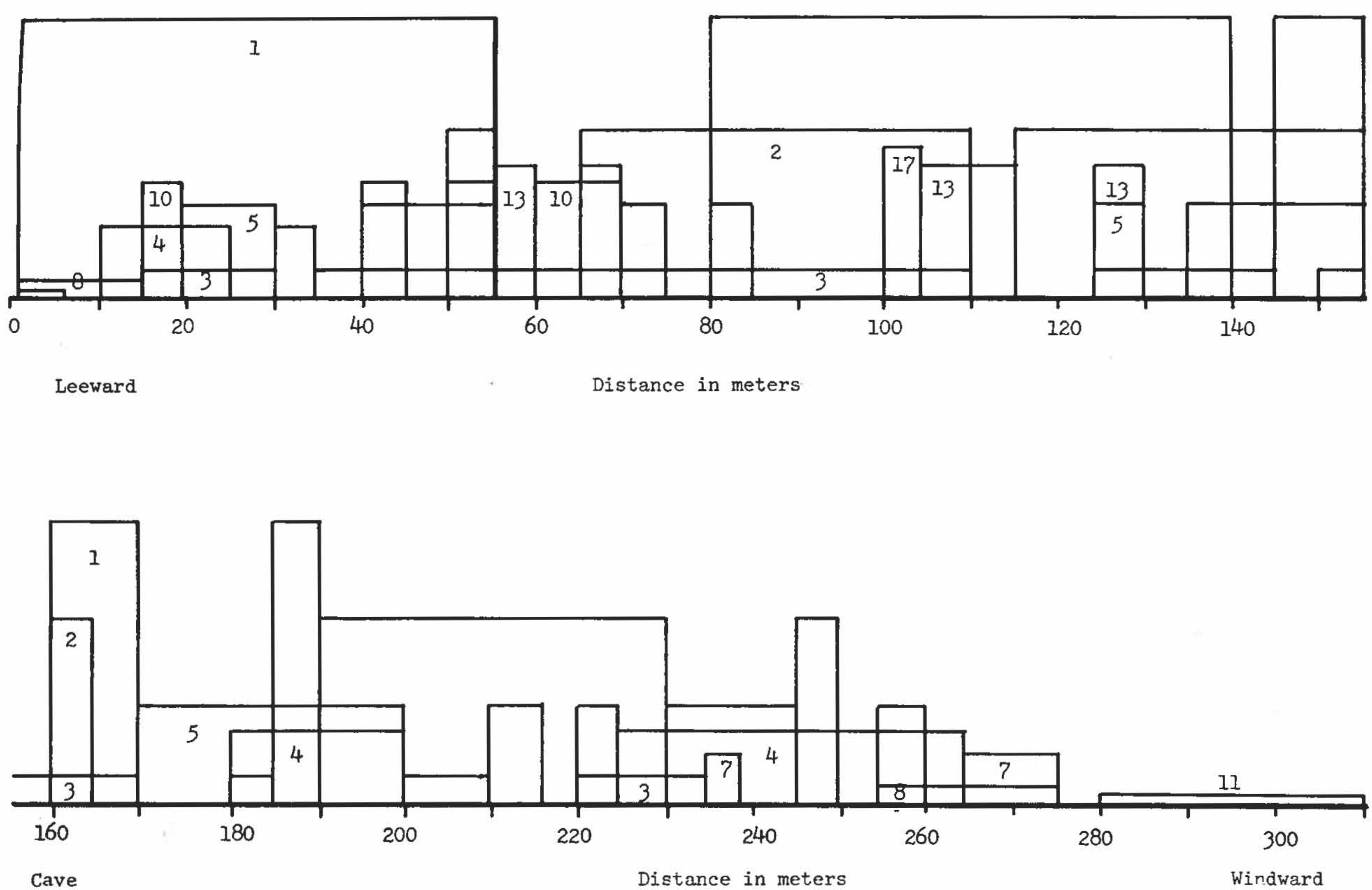
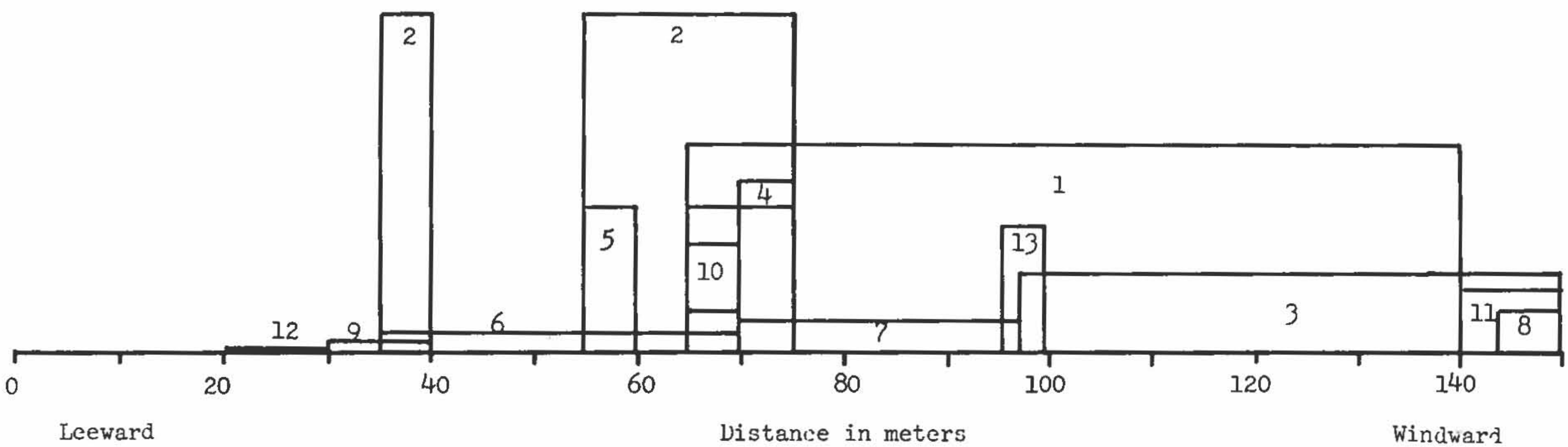


Figure 4. Profile of Transect 1 (longitudinal section of Anae Island) showing relative distribution of major vegetation. Refer to Table 3 for scientific names and cover/sociability values of the plant species. Minor species are included in Table 3.

Trai sect 2 (northern trasverse section)



Transect 3 (middle transverse section)

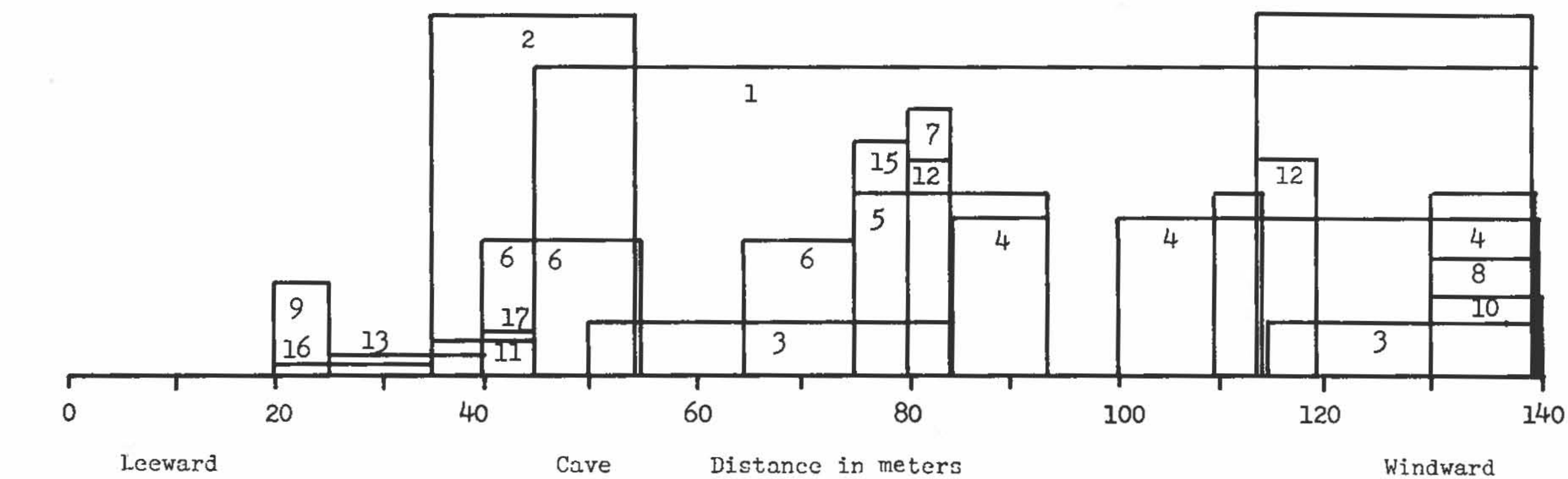


Figure 5. Profiles of Transects 2 (northern transverse section) and 3 (middle transverse section) of Anac Island showing relative distribution of vegetation. Refer to Table 3 for scientific names and cover/sociability values of the plant species.

Table 3. Scientific names and cover/sociability values of plants along Transect 1 (longitudinal section), Transects 2 and 3 (transverse sections) of Anae Island. Refer to Fig. 2 for the locations of the transects. Refer to Table 1 for the explânation of the cover/sociability values.

Transect 1.

Distance in m	0	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300 310
Altitude in m	3	6		9											6	
Area in m^2	2 x 20 = 40															2x10=20
Description of area	*Casuarina* forest				*Casuarina* and Limestone forest						*Leucaena* forest			Open windy area		
Profile No. Plant species	cover.sociability															
1. *Casuarina equisetifolia*	5.5	5.5	5.5		5.5	4.4	4.4	3.4	2.1	1.1						
2. *Leucaena leucocephala*				+.1	5.5	5.5	2.3	3.4	r.1	+.1	5.5	4.4	1.3			
3. *Polypodium scolopendria*	r.1	2.2	5.5	5.5	5.5	3.4	4.4	5.4	4.4	1.2	2.3	2.3				
4. *Wollastonia biflora*	4.4	1.2								4.4		5.5	5.4			
5. *Callicarpa candicans*		1.1	1.1	+.1	r.1		1.1	4.4	1.1	4.4	r.1	+.1	r.1			
6. *Lepturus repens*	4.4	2.3					1.3	r.2	4.4	1.2	r.3	1.3	2.3	r.2		
7. *Pemphis acidula*												+.2		2.3		
8. *Fimbristylis cymosa* ssp. *umbellato-capitata*	1.3	r.3											+.3	4.4	2.3	
9. *Pennisetum polystachion*									1.3					+.3		
10. *Scaevola taccada*	1.1		3.3	r.1												
11. *Sesuvium portulacastrum*	r.3														2.3	1.3
12. *Triphasia trifolia*											r.1					
13. *Morinda citrifolia*				r.1		r.1	1.2									
14. *Hedyotis foetida*							r.1		r.1							
15. *Mikania scandens*			3.4	3.4												
16. *Phyllanthus marianus*				r.1			r.1	r.1								
17. *Carica papaya*						1.1										
18. *Pisonia grandis*					r.1											
19. *Pilea microphylla*											1.3	1.3	+.3	+.3		
20. *Phyllanthus amarus*														r.1		
21. *Vernonia cinerea*	r.1												r.1			

Table 3. Continued.

Transect 3.

Distance in m	0	20	40	60	80	100	120	140
Altitude in m	3	6	9		12	9	3	
Area in m^2	2 x 20 40							
Description of area	Open (leeward)		Casuarina forest Cave		Leucaena & Triphasia forest (windward)			
Profile No. Plant species	cover.sociability							
1. Leucaena leucocephala			4.4	5.5	5.5	5.5	2.2	
2. Casuarina equisetifolia		3.4	3.4				1.1	
3. Polypodium scolopendria			4.4	2.3			1.3	
4. Triphasia trifolia					2.3	5.5		
5. Morinda citrifolia				2.1	+.1	r.1	r.1	
6. Callicarpa candicans			3.2	r.2			r.1	
7. Heritiera longipetiola					3.2			
8. Scaevola taccada							2.1	
9. Pemphis acidula							+.1	
10. Wollastonia biflora							+.2	
11. Lepturus repens		4.4						
12. Phyllanthus marianus					r.1		r.1	
13. Fimbristylis cymosa ssp. umbellato-capitata		2.3					.	
14. Hedyotis foetida var. mariannensis							+.2	
15. Ficus prolixa var. subcordata				r.1				
16. Sesuvium portulacastrum		2.3					+.3	
17. Phyllanthus amarus			r.1					

Table 3. Continued.

Transect 2.

Distance in m: 0 20 40 60 80 100 120 140 160

Altitude in m: 3 | 6 | 9 | 12 | 9 | 6 | 3

Area in m^2: 2 x 20 = 40

Description of area: Open (leeward) | *Casuarina* forest | *Leucaena* & *Triphasia* forest (windward)

Profile No.	Plant species	0–20	20–40	40–60	60–80	80–100	100–120	120–140	140–160	160–
		cover.sociability								
1.	*Leucaena leucocephala*				3.4	5.5	5.5	5.5	5.4	
2.	*Casuarina equisetifolia*		-.1	4.4	4.4					
3.	*Triphasia trifolia*					-.2	3.3	4.4	5.4	
4.	*Morinda citrifolia*				2.1					
5.	*Scaevola taccada*			1.1	1.1				-.1	
6.	*Lepturus repens*		4.3	5.4	1.3					
7.	*Polypodium scolopendria*				3.3	4.3				
8.	*Pemphis acidula*				r.1				2.2	
9.	*Fimbristylis cymosa*		3.3							
10.	*Callicarpa candicans*				-.1					
11.	*Hedyotis foetida*								1.1	
12.	*Sesuvium portulacastrum*		3.3							
13.	*Cycas circinalis*					r.1				

CONCLUSIONS

1. Overall the vegetation of Anae Island may be classified as Halophytic-Xerophytic Scrub.

2. At least five zones of vegetation occur:

   a. *Casuarina* forest
   b. *Leucaena* forest
   c. Windward cliff vegetation
   d. Leeward (outskirts)
   e. Open inland vegetation

3. Stresses produced by storm winds and wave action may limit the development of a climax vegetation.

ACKNOWLEDGMENTS

Appreciation generously goes to Dr. Fosberg gor his constructive suggestions and for identifying the plant species continuously brought to him.

Appreciation also goes to Mr. Frank Lujan for accompanying me to Anae Island and making it possible for me to do this project.

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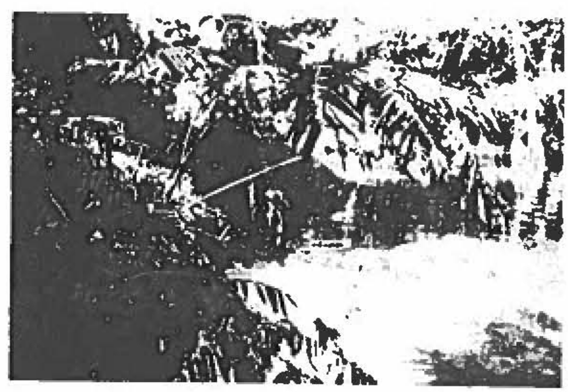
II. SPECIES DISTRIBUTION



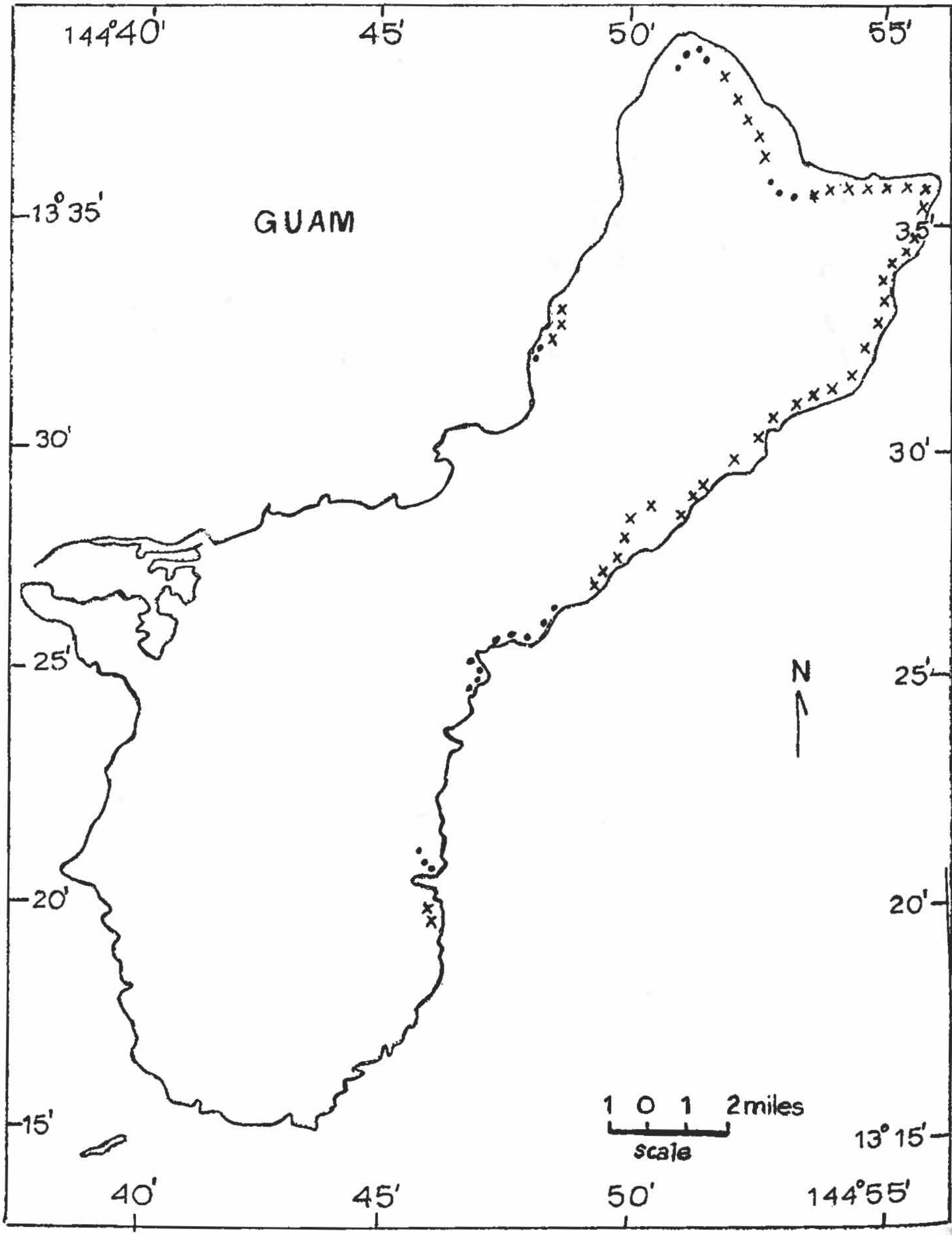


Fig. 1. Distribution of Bikkia tetrandra (L.f.) A. Rich. Legend: .–actual sighting, this study; x–place it is known to occur.

BIKKIA TETRANDRA (L.F.) A. RICH

Jacinto W. Caceres

Bikkia tetrandra, an erect, branching shrub with pale bark, is restricted to exposed limestone cliff faces or limestone boulders near the sea in the Mariana Islands. It contains a flammable element and can be used as a candle when cut into short sections (Moore and McMakin, 1979). The rounded, opposite, crowded leaves are light green; the midrib is paler than the 12 cm long, 6 cm wide blade. The flowers are long, tubular, and pure white; they are trumpet-like, square in cross-section, and occur two or three together in leaf axils. The dark fruit is elongated with a two-celled capsule which contains many small, black seeds.

Bikkia tetrandra grew on the following cliffs (Fig. 1);

1. above the beach on North Pagó Bay both north and south of the Marine Laboratory, University of Guam;

2. above Ipan on the Talofofo Cliffs and from the eastern side of the Talofofo caves area to Ipan Point;

3. at the Ritidian Point cliffs;

4. along the cliffs at Tarague Beach and the cliffs along the road leading to the beach;

5. at the end of the nature trail behind G. W. High School overlooking the Hawaiian Rock quarry are just north of Pago Bay;

6. the cliffs at Two Lovers Point; and

7. above Ricky's Beach at Puntan Pago and above the Marine Hole Beach in Yona south of Pago Bay.

Bikkia tetrandra did not grow on any volcanic boulders or volcanic soils, and none grew very far inland. There were a few areas such as the southern side of the Talofofo cliffline (north side of Talofofo Bay) where Bikkia might be expected; Leucaena leucocephala grew there, instead. It is likely that the area was disturbed, that Leucaena colonized the area, and that Leucaena can outcompete Bikkia. All of the exposed areas from north to south that are bare cliffs probably have this plant, but many were inaccessible.

SPATHOGLOTTIS PLICATA BLUME

Spathoglottis plicata is a versatile, tall, terrestrial orchid that grows in almost any plant community on Guam. It is at home in the sun or shade, on the savanna or on limestone soil, and is distributed from Indomalaysia to the Pacific. This plant has broad, plicate leaves with five prominent, parallel veins. The smooth leaves which are tapered at both ends emerge from a round pseudoblulb that multiplies and becomes larger as the orchid matures. These leaves are up to 120 cm long and 20 cm wide. The flowers of Spathoglottis plicata are apical, racemose and erect. The flower stalk

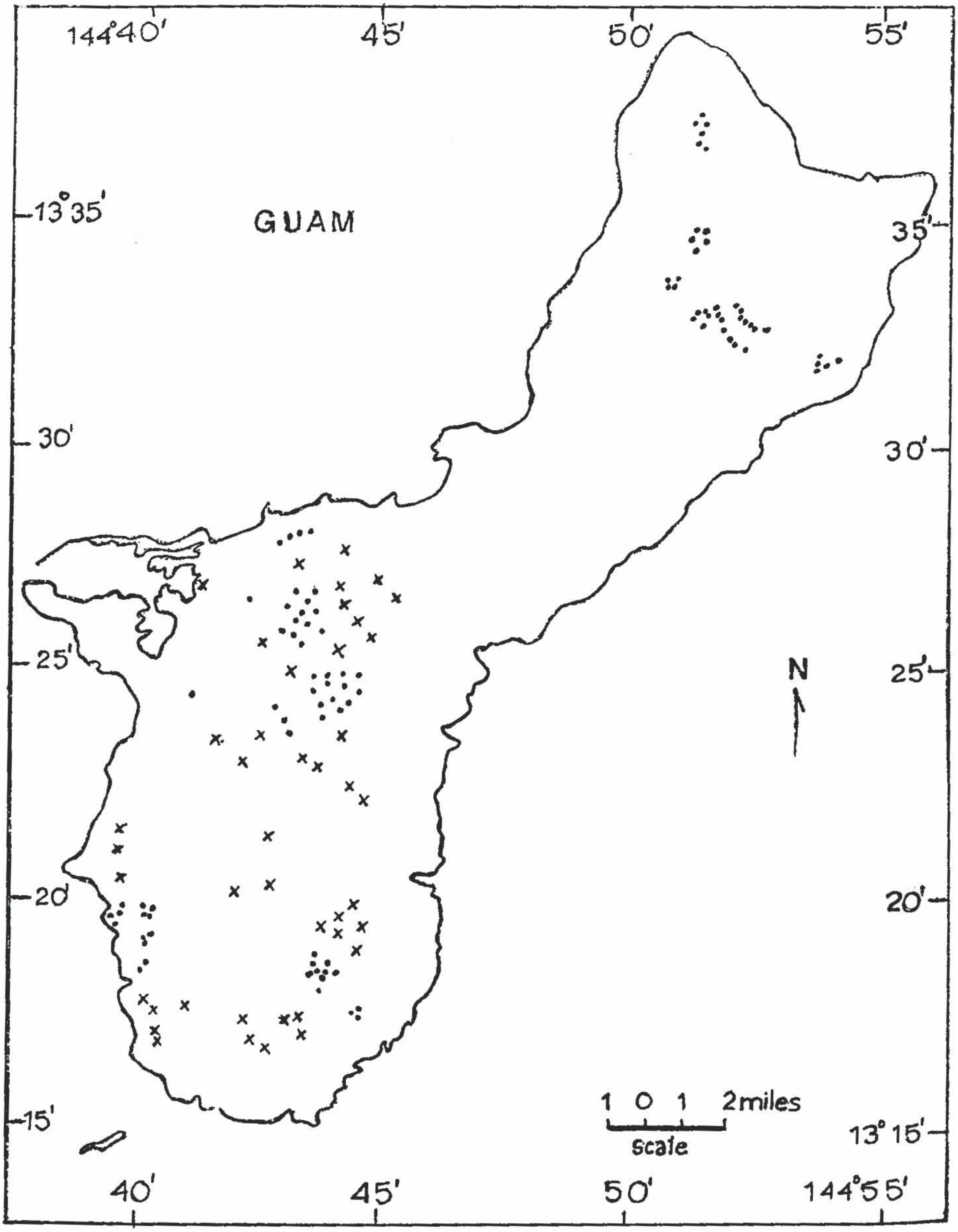


Fig. 2. Distribution of Spathoglottis plicata Bl. Legend: •-actual sighting, this study; x-place it is known to occur.

up to 1 m in height, arises from a basal leaf axil; it bears up to 20 rose-lavender flowers. The fruit of this orchid is cylindrical, grooved and green changing to brown when the fruit matures and breaks open to release hundreds of seeds (Stone, 1970).

Spathoglottis plicata grew in the following savanna areas (Figure 2):

1. on Mt. Alutom - just below the top and along the road,
2. in the DanDan area along the road and surrounding areas to the NASA gate,
3. in the Windward Hills area along the trail to Tarzan Falls and behind Apra Heights across from the motorcycle track,
4. on the trail to Mt. Jumullong Manglo and surrounding areas,
5. along the road just north of Umatac,
6. in the area of Cetti Bay overlook,
7. on Mt. Santa Rosa and surrounding area,
8. in the Mataguac Hill area of Yigo, and
9. in the area around Inarajan Junior High School.

Spathoglottis plicata was also found in the following disturbed roadside areas:

1. just north of N.C.S. main gate,
2. at the Potts Junction area,
3. along the dirt road to Ritidian Point,
4. Alongside two of the dirt roads just off Marine Drive southwest of Andersen main gate, and

In this study S. plicata was not found in any limestone areas except in disturbed areas, or in any of several river and ravine areas which were checked, although it could grow in such places. It might be that Spathoglottis plicata requires an open area to grow in and most limestone forests, rivers banks and ravines are already well-occupied, and ground areas are shaded. If such were to be cleared it would probably grow there also. Meanwhile, savannas, with low vegetation, offer plenty of open, unshaded areas, and it is abundant there.

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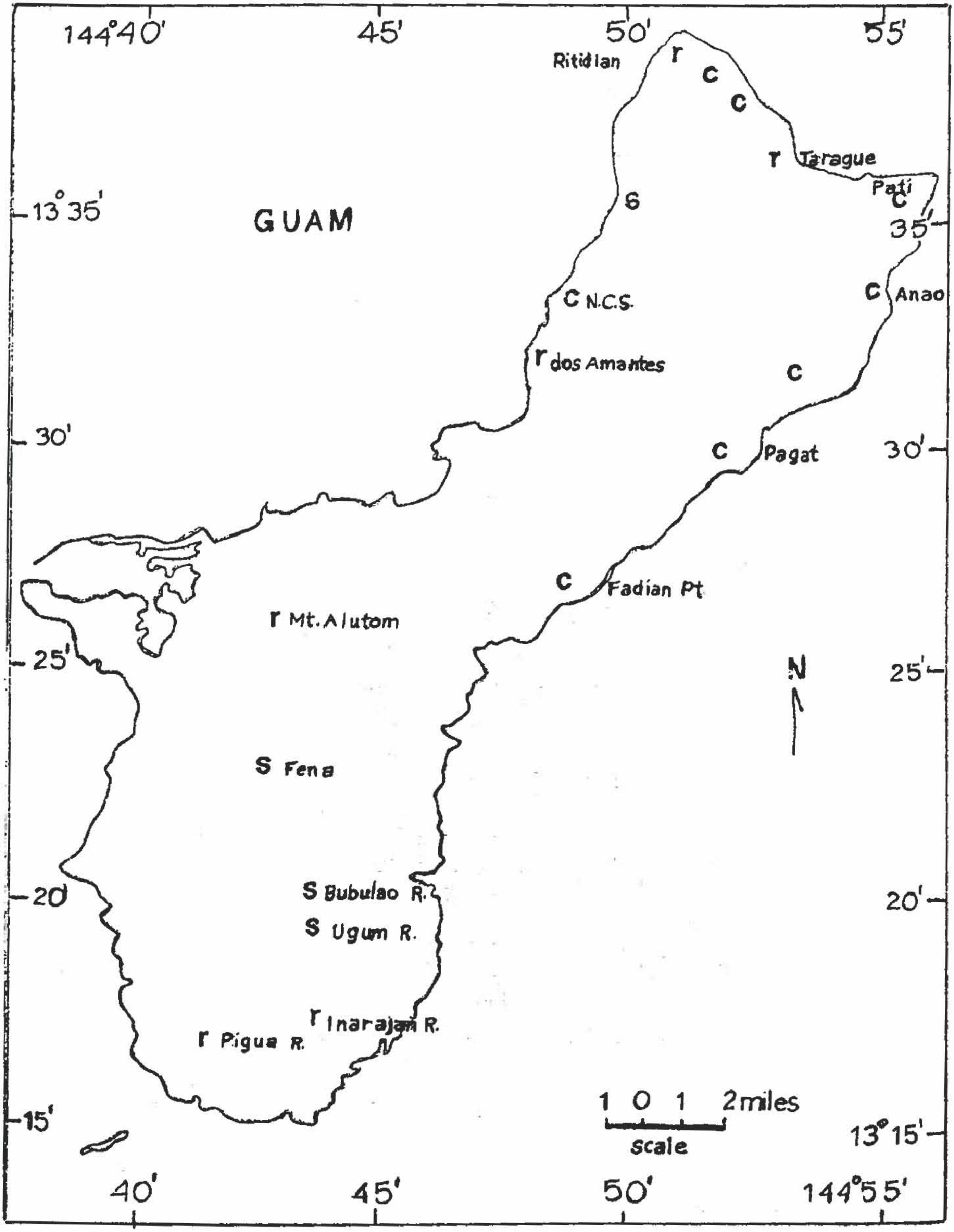

Fig. 1. Distribution of Cycas circinalis L. in this study. Legend: r = 1-10; s = 10-25; c = >25.

CYCAS CIRCINALIS L.

Peter J. Chargualaf

Cycas circinalis L., fadang, has been used by the inhabitants of Guam for a long time. This study was designed to discuss this species and map its distribution in selected parts of Guam.

Cycas is a small, palm-like tree with a single trunk which grows to a height of 3-5 m. The fronds, which are leathery, glossy, and pinnate, form a crown around the top of the trunk. Cycas is dioecious; pollen is produced by a large (0.5 - 1 m) erect cone borne in the center of the male plant trunk top, and ovules are borne on the surface of spatulate, woolly, brown leaf-like structures around the crown of the female plant. Each "leaf" can bear up to 6 smooth, ovoid, orange-brown seeds (Stone, 1970).

On Guam, cycad seeds were an important food staple of the ancient Chamorros. These seeds contain hydrocyanic acid, which is extremely poisonous and must be extracted by grating the seeds and then soaking the pulp in water, which must be changed every 15-18 hours. It is usual to change the water at least 10-12 times, which makes this a laborious undertaking. The flour which finally results is usually made into flat cakes, or tortillas, and then cooked (Merrill, 1946).

The seeds were also boiled, then pounded; this produced a paste which was used as laundry starch. The juice from seeds has been used for medicinal purposes in the treatment of open wounds, leg ulcers, abscesses, and boils. The exudate hardens and the wound usually heals after several applications (Moore and McMakin, 1980). According to Stone (1970), the trunk furnishes an edible, starchy pith (sago).

Cycas is most common in limestone habitats, though it is occasionally found in the volcanic savanna and ravine forest vegetation of southern Guam. Its distribution ranges from Zanizibar and the African coast through the Mariana Islands (Aguijan, Rota, and Guam), and south to Yap, Palau and Fiji. It often grows in patches or clumps, and though it usually spreads by seed it can be propagated by cutting sections from the trunk. Such cuttings can develop roots, though the females appear to survive better than the males.

Cycads found during this study are mapped in Figure 1. The relative abundance numbers are quite subjective and refer to estimated numbers in 4, 10 m^2 plots in the area. It should not be surprising that this species can occur in the southern, volcanic substrates because such areas have patches of limestone.

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ANGIOPTERIS DURVILLEANA DE VRIESE AND CYATHEA LUNULATA (FORST.) COPELAND

James Kodama

ANGIOPTERIS DURVILLEANA DE VRIESE

The giant fern is possibly endemic to Guam, though it may be identical with other Pacific-Philippine forms. It is a huge, terrestrial, trunkless fern with large bipinnate fronds growing from the base. The fronds reach 3-4.5 m in length. It is typically found in shady moist ravines (Stone, 1970).

The specimens observed for this study were located at Yigo Springs just behind the Peace Memorial, Upper Tocha Valley, Geus Valley in Merizo, and in the ravine above the Cetti Bay overlook (Fig. 1).

Previous studies have described specimens along the Ugum and Bubulao Rivers (Raulerson, et al. 1978), and along the Inarajan River and its tributaries (Chernin, et al. 1979). A herbarium specimen was found along a stream in Mt. Santa Rosa.

All plants were found along streams, which on Guam are found on volcanic substrates and, rarely, on argillaceous limestone; Angiopteris is probably limited to such habitats.

CYATHEA LUNULATA (FORST.) COPELAND

Cyathea is a large fern with a trunk that reaches 4-5 m. The lacy fronds are tripinnate and dotted with round sori (Stone, 1970). This tree fern is indigenous to Micronesia and Polynesia. It is rare on Guam and can be found around Fena Lake and in the ravines of southern Guam. It occurs along the trail up Jumullong Manglo and on the slope east of the main ridge (Figs. 1 & 2).

Almost all of the specimens noted were located on the fringes of the ravine forests. Several occurred as much as 20 m into the swordgrass savanna outside of the forest. This means they probably can survive in the savanna and were more abundant there at one time. It is likely that savanna fires and people (who transplant this species to landscape their properties) have influenced the present distribution of this species.

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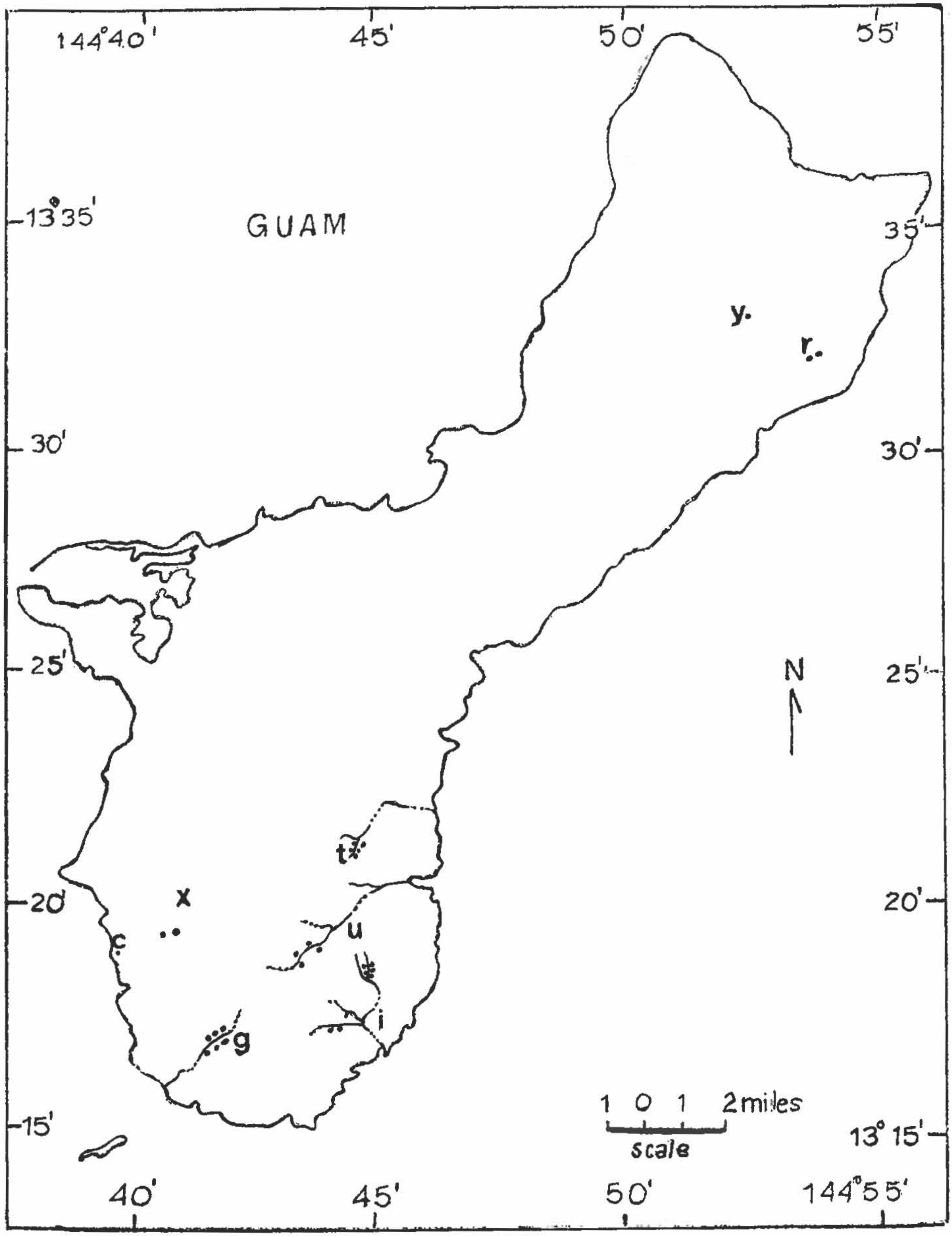

Fig. 1. Collecting sites. Mt. Jumullong Manglo (X), Cetti Bay (C), Geus River (g), Inarajan River (i), Ugum River (u), Togcha River (t), Mt. Santa Rosa (r), and Yigo Springs (y).

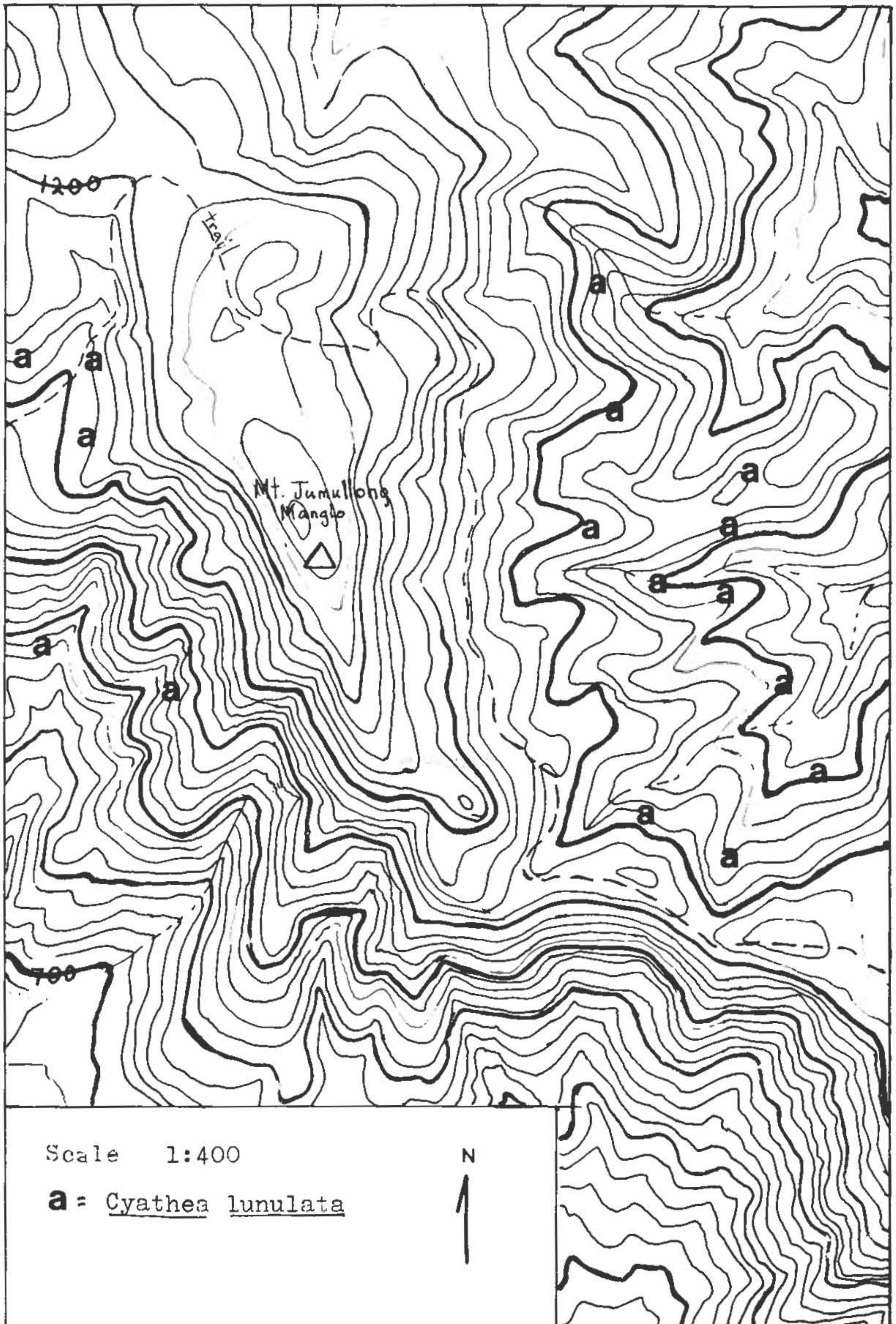

Fig. 2. Individual Cyathea lunulata (Forst.) Copeland in the Mt. Jumullong Manglo area.

CEIBA PENTANDRA (L.) GAERT. (ATGEDON DE MANILA) AND TERMINALIA CATAPPA L. (TALISAI)

Anthony P. Pangelinan and Jeanne M. Belanger

INTRODUCTION

Economic plants play important roles in many Pacific cultures. On Guam, former economic plants are being neglected, and their roles as economic plants are changing. The Chamorros formerly considered many of their subsistent economic plants to be very valuable, but with easier access to the island, and more influx of foreign foods and materials, the values of many of the local people have changed and the importance of these plants has diminished.

The distributions of two plants, Ceiba pentandra and Terminalis catappa, known locally as Atgedon de Manila and Talisai, respectively, are presented. These particular plants were chosen primarily because of their easily recognizable features and because they are representative of plants whose importance has diminished. Ceiba pentandra is a fairly large tree with a whitish or grayish trunk, reaching 10-15 m in height; branches are arranged in horizontal tiers. The fruits are cylindrical with pointed ends; they are conspicuous because leaves are shed while the fruits mature (from green to brown), and the fruits alone hang from the branches (Stone, 1970).

During times of famine, the seeds have been removed from the interior of the fruit and eaten. The "silk-cotton" hairs around the seeds can be used as pillow stuffing. These trees were useful for fruitbat hunters since the fruitbats hang from the trees (camouflaged as dead fruit) while they eat the seeds from adjacent fruits. However, fruitbats are now scarce on Guam, so their value to hunters has diminished, and the fibers are less important as pillow stuffers because pillows can be store-bought.

T. catappa is also quite distinguishable because of its pagoda-like structure; the branches are whorled and the lower branches are the longest, while upper branches are progressively shorter. The leaves cluster towards the ends of the branches and turn reddish as they wither. However, the fruit is not easily seen from a distance since it is only about 5 cm long.

The trunk of T. catappa, which is very straight, has been used in building temporary structures. The fruit is quite delicious; both the skin and the nut within are edible. These trees are planted although they may also grow naturally (Stone, 1970).

FIELD METHODS

People familiar with the distribution of these two species gave information which helped start this survey. Following these initial inquiries a field survey was conducted by car, with periodic stops at high points where the area was searched using binoculars. The road survey permitted transversing most of the island's roads but was also a limitation since many of the interior regions were not accessible by road and may have been overlooked.

Plants seen were plotted on a 1954, U.S. Army 1:50,000 map. These plots were later transferred to smaller maps (Figs. 1 & 2), which diminished our accuracy even more. However, the distribution, as expected, indicated that the plants were located in or near rural areas. The two species were not mapped together because many of the plant areas overlapped, and the size of the maps made it difficult to use two different symbols for the plotting. The dots represent actual plants sighted, so they also represent counts of these plants.

SURVEY RESULTS AND CONCLUSIONS

Most of the plants plotted were adjacent to roads, or close enough to be easily spotted with binoculars. As indicated previously, this distribution does not include many interior sites, although some plants have been seen in the interior on hikes.

Younger trees were almost always found in rural areas; very few, or no representatives were located in urban areas such as Dededo, Barrigada Heights, Sinajana, and Yona, yet they were present or even common in these villages as few as 10 years ago. Many of the larger trees were located in areas which are now and were previously rural, or in presently uninhabited regions. Some of these areas included prehistoric sites; many other plants adjacent to family dwellings have been used daily as far back as pre-war times. Many trees which were quite conspicuous (the lines of Atgedon which once were quite plentiful in Chalan Pago and along Route 4) were destroyed to make way for larger roads, which seems quite unnecessary.

As indicated by the maps, most of the plants were found in the volcanic southern areas of Guam. They were not limited to these sites, and may grow on limestone areas. They also seem to be able to survive under stressful weather conditions, and can recover even when broken off. Talisai have only recently begun to fruit again, however; beetles have produced serious problems for this species.

Many other plants have undergone similar changes as new, not necessarily better ideas have been promoted, and as modern, synthetic products have become more accessible. It is possible that these economic plants may be lost completely to the island, and these plants should be studied with an interest in promoting continued use. Such use of economic plants will help keep them from being lost, but it is man's thoughtfulness or thoughtlessness which will in the end determine this.

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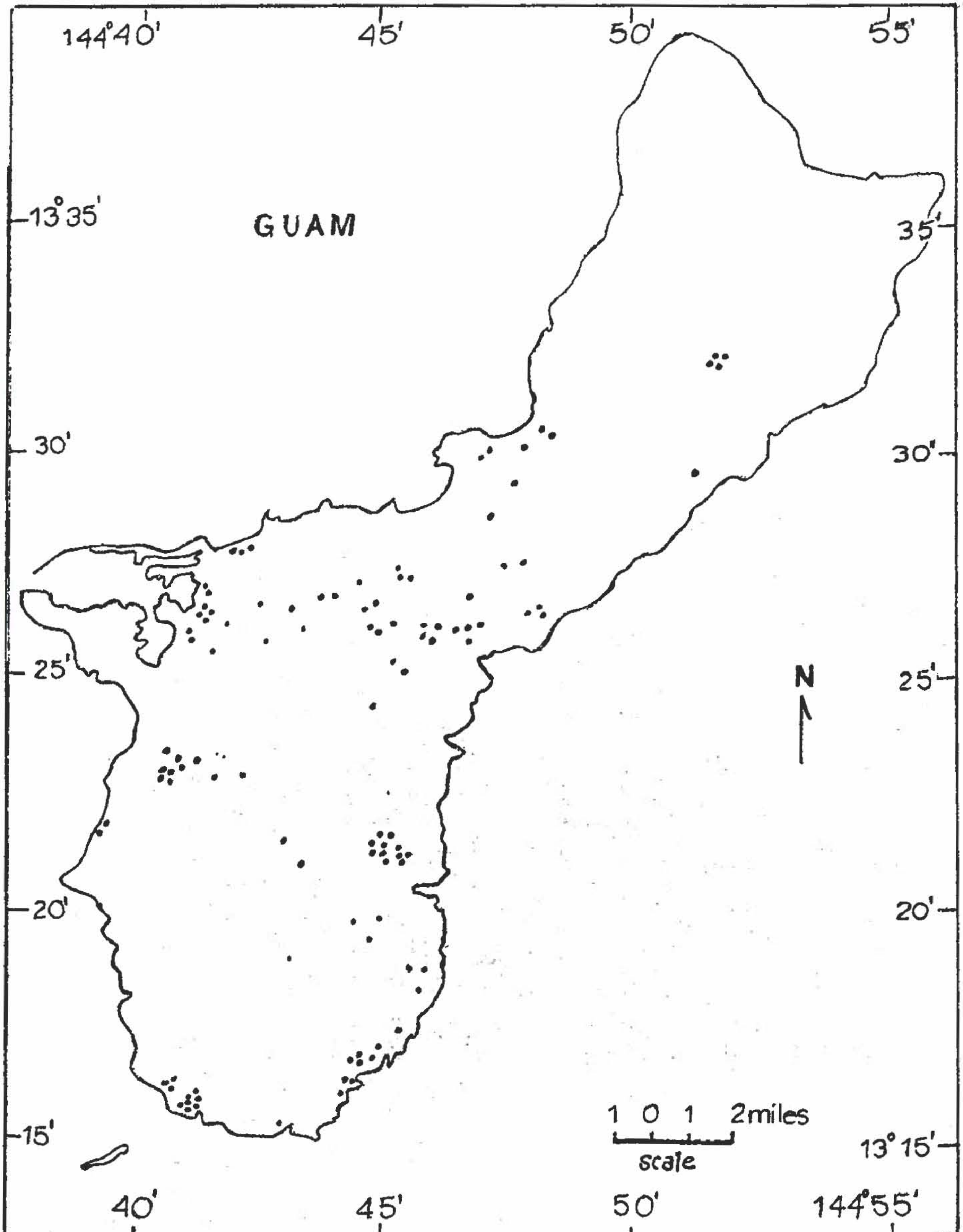

Fig. 1. Distribution of Ceiba pentandra (L.) Gaert. Each dot represents one tree.

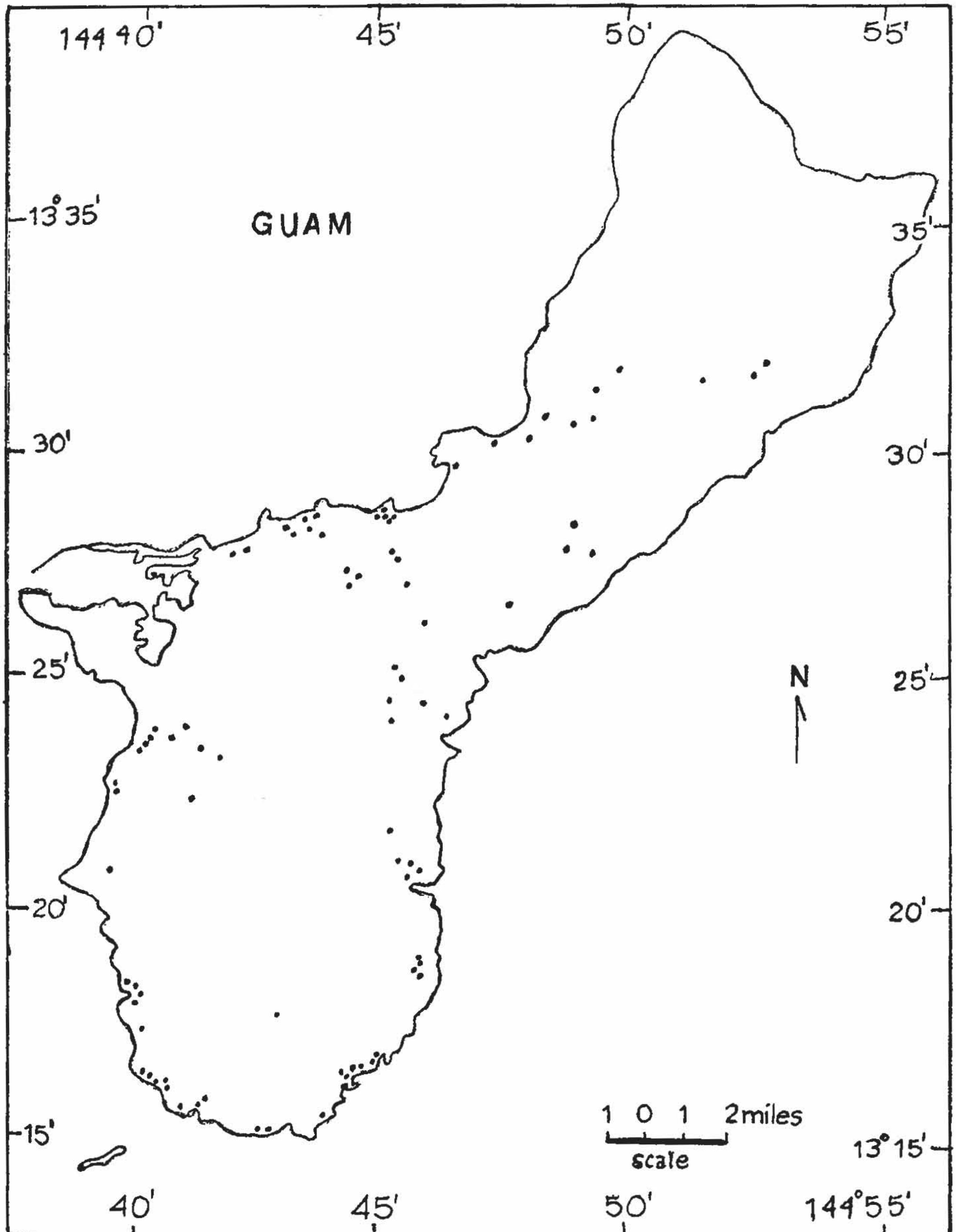

Fig. 2. Distribution of Terminalia catappa L. Each dot represents one tree.

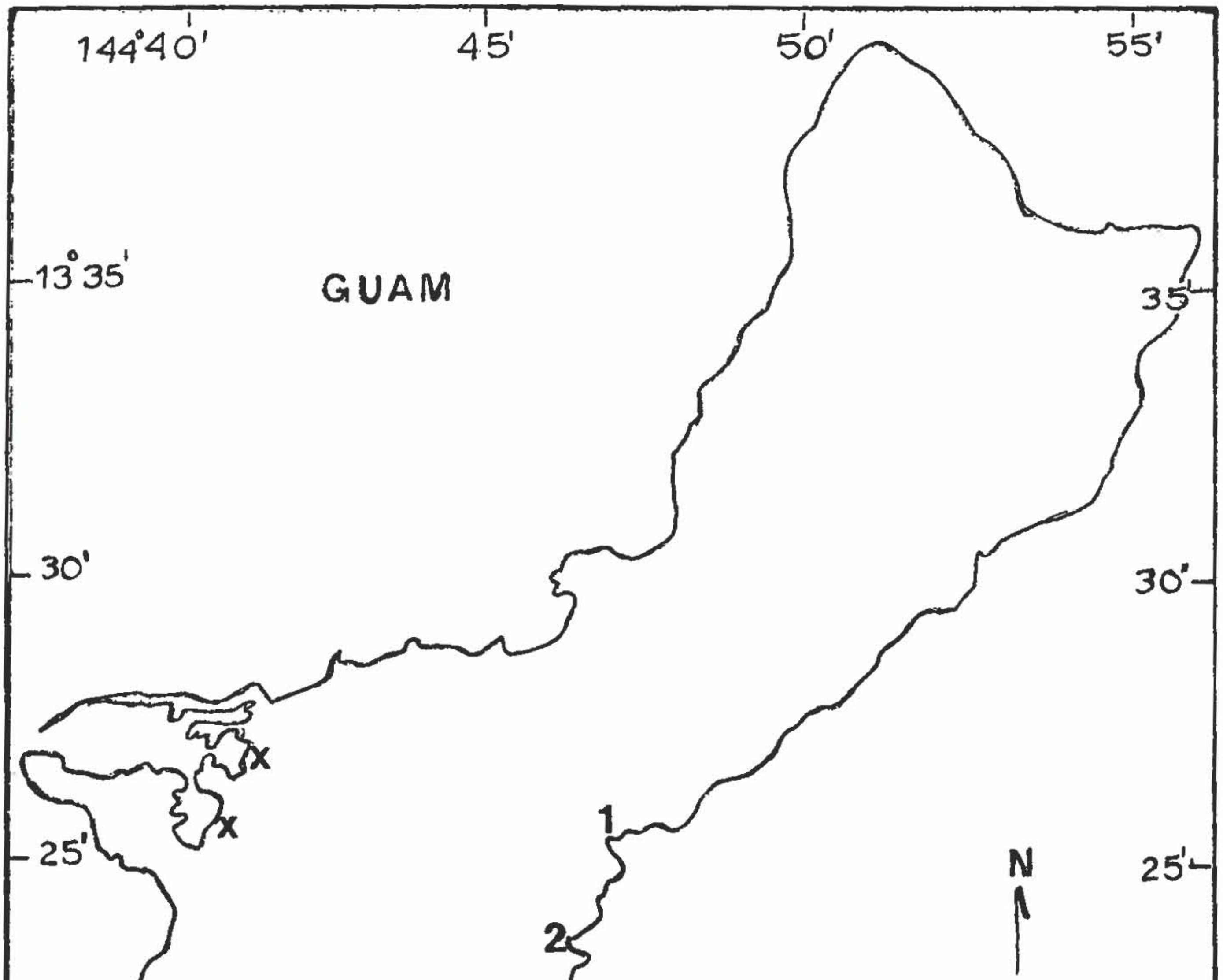

Fig. 1. Distribution of Nypa fruticans Wurmb. Numbers refer to sites of this study; X indicates other places nipa is known to occur.

ISLAND DISTRIBUTION OF *NYPA FRUTICANS* WURMB.

Anthony Ramirez

Nypa fruticans found in this study grew along the mouths of six rivers on the southeast portion of Guam; all of these rivers opened into bays which led into the open sea.

Nipa grew in muddy soil along river banks; most plants were partially submerged in saline waters. Nipa's fruit was not seen, but several seedlings protruded from fibrous pods. Many fronds of most adult trees had been cut off; some trees had been killed by indiscriminate cutting.

The six river mouths surveyed were (Figure 1):

1. Pago. Nipa extended on both sides, north and south banks, beginning at the river's outlet into the bay and about 150 m west toward the bridge. A small cluster of trees also occurred on the south bank inland from the bridge.

2. Ylig. The only nipa here was a small cluster of trees on the south bank, east of the Ylig bridge.

3. Talofofo. Nipa occupied a fairly large area; it extended inland about 200 m on the south bank (west of the bridge).

4. Inarajan. The river forks into two outlets toward the bay. Nipa grew on the south bank of the north outlet, and along both riverbanks of the south outlet. A small group of trees grew along Inarajan Bay also.

5. Agfayan. Nipa grew on the south bank and extended west of the bridge for 100 m.

6. Ajayan. Nipa was limited to a very small cluster of trees on the south bank and west of the bridge.

Nipa had been reported from these sites, and from the mouth of the Laguas River (Sasa Bay, outer Apra Harbor), along the Atantano River of inner Apra Harbor, and the Geus River of Merizo, by Moore et al. (1977). According to Fosberg (1960), *Nypa* is typically a mangrove species in its natural habitats; the fact that it is not usually part of a mangrove community on Guam may indicate that it is an introduced species here.

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III. EFFECTS OF MAN ON GUAM SPECIES AND VEGETATION

A SURVEY OF INTSIA BIJUGA (COLEBR.) O. KTZE. IN THE NORTHERN LIMESTONE FOREST

Celestino F. Aguon

ABSTRACT

Transects and general exploration of an area permitted the locating of Intsia bijuga and its associates on hard limestone habitats of northern Guam. Data indicated that the largest and most numerous specimens of Intsia were located in the northern and central parts of the sampling area. Logging is probably responsible for the reduction in distribution, individual size and population size, so that the present population of Intsia bijuga is only a remnant of one which was much larger.

INTRODUCTION

The northern part of Guam consists of a limestone plateau or mesa which slopes from a high point in the north (about 182.9 m) to a low point in the center (about 61 m). The limestone of the plateau is a product of cumulative reef growth of coral and algae; this was lifted above sea level during the Pleistocene, as indicated by nips at different levels along cliffs. Furthermore, nips at different levels suggest intermittent lifting, or sea level rising or falling, rather than a single large uplift (Tracey et al., 1964).

The limestone plateau is not pure limestone, but is composed of three major sediments: an upper layer of argillaceous foraminiferal micropora coquinite which gives the soil a pink, brown and orange-red coloration; a middle layer of pure limestone; and a lower layer of pure foraminiferal micropora coquinite and volcanic material (Hathaway and Carrol, 1969).

The northern limestone plateau is marked by two prominent volcanic hills: Mount Santa Rosa (262 m) and Mataguac Hill (192 m); and Barrigada Hill (203 m), which is limestone. Savanna vegetation is well developed on Mount Santa Rosa (Stone, 1970). A fault zone at Pago Bay separates the southern volcanic formation and the northern plateau (Tracey et al., 1964).

The gradual uplift of the coral platform allowed the area to be less affected by salt and salt spray. Consequently, the continuous coral platform uplift allowed the original strand vegetation to be invaded by a variety of species as the environment became mesophytic. Therefore, the limestone forest is actually a modified strand type (Fosberg, 1960).

Species of the limestone forest generally belong to the genera: Ficus, Pandanus, Artocarpus, Intsia, Elaeocarpus, etc. Ferns, epiphytes, and vines are also common in the highly developed forest, which is found usually on level ground (Fosberg, 1960).

Intsia bijuga is a tree with durable, heavy, termite-resistant wood; because it was highly valued, it was heavily logged in the early 1900's (Stone, 1970; Behrens, 1976), and no account of its population size and average tree size has been reported.

Between 5 and 20 July, 1980, a survey of Intsia bijuga in the northern areas of Guam was conducted. This survey was to determine population size, individual tree size (average tree size per area), and distribution of this species on the limestone plateau of northern Guam; and to assess the impact of logging as it was done in the early 1900's and as it continues today.

MATERIALS AND METHODS

Data were derived from 50 m transects. Six points were established 10 m apart in each transect; at each point all woody species within 1 m of the point, and the number of individuals, were recorded.

The heights and diameters of breast height (dbh) were recorded for all Intsia trees and seedlings found in the transects and in the areas. The circumference of seedlings was measured below the first branch. All trees measured which were not part of the transects were recorded separately or marked with an asterisk. Transects in areas bordering cliffs were made perpendicular to the cliffline (Fig. 1).

The following materials were needed: a 50 m transect line marked at 10 m intervals; metric tape measure at least 3 m long; clipboard, sheets of paper, and several pencils; and range finder, to measure the height of the tree canopy.

The following calculations were required:

1. Calculation of diameter breast height (dbh): the circumference was converted to diameter: $C = \pi d$;

2. Species Frequency = The number of points in which species occurred/total number of points;

3. Relative Abundance (R.A.) = The number of individuals of a species/the total number of individuals of a species recorded;

4. Density = Total number of individuals recorded in the transect/area of transect in hectares; and

5. Species Incidence = The number of individuals/the number of points at which the species was recorded.

DISCUSSION

Intsia bijuga of the family Leguminosae has a fairly extensive geographic distribution (Fig. 2); it occurs in eastern Madagascar, southeast Asia, through Malesia to northern Australia, and into the Pacific as far as the Marshall Islands and Samoa. It has not reached Taiwan or Hawaii (Van Steenis and Van Balgooy, 1966; Stone, 1970). This distribution may have resulted from the bouyancy of the seed and ocean currents; Intsia has strand vegetation characteristics which permit colonization of open shore line sites. Polunin (1960) noted that seeds may be dispersed over thousands of miles; it is likely that a series of island colonizations, over thousands of years, produced the present geographic range.

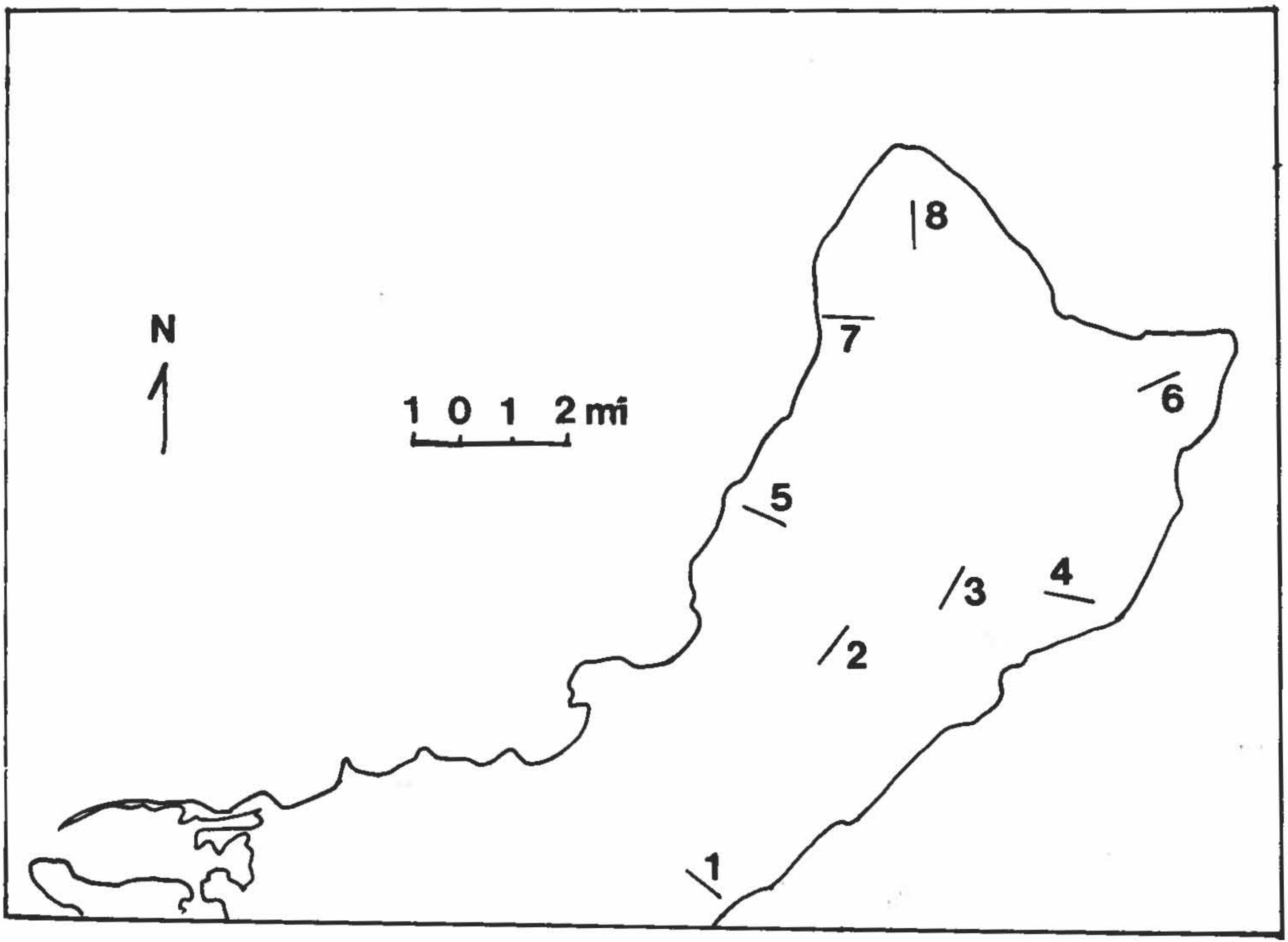

Fig. 1. Transect locations in northern Guam.

Legend:
1. Tolang, east of G.W.H.S.
2. East of Mt. Barrigada.
3. West of Asdunculas.
4. East of Lajuna area.
5. East of Amantes Point.
6. Pati Point area.
7. North of Urano Point.
8. Ritidian Point area.

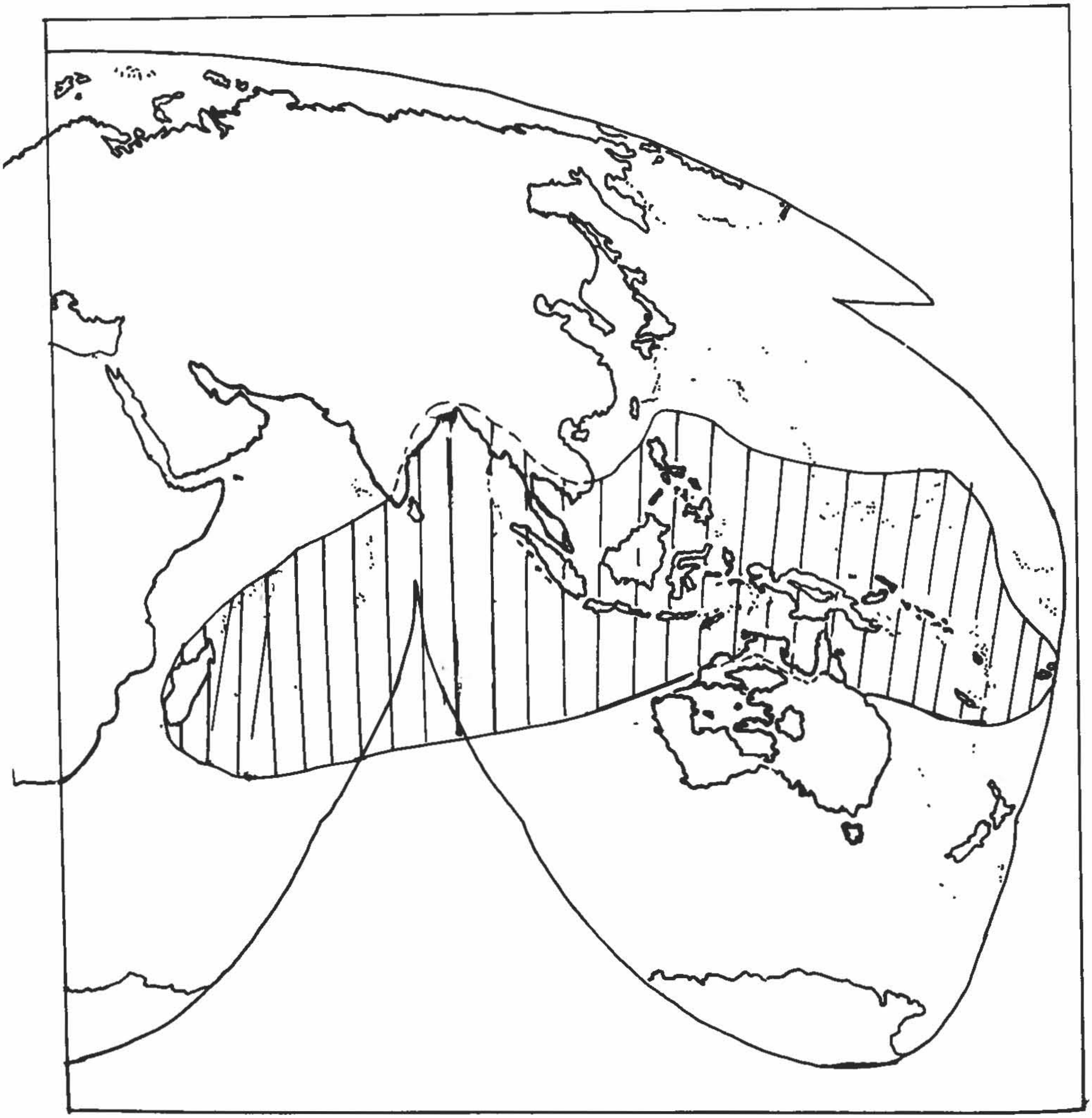

Fig. 2. Geographic distribution of Intsia bijuga (Colebr.) O. Ktze.
Map from van Steenis and van Balgooy, 1966.

Intsia may have been one of the earlier colonizers of Guam, along with other beach strand plants. However it is now part of the limestone forest which could have occurred through a series of coral platform uplifts, or because its young could tolerate shade. It is likely that larger trees were present in greater abundance during the early part of the twentieth century, but logging so devasted the population that what is seen now are only those seedlings which were too small to harvest at the time most of the logging was done.

Data from transects taken in several areas of the northern plateau are presented in Table 1; the transects are mapped on Figure 1. It can be noted that plateau forests vary, so that some are dominated by one or two species (transects 4 and 5), while others have a mixture of dominant species (transects 2 and 3).

The survey indicated that *Intsia* is most common in the eastern cliffline forest, in all northern forest areas, and in the upper western forest areas to Hilaan Point (Fig. 3 and Table 2). The density, which ranged from 100-200 indiv./ha, was higher in areas of the northern section; *Intsia* was not recorded in the southwest and southwest transects (Amantes and Tolang), though several trees (> 50 indiv./ha) were present in Tolang area (Tables 3 and 4).

Intsia of the northern (Pati-Ritidian area) and central (Barrigada-East Asdunculas) transects had greater average diameter and canopy height values that those of other areas. It is possible that these are areas of early *Intsia* colonization, so that individual trees are older and larger; it is also possible that these sites are more protected from typhoons. It is most likely, however, that todays largest *Intsia* specimens are found in areas most inaccessible to logging. The low average diameter and canopy height values in the upper northwestern areas probably result from heavy logging. Consequently, not only smaller trees were found, but also fewer trees.

Figure 4 demonstrates an exponential relationship between canopy height and basal area. Possibly, *Intsia* on Guam grows to a maximum height of about 6 meters, but continues to grow in diameter, or basally. If basal growth also has a maximum, it is not known.

CONCLUSIONS

1. Large trees are found inland, probably because these inland areas were less exploited during period of heavy logging.

2. Present small numbers and size of *Intsia* reflect heavy logging activities in the past and general reduction in suitable habitat.

3. *Intsia* has a wide distribution which has been extended by its strand vegetation characteristics and limited by the direction and strength of ocean currents.

Table 1. Results from the vegetation transects.

Transects	No. Pts. Observed	Total Indiv.	Freq.	R.A.	Density/hectare
1. Tolang					
<u>Ficus</u>	1	1	.167	.200	100
<u>Guamia</u>	2	2	.333	.400	200
<u>Aglaia</u>	3	5	.500	1.00	500
<u>Cycas</u>	4	4	.667	.800	400
<u>Neisosperma</u>	1	1	.167	.20	100
<u>Triphasia</u>	1	2	.167	.200	100
2. Barrigada Hill					
<u>Triphasia</u>	4	6	.364	1.00	300
<u>Cycas</u>	5	5	.455	.833	250
<u>Pandanus</u>	3	3	.273	.50	150
<u>Annona</u>	1	1	.091	.167	50
<u>Aglaia</u>	1	1	.091	.167	50
<u>Eugenia</u>	2	2	.182	.333	100
<u>Guamia</u>	1	1	.091	.167	50
<u>Neisosperma</u>	1	1	.091	.167	50
<u>Intsia</u>	3	4	.273	.167	200
<u>Capsicum</u>	3	3	.273	.50	150
3. West Asdunlucas					
<u>Aglaia</u>	5	6	.455	1.00	300
<u>Triphasia</u>	4	6	.364	1.00	300
<u>Pandanus</u>	3	3	.273	.500	150
<u>Pipturus</u>	2	2	.182	.333	100
<u>Guamia</u>	2	2	.182	.333	100
<u>Discocalyx</u>	2	2	.182	.333	100
<u>Cycas</u>	1	1	.091	.167	50
<u>Intsia</u>	1	1	.091	.167	50
4. Lajuna West					
<u>Pandanus</u>	1	3	.167	1.0	500
<u>Macaranga</u>	1	1	.167	.333	166.67
<u>Aglaia</u>	1	1	.167	.333	166.67
<u>Intsia</u>	1	1	.167	.333	166.67
5. Amantes Point					
<u>Pandanus</u>	5	10	.833	1.00	1000
<u>Triphasia</u>	3	6	.500	.600	600
<u>Aglaia</u>	1	1	.167	.100	100
<u>Eugenia</u>	1	1	.167	.100	100
<u>Carica</u>	1	1	.167	.100	100

Table 1. Continued

Transects	No. Pts. Observed	Total Indiv.	Freq.	R.A.	Density/hectare
6. Pati Point					
Guamia	3	5	.500	1.00	500
Ochrosia	2	4	.333	.80	400
Wikstroemia	4	5	.667	1.0	500
Aglaia	1	1	.167	.200	100
Ficus	1	1	.167	.200	100
Cestrum	1	1	.167	.200	100
Intsia	1	1	.167	.200	100
7. Uruno Point					
Cynometra	6	6	1.00	1.00	600
Aglaia	5	6	.833	1.00	600
Eugenia	3	3	.500	.500	300
Triphasia	2	2	.333	.333	200
Guamia	1	1	.167	.167	100
Maytenus	1	1	.167	.167	100
Morinda	1	1	.167	.167	100
Intsia	1	1	.167	.167	100
8. Ritidian Point					
Aglaia	6	10	1.00	1.00	1000
Eugenia	3	3	.500	.300	300
Psychotria	1	1	.167	.10	100
Cycas	2	2	.333	.100	200
Macaranga	1	1	.167	.200	100
Intsia	1	1	.167	.100	100

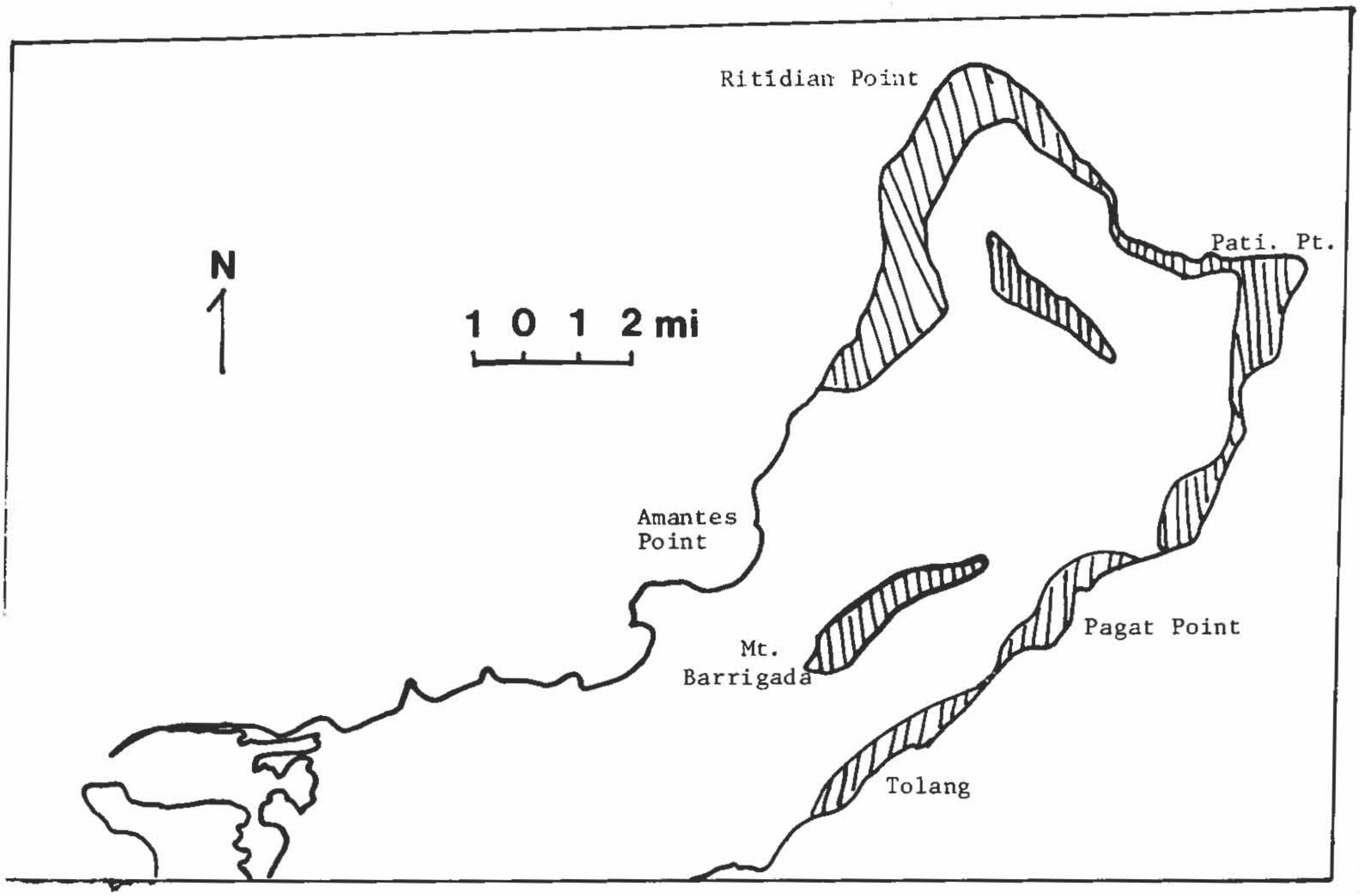

Fig. 3. Distribution of Intsia bijuga (Colebr.) O. Ktze. in northern Guam.

Table 2. Transect data for Intsia bijuga.

Transect	Total Points	Points Observed	Total Indiv.	Transect Length (m)	Area Sampled (ha)	Freq.	Sp. Inc.	Density per Hectare
1. Tolang	6	0	0	50	0.01	- - -	- - -	- - -
2. East Barrigada Hill	11	3	4	100	0.02	0.27	1.33	200
3. West Asdunlucas	11	1	1	100	0.02	0.09	1.00	50
4. Lajuan	4	1	1	30	0.006	0.25	1.00	166.7
5. Amantes Point	6	0	0	50	0.01	- - -	- - -	- - -
6. Pati Point	6	1	1	50	0.01	0.17	1.00	100
7. No. Uruno Point	6	1	1	50	0.01	0.17	1.00	100
8. Ritidian Point	6	1	1	50	0.01	0.17	1.00	100

Table 3. Combined transect data: Intsia bijuga.

Transects	N	$\bar{X}$ ht. (cu)	$\bar{X}$ dbh (cu)	Density per Hectare
Eastern Area (Transects 1 & 4)	8	380	17.6	62.5
Western Area (Transects 5 & 7)	11	567	27.3	50.0
Northern Area (Transects 6 & 8)	4	601	35.0	100.0
Central Area (Transects 2 & 3)	18	609	30.5	125.0

Table 4. Data combined from transects and from local area.

Transects	N	$\bar{X}$ ht. (cu)	? Sid.	$\bar{X}$ dbh (cu)	? Sid.
1. Tolang	4	260	184.8	18.6	19.8
2. East Barrigada Hill	12	544	237.8	24.9	23.8
3. West Asdunlucas	6	674	280.7	35.9	42.6
4. Lajuna	4	500	88.0	16.6	8.9
5. Amantes Point	0	- -	- -	- -	- -
6. Pati Point	2	583	88.0	35.6	1.4
7. No. Uruno Point	11	567	158.6	27.3	24.0
8. Ritidian Point	2	620	25.1	34.4	11.4

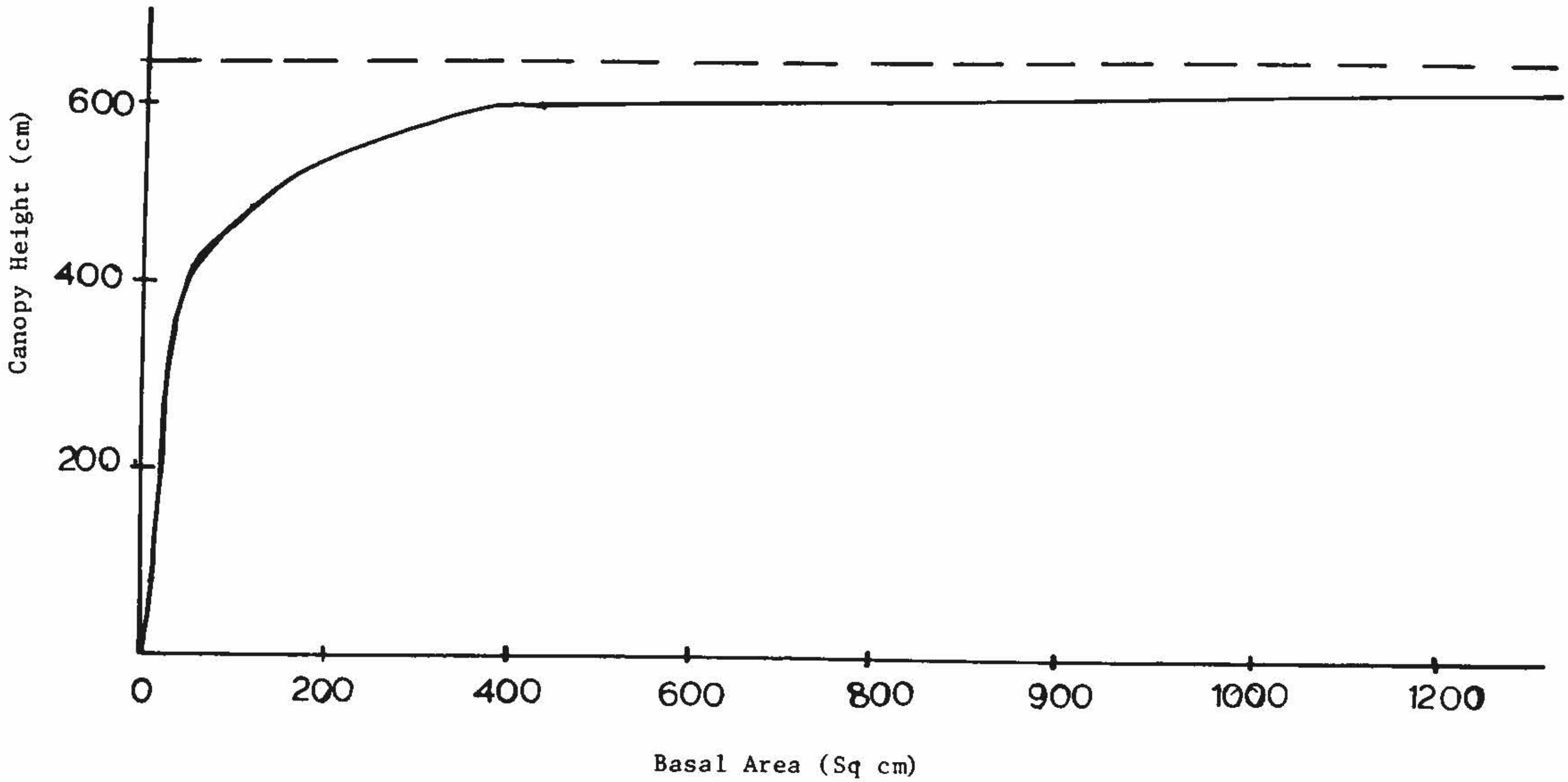

Figure 4. Basal area versus canopy height.

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DISTRIBUTION OF LEUCAENA LEUCOCEPHALA (LAM.) DE WIT IN AN AREA OF NORTHERN GUAM.

Linda J. Dunn and Debra J. Van Sciver

ABSTRACT

It has been suggested that tangantangan [Leucaena leucocephala (Lam.) deWit], a legume which has root nodules containing nitrogen-fixing bacteria, is a major contributor to the high nitrate levels in water from the Ghyben-Herzberg lens system of the limestone substrates of northern Guam. The distribution of tangantangan in a 21 square kilometer area of northern Guam was mapped. This species was not abundant, or even common, in most of the study site. If the amount of nitrates added is directly proportional to the abundance of tangantangan, then it is unlikely that the tangantangan of the study site contributed greatly to the high nitrate level of the lens water.

INTRODUCTION

A study was done of the distribution of Leucaena leucocephala (Lam.) deWit (Leguminosae, subfamily Mimosoidae), in a twenty-one square kilometer area in northern Guam. Leucaena leucocephala, locally known as tangantangan, is an erect, slender shrub or small tree with bipinnate leaves with many leaflets (Stone, 1970). The shrub or small tree may be of any height up to 10 m, depending on the age and wetness of the location (Fosberg, 1960). It is a native of tropical America that is virtually pantropical. Shortly after World War II the local Department of Agriculture had huge amounts of Leucaena seed distributed over the island by airplane (Fosberg, 1960).

Leucaena is considered a disturbed area plant and is now very abundant on roadsides and in areas of the limestone part of the island. It is established to a limited extent in the volcanic southern part of the island. Leucaena can form such dense thickets that travel through them can be extremely difficult.

The lens system of northern Guam supplies much of the potable water on Guam, and in recent years there has been concern about nitrate levels in lens system water. Nostoc, a nitrogen-fixing blue-green alga, and tangantangan, a legume with nitrogen-fixing bacteria in root nodules, are abundant and have been suggested as sources of the extra nitrates. A study of Nostoc muscorum (Grosenbaugh, 1979) indicated that it was not a major contributor of nitrate to the groundwater of Guam. If Leucaena were a source for nitrates in the lens water, then it is likely that the amount of tangantangan would be directly related to the amount of nitrates in the water. A study of the distribution of Leucaena leucocephala should provide information about its abundance. A site of 21 square kilometers which contained several water pumping stations was chosen as the survey site.

MATERIALS AND METHODS

The survey area is presented in Figures 1 and 2. The field work was done by driving through the accessible areas and noting the distribution of

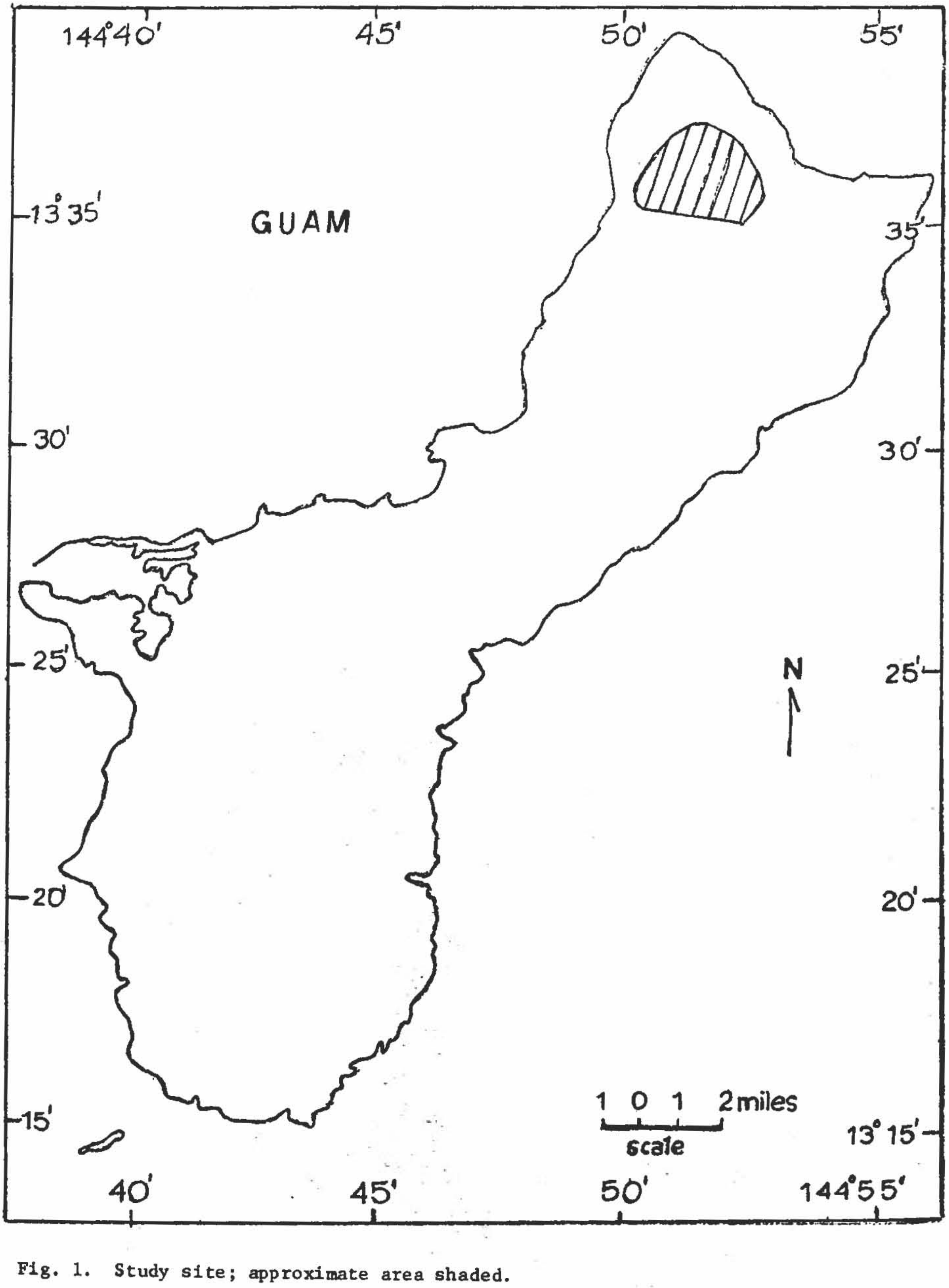


Fig. 1. Study site; approximate area shaded.

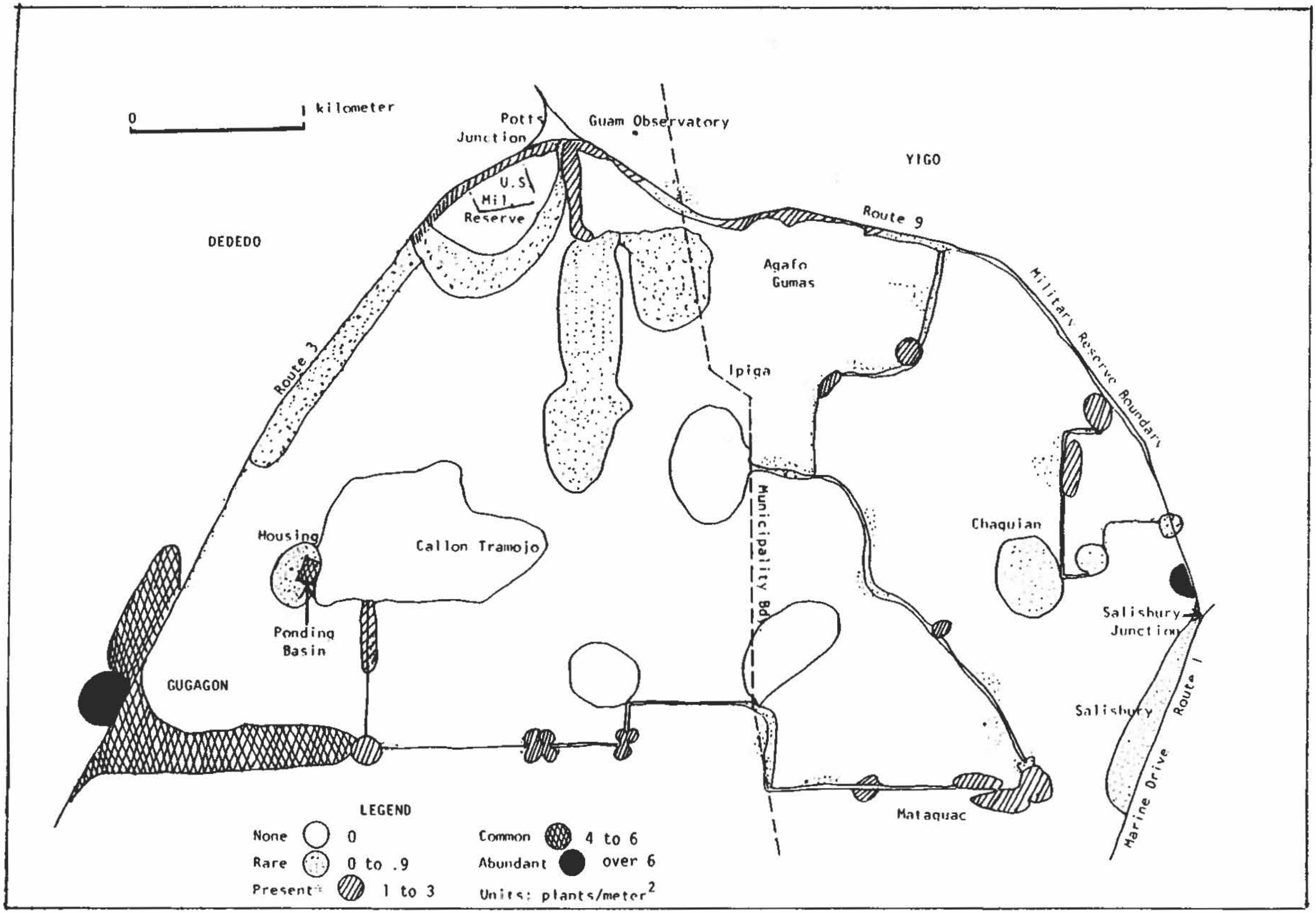
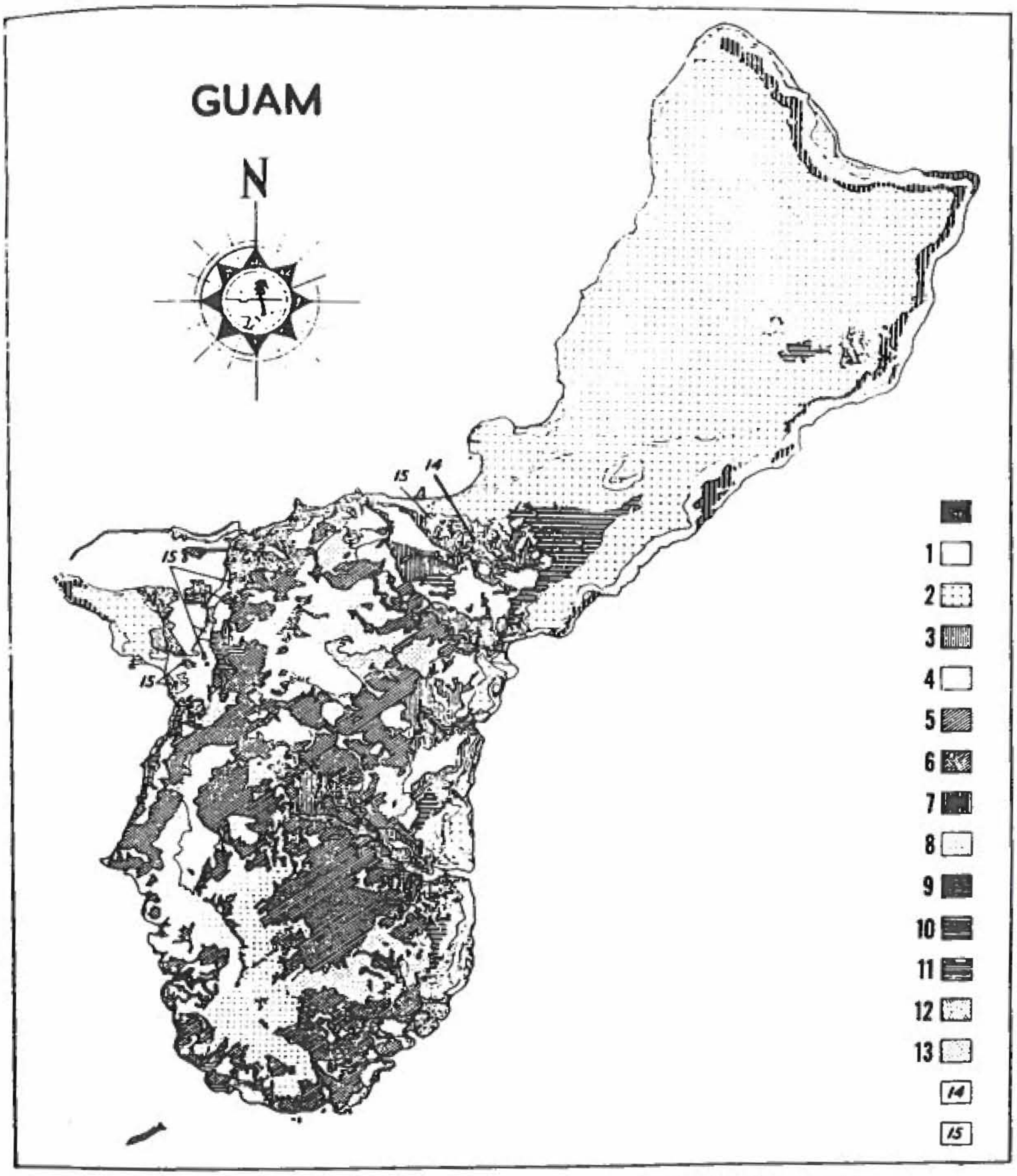


Figure 2. Map of survey area. Density measurements apply only to the immediate area surrounding observed plants and does not denote the actual density of the area.



Map 3. Soil Map of Guam. North: limestone. South: laterites, basalts, argillaceous soils, etc. Note extensive limestone 'mesa' in N. Guam.

Fig. 3. Soil map of Guam (Stone, 1970). Legend on page opposite.

Map 3
SOIL MAP
Key to symbols

No.

0 Solid black = fresh water.

1 Limestone. (a) Guam clay; reddish, granular, friable, generally shallow.
(b) Gently sloping land with boulders, exposed rock, etc. Soil sparse.
(c) Same, but steep land or cliffs.

2 Toto clay; generally deep on argillaceous limestone; brown to pale yellow, firm, acid, moderately plastic, high shrink/expand cap'y.

3 Chacha clay; or Saipan clay; moderately to very deep on argillaceous limestone; neutral to acid; yellowish to brown or reddish.

4 Chacha and Saipan clay with very shallow Yona clay on convex ridgetops.

5 Yona clay on ridgetops, Chacha clay on intervening slopes, with small areas of shallow stony phase of Saipan clay. Brownish, granular.

6 Latosols. (a) Atate clay; deep reddish mottled, plastic to hard C horizon, pale yellow, olive, or gray in lower part; also Agat clay.
(b) Agat clay and Asan clay; C horixon pale yellow to olive or gray; Atate clay sparse.
(c) Chiefly Agat clay and Asan clay with some rocks.

9 Pago clay; non-calcar eous; deep, firm, plastic. Drainage good to moderate.

10 Inarajan clay; neutral to alkaline, generally with high water-table, poorly drained, often flooded. Shallow or deep, moderately firm.

11 Muck: usu. submerged and highly organic, with 20–50%±decomposed organic matter.

12 Shioya limesand; pale brown to white, with some dark organic color. Fine to coarse grained. *Beaches.*

14 Artificial: chiefly gravel mixed with limesand; also rubble, etc. Includes dumps.

Leucaena leucocephala. Tangantangan in other localities was counted by censusing the entire area on foot; this method was adequate and a more technical method was not called for. Only areas that were actually traversed were mapped. The density measurements of plants apply only to areas surrounding observed plants, and do not denote the actual area densities of plants.

DISCUSSION

The northern end of Guam is an elevated limestone plateau 91-183 m above sea level. Soil found there is composed largely of coralline limestone (Fig. 3) and the pH is basic; it is well drained and able to support a larger flora than that of volcanic soils (Stone, 1970). Tangantangan is found on basic soils, such as those with high limestone content. It is extremely adaptable to varying climatic conditions; once established it is very difficult to eradicate. On Guam, *Leucaena* is usually found as an "edge species".

Tangantangan was not present in most of the areas surveyed (Fig. 2). In the entire survey area the density of tangantangan was extremely low, though isolated patches within the area had densities ranging from < 5 plants to several hundred per 100 m^2. The legume, when present, was generally restricted to areas along roadsides, and usually did not occur in the interiors of the limestone forests. Tangantangan was present or common typically at road intersections and near numerous small ranches and farms in the site. These were disturbed areas; in more natural sites, such as dense limestone-*Pandanus* forests or wide open savanna areas, tangantangan was rare or absent. It is interesting to note that tangantangan had not established itself in areas of thick *Polypodium scolopendria*, *Nephrolepis hirsutula*, or *Lippia nodiflora*, even though there were some plants in the immediate area to serve as seed sources.

CONCLUSIONS

In the area surveyed, tangantangan does not appear to be a valuable contributor of nitrates to the Guam water lens system. There are very few sites in the study area where tangantangan is either abundant or common, although perhaps there is enough of the legume present in small areas to enrich the soil locally, and thus fertilize itself and neighboring vegetation. It is highly unlikely that enough nitrates to leach from the soil layer into the groundwater are produced by the tangantangan of the study site, though it is still possible that tangantangan contributes to the high nitrogen content of the water leached from areas of thick growth. Additional surveys should be made to map the growth of tangantangan in northern Guam; detailed mapping of *Leucaena leucocephala* should clarify its possible role as a contributor of nitrates to the groundwater system.

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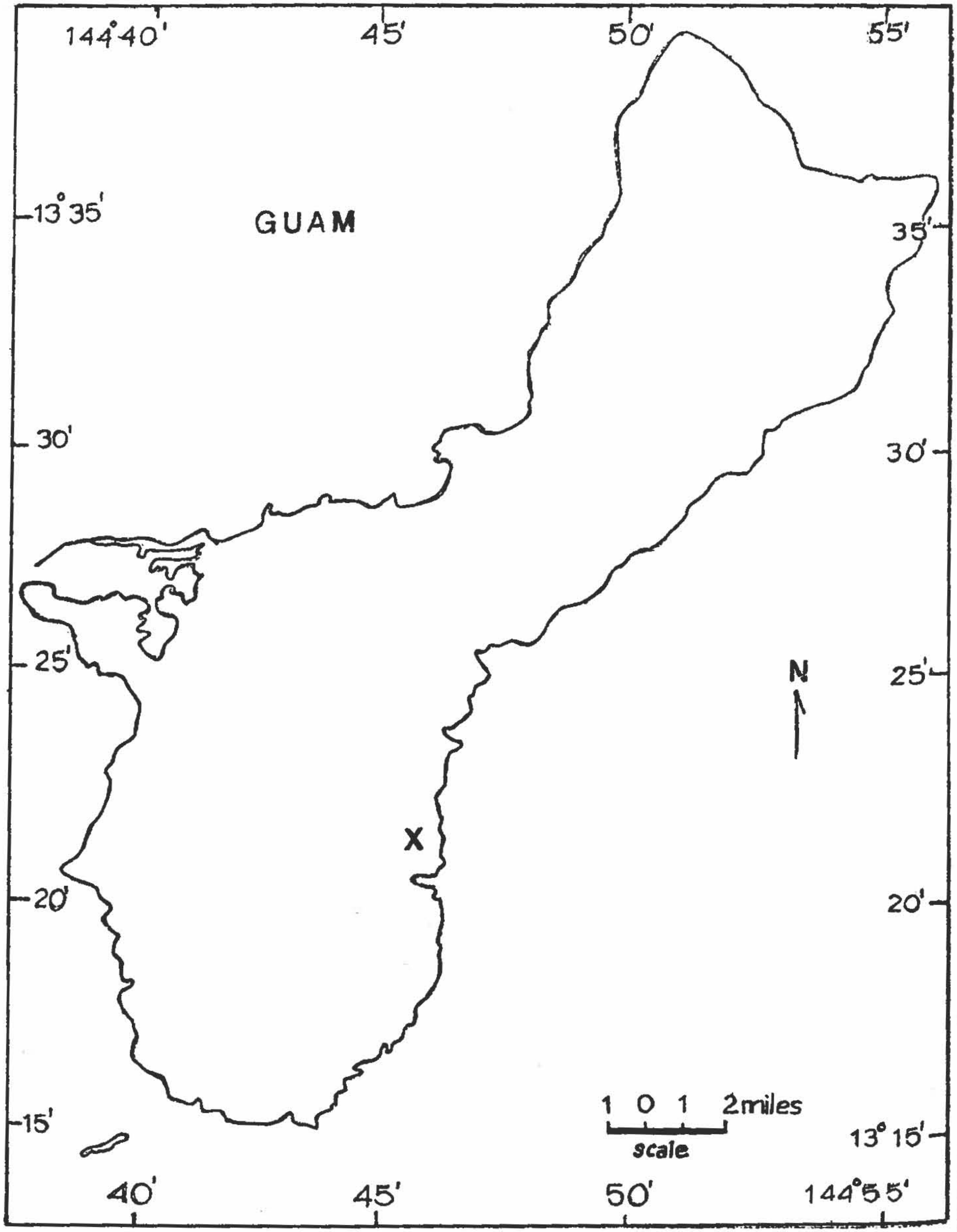

Fig. 1. The Okiyama subdivision, Ipan, Talofofo, indicated by x.

A COMPARISON OF THE VEGETATION ON DISTURBED AND UNDISTURBED HARD LIMESTONE

James Kodama

DESCRIPTION OF THE AREA OF COMPARISON:

The area was located within the hard limestone forest of Ipan, Talofofo. The disturbed land, the Okiyama Subdivision (Fig. 1), was bulldozed from the forest about ten years ago. Though most vegetaion was removed, some large trees were saved on several lots. The disturbed lots were designated "A" and "B" on the map; the undisturbed section is shown as "C", immediately south of "A" (Fig. 2).

DESCRIPTION OF THE DISTURBED SECTIONS:

After the bulldozing of the lots a weedy community of plants took over as a vegetation cover. Five years ago the dominant plants were Bidens and Carica papaya; since then many grass fires have swept over the lots. At the time of this study the flora of sections A and B continued to be a weed community made up of grasses and Leucaena. Section A was almost totally covered with Pennisetum, but there were a very few Morinda, Leucaena and Premna. Section B was completely covered with a thick growth of Leucaena; Pennisetum continued to survive in the undergrowth, and a scattering of Triphasia was present.

THE FLORA OF THE ADJACENT UNDISTURBED FOREST:

Section C did not show any signs of disturbance. The ground was covered with large, rugged, pitted limestone rocks and boulders. There were a few collapsed caverns in the site. At the edge of the forest was a weedy community of plants, but further into the forest the trees became taller and there were fewer weeds in the undergrowth. The plants here were Neisosperma oppositifolia, Guamia mariannae, Cycas circinalis, Davallia solida, Mammea odorata, Instia bijuga, Hibiscus tiliaceus, Aglaia mariannensis, Morinda citrifolia and Ficus prolixa; these are typical species of hard limestone substrates (Fosberg, 1960).

CONCLUSIONS:

The occasional fires have maintained section A as a grass community, but this community could be replaced easily by a Leucaena community (like Section B). It will be difficult for the original limestone forest plants to be re-established in the disturbed A and B areas, even though specimens which could seed A and B are present in area C.

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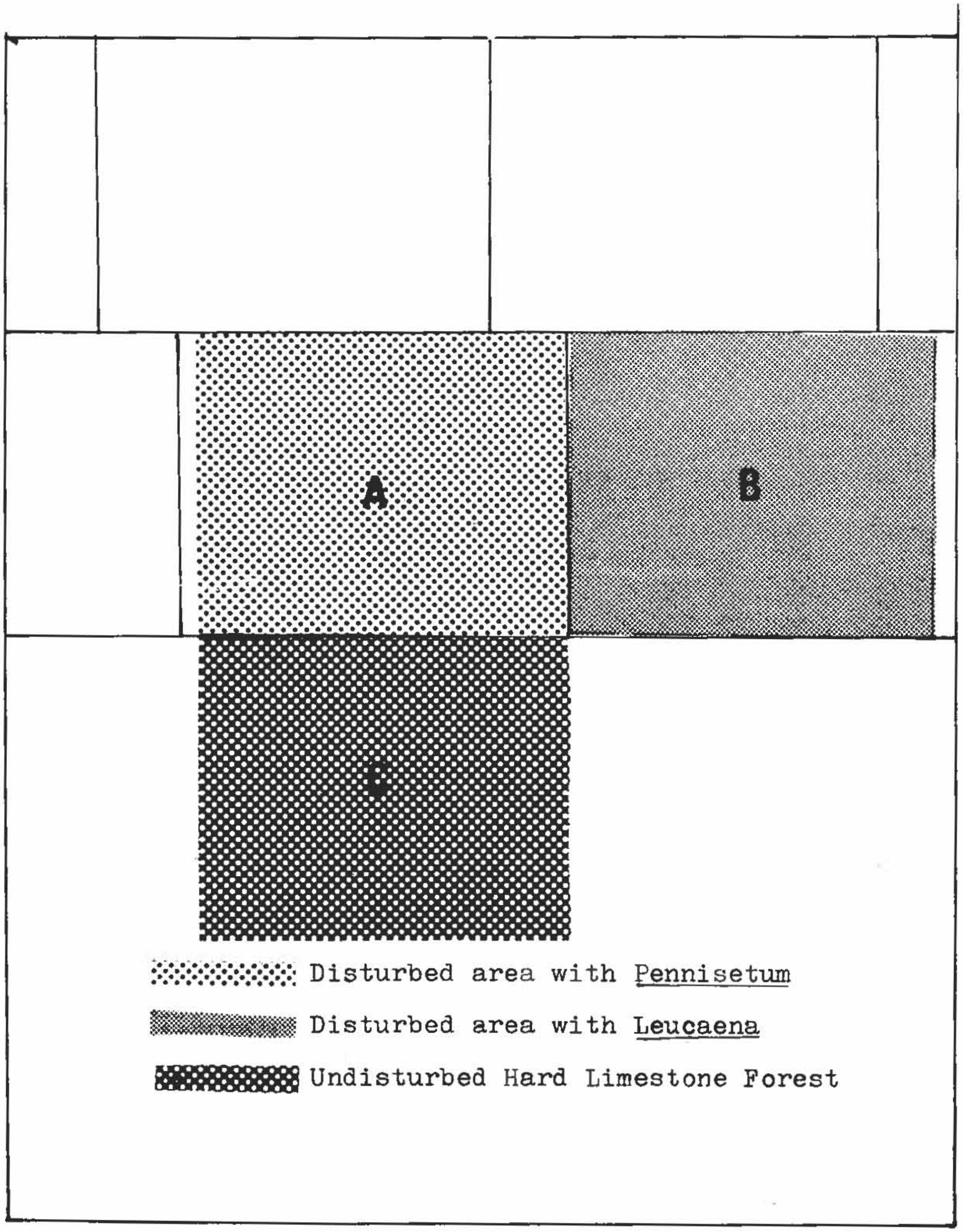

Fig. 2. Experimental plots of the Okiyama subdivision.

Dimeria GRASSLANDS ALONG GUAM'S SOUTHERN CUESTA SUMMIT

David E. Pendleton

ABSTPACT

Dimeria grasslands are discussed as the possible climax association of savanna vegetation. The subsidized swordgrass communities are highly competitive with *Dimeria* under present conditions. Past and future evolution of *Dimeria* grasslands are discussed.

INTRODUCTION

Much of southern Guam's volcanic soil is covered by vegetation that has been referred to as savanna. Along the cuesta summit in the area of Mount Jumullong Manglo and Mount Bolanos, and upon the ridges separating the deep ravines there exist these savanna grasslands (Figures 1 and 2). Generally, the term savanna is used to describe a landscape which is at least moderately flat, and covered with grasslands and scattered trees. However, Guam's southern cuesta summit is formed by very steep west slopes and a somewhat lesser gradient on the eastern slopes. Deep ravines have been formed on both sides of the summit, creating a rugged, mountainous aspect, though maximum elevation is only 406 m (1332 ft). No trees are scattered among the grasslands in this region, except where the ravine forests and grasslands meet. Often, federico palms, (*Cycas circinalis*), which represent the farthest encroachment of the forest into the grasslands, are scattered among the grass at this juncture.

Figure 2 demonstrates the extent of the various vegetation formations in southwest Guam (Fosberg, 1960). Fosberg mapped smaller areas of grassland within the ravine forests and scattered ravine forest watersheds in the savanna, but Figure 2 shows only the major associations. Today, the grasslands appear to be more extensive, especially to the southeast of the summit trail. Northeast of Mount Jumullong Manglo, the topography is no less rugged, but the ridges are almost entirely forested. The composition of this forest is probably similar to the ravine forest vegetation found in the ravines between Mount Jumullong Manglo and Mount Bolanos. Northwest of Mount Jumullong Manglo is the limestone forest, which is comparable to the relatively undisturbed limestone forests found in the more inaccessible regions of northern Guam. A dissected limestone cap on the ridgetop provides the typically rough surface (Figure 3). The proliferation of grasslands to the south of Mount Jumullong Manglo is related to the large number of trails.

According to Fosberg (1960), there is little doubt that Guam was almost entirely forested before the advent of man. Large areas of these forests have been destroyed. It seems most probable that man-made fire has been the principal cause of this destruction. In southern Guam, before the war, the savanna area was burned almost every year; the fires were set deliberately to get rid of the swordgrass (Fosberg, 1960). In those areas where man has had little or no access, the forest remain.

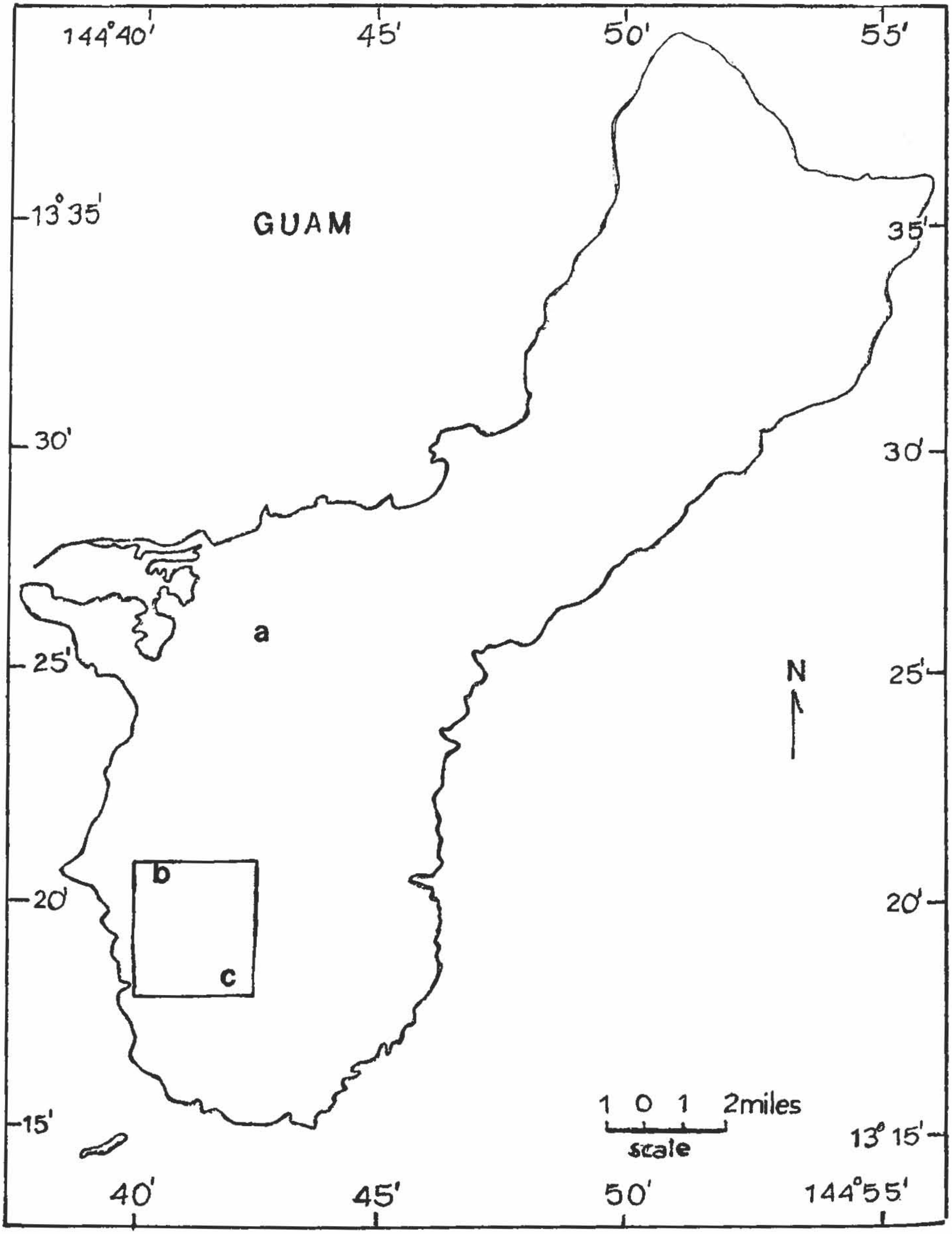

Fig. 1. Study sites. Legend: a = Mt. Alutom; b = Mt. Lamlam; c = Mt. Bolanos. Rectangle represents area shown in Figure 2.

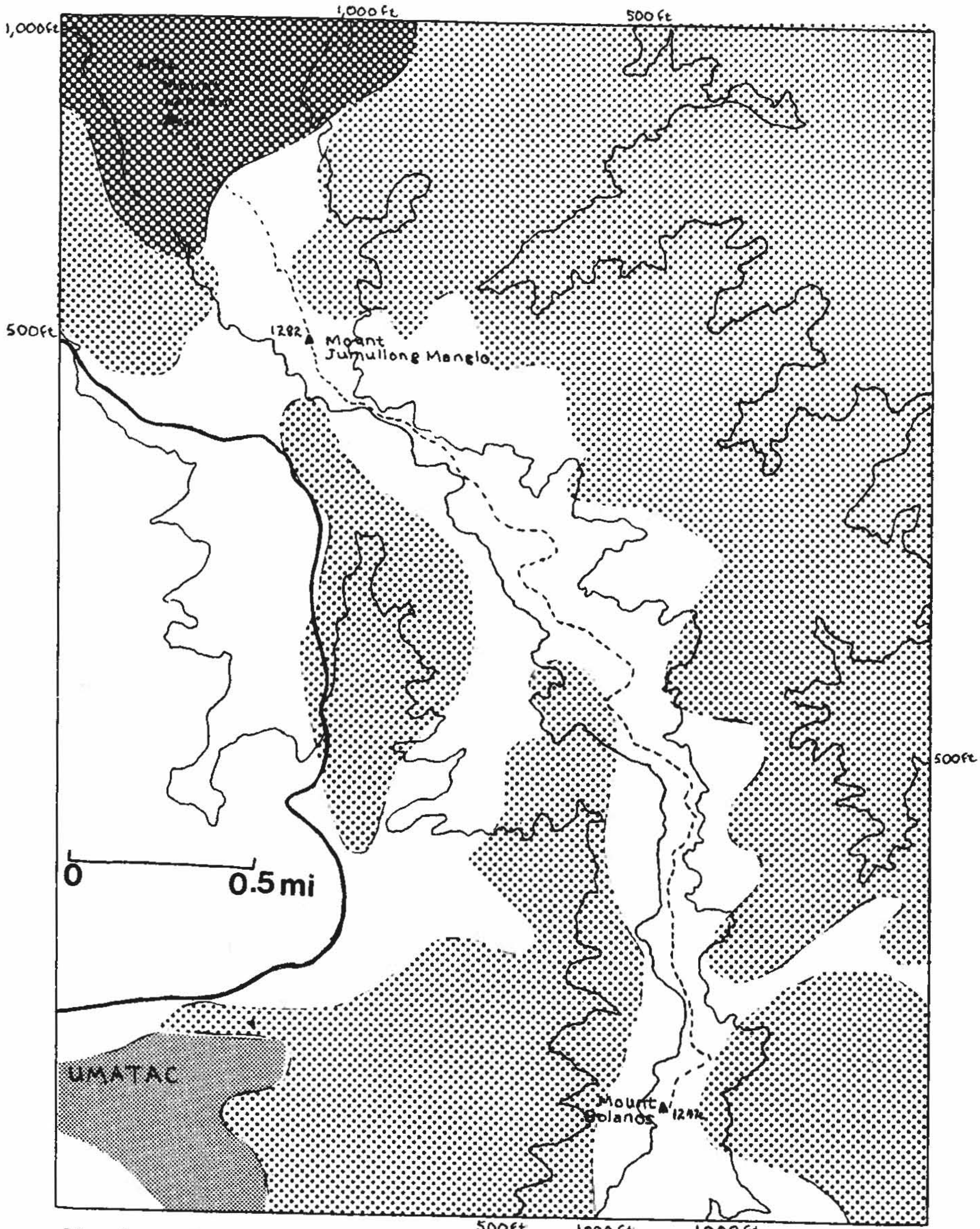

Fig. 2. Vegetation Associations of southern Guam.

Legend: savanna, ravine forest, limestone forest, strand

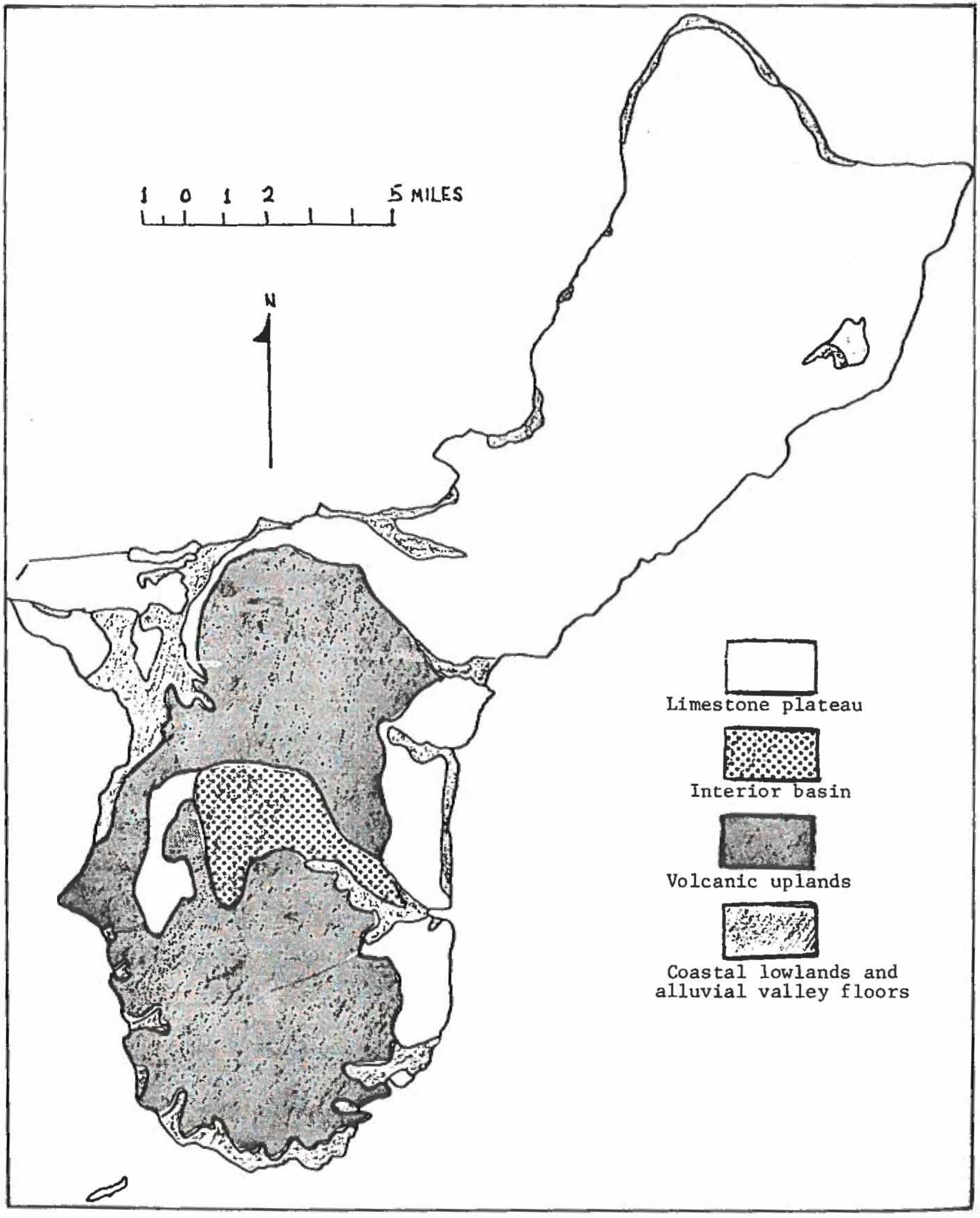

Fig. 3. Physiographic regions of southern Guam (Tracey et al., 1964).

The savanna region of Guam can be divided into four distinct types of vegetation: swordgrass grasslands, Phragmites swamps, mixed shrub communities, and Dimeria grasslands (Falanruw, 1976). Swordgrass (Miscanthus floridulus) grasslands are very common. Extensive areas along the cuesta summit are almost pure stands of dense swordgrass. Often, no other species is visible until close inspection shows small herbaceous plants such as Centella asiatica and Hyptis capitata beneath the grass blades. Dense stands of tall Phragmites karka are found in marshy areas, but only a few small patches of this grass exist in flat areas near the summit trail. Along the trail between Mount Jumullong Manglo and Mount Bolanos there are a few scattered shrubs, but no definite communities of this type. Dimeria grasslands are patches of the soft, low grass named Dimeria chloridiformis, which were often mixed with sedges and some of the species of the mixed-shrub community.

About five kilometers north of Mount Lamlam lies Mount Alutom. Many roads and trails wind through the region, and, not surprisingly, grasslands cover most of the surface, excluded only from the deep ravines. Near the summit of Mount Alutom, small areas of Dimeria grasslands can be found. Two 1 m^2 plots in separate Dimeria areas were sampled. Plant species were listed and their abundances were calculated (Table 1). The degree of similarity between the Dimeria quadrats was obviously great, considering both visual impressions and a calculated index of similarity value of 0.8. Also, when the plant species were ranked according to estimated biomass of each species, the similarity between these quadrats was quite striking (Table 2). These plots can be considered to be typical of Dimeria community plant assemblages, and, indeed, were selected for that purpose. However, as noted by Fosberg (1960), the savanna vegetation is quite variable in aspect, because of the varying degree of dominance of several of its components. This observation is quite appropriate for the Dimeria grasslands upon Guam's southern cuesta summit.

The distribution of typical Dimeria grasslands along the cuesta summit was found to be quite limited. Although Dimeria chloridiformis was scattered about in a variety of plant assemblages, there were only about twenty (20) patches similar to the representative samples of Mount Alutom. These Dimeria areas ranged in size from less than 20 m^2 to slightly more than 800 m^2. The area covered by these small patches represented less than 5% of the savanna sampled. Most of the savanna vegetation of the cuesta summit was Miscanthus grasslands. The frequency of Dimeria communities along the summit trail increased to the south, and is probably related to the less rugged topography further south; wider areas of relatively flat lands, apparently favorable to Dimeria, became more common.

Dimeria chloridiformis was also common in at least three other situations. First, in small flat areas, where either standing water was common, or the soil was poor, or both, small Dimeria tufts were widely separated. Few other plants grew in most of these areas, though in a few places, the fern Lindsaea ensifolia rivaled Dimeria for dominance. Second, Dimeria clumps were scattered along the trail, often in strips along the edge of the worn paths, and occasionally, on untravelled portions in the middle of the trail. Third, Dimeria chloridiformis was seen among what appeared to be pure stands of swordgrass, and in this situation the individual Dimeria tufts seemed to be largest and most healthy. Frequently, these mixed grasslands occurred near the Dimeria grasslands, but were not confined to such areas.

Table 1. Species density in Dimeria grassland quadrats

Species	QUADRAT 1 # of plants or clumps	QUADRAT 1 # of stems per clumps	QUADRAT 1 Total "stems" per meter^2	QUADRAT 2 # of plants or clumps	QUADRAT 2 # of stems per clumps	QUADRAT 2 Total "stems" per meter^2
Gleicheniaceae						
Dicranopteris linearis	6	3 fronds	18	- -	- -	- -
Pteridaceae						
Lindsaea ensifolia	- -	- -	- -	2	4	8
Cyperaceae						
Fimbristylis tristachya	7	20	140	4	15	60
Rhynchospora rubra	15	20	300	2	20	40
Gramineae						
Chrysopogon aciculatus	6	2	12	- -	- -	- -
Dimeria chloridiformis	30	40	1200	48	30	1440
Pennisetum polystachyon	10	4	40	17	2	34
Orchidaceae						
Spathogloltis plicata	1	3	3	2	1	2
Labiatae						
Hyptis capitata	17	1	17	20	1	20
Maluaceae						
Sida rhombifolia	- -	- -	- -	11	1	11
Umbelliferae						
Centella asiatica	8	1	8	- -	- -	- -*
Verbenaceae						
Stachytarpheta indica	20	1	20	10	1	10**

* - some seedlings

** - numerous seedlings

Table 2. Quadrat species ranked according to biomass (lowest numbers = highest biomass).

QUADRAT 1		QUADRAT 2	
1	Dimeria chloridiformis	1	Dimeria chloridiformis
2	Rhynchospora rubra	2	Fimbristylis tristachya
3	Fimbristylis tristachya	3	Rhynchospora rubra
4	Pennisetum polystachion	4	Pennisetum polystachion
5	Dicranopteris linearis	5	Lindsaea ensifolia
6	Chrysopogon aciculatus	6	Sida rhombifolia
7	Stachytarpheta indica	7	Stachytarpheta indica
8	Hyptis capitata	8	Spathoglottis plicata
9	Spathoglottis plicata	9	Hyptis capitata
10	Centella asiatica	10	Centella asiatica

The extent of Dimeria grasslands, and probably all of Guam's savanna vegetation, is directly related to fire. Evidence of past fires can be seen virtually everywhere on the cuesta summit, from Mount Jumullong Manglo to Mount Bolanos. Most tufts of grass had blackened areas near the base. But, unlike swordgrass, the range of Dimeria grasslands is not increased by frequent fires. Considering that there is some evidence that Dimeria grassland is a climax community (Raulerson, pers. comm.), fire would certainly not enhance its development. Climax communities are not known to exist in areas frequently devastated by storms, landslides, bulldozers, or fire. Evidently, competition between Dimeria and Miscanthus exists, with frequent fires favoring the growth of Miscanthus at the expense of Dimeria grasslands and ravine forests.

A reasonable question, at this point, might be, "If Dimeria grasslands aren't fire tolerant, why haven't they been completely eliminated by the frequent fires?" The answer may lie in the fact that Dimeria plots occupy small areas of flat land, where water does not run off quickly; and the individual tufts, which do not grow luxuriantly (they are frequently less than 50 cm tall), are frequently 10 to 20 cm from neighboring clumps. When fires range up the slopes, the flatter and somewhat wetter Dimeria plots may create a slight firebreak. The small standing crop, when compared to swordgrass, would lend less fuel to the blaze, thus helping to prevent the death of rootstocks and, consequently, complete annihilation.

While a Dimeria plot may not be eliminated by a single fire, successsive burns allow Miscanthus to gain a foot-hold and eventually overwhelm the climax community. This encroachment of swordgrass may be explained thus: When fire reaches the border between swordgrass and Dimeria plots, the Miscanthus provides ample material to fuel an intense blaze, which affects nearby Dimeria plants to the greatest degree. After the fire the swordgrass, which has remained alive, invades the Dimeria area. Although some Dimeria grassland plants remain, Miscanthus is scattered within its borders. When the next fire passes through, more fuel is then available within the Dimeria community, the blaze is hotter, and more of the Dimeria is eliminated. The greater the frequency and intensity of these burns, the faster encroachment can occur. This process is suggested by the fact that the borders are not simple lines with swordgrass on one side and Dimeria community on the other. Although somewhat fanciful, the way clumps of Miscanthus are scattered within Dimeria plots, along their borders, often on the downslope side, gives the appearance of a swordgrass invasion.

The existence of Dimeria chloridiformis along the summit trail also appears related to periodic fires. One small Miscanthus area along the trail had apparently burned recently, but the path worn through the grass seemed to act as a firebreak, as only small, separate areas on one side had burned. The upslope region alongside the path, because of its slightly greater protection from fire, would be slightly more favorable for Dimeria growth.

The rather luxuriant tufts of Dimeria, widely dispersed in almost pure swordgrass stands, give some evidence that environmental conditions within Dimeria grasslands are not maximal for Dimeria productivity. Apparently, those areas where Miscanthus is dominant are also favorable habitats for Dimeria, but competition from Miscanthus, subsidized by fire, restricts its expansion. This also implies that only habitats unfavorable to Miscanthus are occupied by Dimeria grasslands. A similar pattern may have also existed when the area was almost entirely forested, in that only those areas unfavorable to forest growth, such as flat, bog-like regions, where standing water existed for long periods of time, were inhabited by Dimeria grasslands. No doubt, Dimeria chloridiformis would have grown more upon the slopes if forest vegetation competition had not been so great. Today, the flatter areas tend to minimize the effects of fire, which minimizes the encroachment of swordgrass. Also, the frequent standing water, or resultant soil, may be inhospitable to Miscanthus. So, the Dimeria grasslands continue to exist in those small areas unfavorable for the region's dominant vegetation and continue to be excluded by the dominant vegetation from the more favorable areas.

If fires could be eliminated from this region, eventually the forest would probably, once again, cover almost the entire area. How long this process would take is difficult to assess. However, an interesting possibility, before complete reforestation, would be the development of large areas of Dimeria grasslands. Without a fire subsidy, Miscanthus would be less competitive than it is now. It seems entirely possible that gradually Dimeria could overcome its rival before ravine forests move up onto the higher ridges and cuesta summit.

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ACKNOWLEDGEMENTS

May of the plants within the Mount Alutom plots were identified by Dr. Lynn Raulerson. Chip Romeo, Gerri Lemar and Dave Anderson collected many of the plants at Mount Alutom. And Joe Weide provided interesting discussion during our treks along the summit trail.

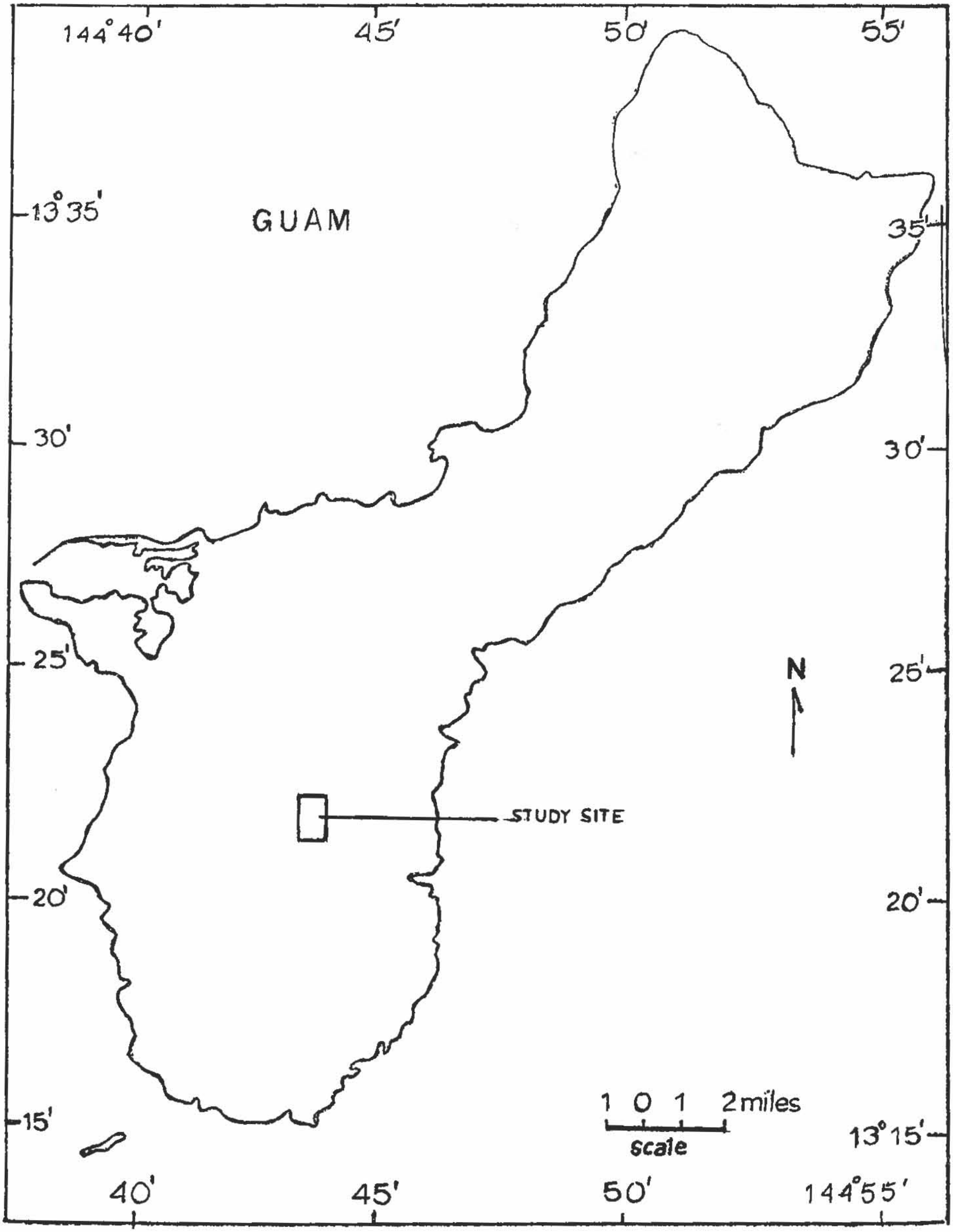

Fig. 1. Savanna study site.

A STUDY OF VEGETATION PATTERNS IN THE SAVANNA OF GUAM

Charles J. Romeo

ABSTRACT

Extensive savanna grasslands have developed on the volcanic portions of Guam, presumably through the activities of man such as clearing and burning. Casuarina equisetifolia is one of the principal trees that is able to colonize the grasslands, however, its susceptibility to fire severely limits its development and expansion. Dense stands of Casuarina do occur in localized, small patches, and areas of erosion provide an opportunity for the patches to develop by acting as firebreaks.

INTRODUCTION

The savanna or grassland vegetation of Guam is a characteristic formation of plants which is extensively developed on the volcanic substrates of the island. The degree and extent of this grassland is reported to be maintained by the activities of man, especially man-made fire (Fosberg, 1960). Before the advent of man the volcanic slopes were probably almost entirely forested and presented a closed vegetation with little chance for the establishment or expansion of grassland vegetation, which may have occupied a few hilltops. With the destruction and opening up of the forest vegetation, these limited grasslands have been able to expand. Furthermore, frequent burning has prevented the reestablishment of a forest vegetation by killing the trees and allowing those plants more capable of surviving fires, notably Miscanthus floridulus, to dominate.

Casuarina equisetifolia, which can colonize savannas, is readily susceptible to fire and rarely achieves anything more than a scattered distribution in the grasslands. If fires were prevented an open Casuarina forest might develop that could displace some of the grassland, because areas beneath Casuarina are covered by dense layers of needles that inhibit understory development.

For this report an area of reasonably dense flourishing Casaurina growth was located in the mid-island savanna (Fig. 1) and compared with a similar area of trees burnt and killed by fire; such areas were few small and local. One was located in the east plot of the sample area (Fig. 2). Across the unpaved road was an extensive area of dead Casuarina; they were killed in a fire in 1978. The area of killed trees apparently had been free of fire for many years before 1978; the dead trees were large and abundant, and one measured approximately 22 cm dbh and 7 m in height.

The purpose of this project was to determine differences between those two plots. They were separated only by a dirt road, but one had maintained a live, healthy population of Casuarina and the other had not. Two possible differences were vegetation patterns and substrate patterns. The sample area is described in Table 1 and the plant species of the east and west plots (verified by F. R. Fosberg) are listed in Table 2. Limited transect data from the east and west plots are presented in Table 3; tree size and density in the two plots were compared.

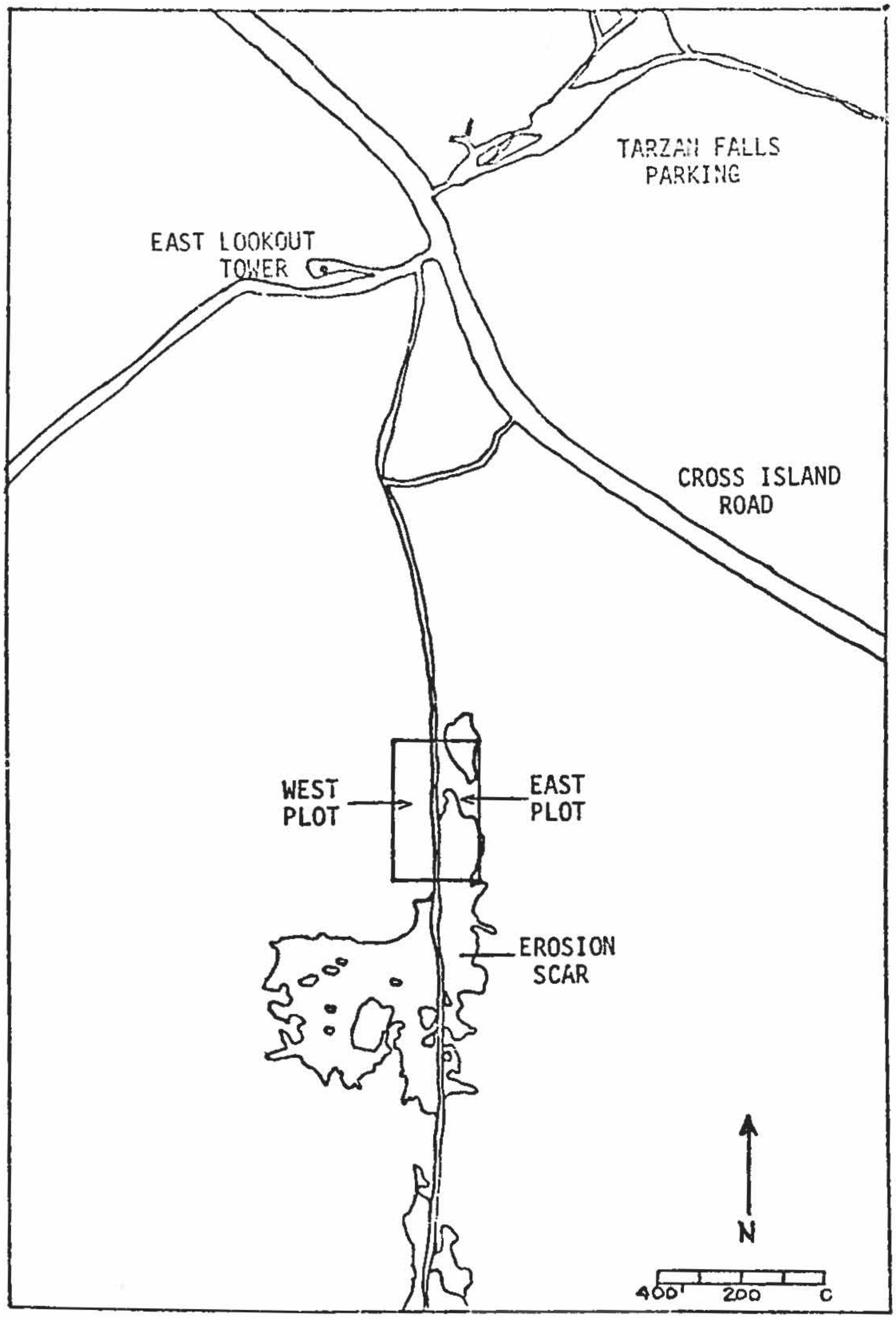

Fig. 2. Map of sampling area showing east and west plots, and erosion scar area.

Table 1. Description of Sample Area.

LOCATION:	13 24' 40" E and 144 43' 14" N South of the Cross-Island Road near the east Lookout Tower, along an unpaved road at an elevation of 144 m approaching a severely erosion scarred area. The road is gently sloping (10 percent) and the terrain drops off in a westerly direction.
SUBSTRATE:	Volcanic uplands with a red clay soil. Soil presumed to be Atate clay - consisting of a red granular acid clay latosol.
COMMUNITY:	Savanna grassland consisting primarily of _Pennisetum polystachyon_ to the east of the site. There are very localized patches of live _Casuarina equisetifolia_ up to 5 m in height. In the _Pennisetum_ grassland to the east there are a very few large _Casuarina_ (up to 10 m in height) which at one time must have represented a developing _Casuarina_ forest.
SIZE OF SAMPLE AREA:	Approximately 100 m along the unpaved road and 20-30 m to either side.
STRATIFICATION:	East of the road is a localized live _Casuarina_ patch 5 m tall growing on an eroded surface; about 50% cover. Understory of grasses and herbaceous plants; less than 5% cover. _Casuarina_ needle layer 1-2 m thick; about 50% cover. _Pennisetum_ grassland to the east beyond erosion scar; up to 1.5 m tall; 100% cover. West of road are numerous dead _Casuarina_; 5 m plus tall; 5% cover (trunk space). _Miscanthus_ grassland; up to 2 m tall; 80% cover. Herbaceous plants 0.3 m - 1 m tall; 20% cover. Young _Casuarina_ < 0.3 m tall; < 1% cover.
REMARKS:	The area to the west of the road was extensively burned in 1978, killing virtually all the trees in the area. There are also a few scattered patches of cultivated _Tectona grandis_ and _Eucalyptus_ sp. The nature and cause of the erosion scar is unknown.
DATE:	July 18, 1980.

Table 2. List of plants occurring in plots to the east and west of the road.

WEST PLOT	EAST PLOT
CASUARINACEAE	CASUARINACEAE
Casuarina equisetifolia	*Casuarina equisetifolia*
COMPOSITAE	COMPOSITAE
Ageratum conyzoides	*Bidens alba* (?)
Bidens pilosa	*Bidens pilosa*
	Tridax procumbrens
CYPERACEAE	CYPERACEAE
Fimbristylis cymosa	*Fimbristylis cymosa*
Fimbristylis tristachya	*Fimbristylis dichotoma*
Rhynchospora rubra	*Fimbristylis tristachya*
GLEICHENIACEAE	
Dicranopteris linearis	
GOODENIACEAE	GOODENIACEAE
Scaevola taccada	*Scaevola taccada*
GRAMINEAE	GRAMINEAE
Bothriocloa blahdii	*Chrysopogon aciculatus*
Chrysopogon aciculatus	*Dimeria chloridiformis*
Dimeria chloridiformis	*Miscanthus floridulus*
Miscanthus floridulus	*Pennisetum polystachyon*
Pennisetum polystachyon	
LABIATAE	LABIATAE
Hyptis capitata	*Hyptis capitata*
	Hyptis pectinata (?)
LAURACEAE	LAURACEAE
Cassytha filiformis	*Cassytha filiformis*

Table 2. Continued

WEST PLOT	EAST PLOT
LEGUMINOSAE	LEGUMINOSAE
Crotalaria retusa	*Alysicarpus vaginalis*
Desmodium triflorum	*Crotalaria retusa*
Mimosa pudica	*Mimosa pudica*
MYRTACEAE	MELASTOMATACEAE
Myrtella bennigseniana	*Melastoma marianum*
ORCHIDACEAE	ORCHIDACEAE
Spathoglottis plicata	*Spathoglottis plicata*
PASSIFLORACEAE	
Passiflora suberosa	
POLYGALACEAE	POLYGALACEAE
Polygala paniculata	*Polygala paniculata*
PTERIDACEAE	
Lindsea ensifolia	
RUBIACEAE	RUBIACEAE
Mitracarpus hirtus	*Spermacoce assurgens*
Spermacoce assurgens	
STERCULIACEAE	STERCULIACEAE
Waltheria indica	*Waltheria indica*
UMBELLIFERAE	UMBELLIFERAE
Centella asiatica	*Centella asiatica*
VERBENACEAE	VERBENACEAE
Stachytarpheta jamaicensis	*Stachytarpheta jamaicensis*
Tectona grandis	

Table 3. Transects of live and dead *Casuarina* in the east and west plots.

WEST PLOT

TRANSECT 1
(3m x 20m)

Circumference at chest height (cm)	Number of Trees
1 cm	2 dead
2 cm	1 "
3 cm	1 "
3.5 cm	1 "
7 cm	1 "
10 cm	1 "
19 cm	1 "
30 cm	1 "
	9 Total

TRANSECT 2
(3m x 20m)

Circumference at chest height(cm)	Number of Trees
1 cm	1 dead
2 cm	2 "
3 cm	1 "
4 cm	4 "
5 cm	2 "
6 cm	1 "
7 cm	1 "
8 cm	1 "
18 cm	1 "
28 cm	1 "
	15 Total

EAST PLOT

TRANSECT 3
(3m x 30m)

Circumference at chest height (cm)	Number of Trees
3 cm	2 live
11 cm	1 "
13 cm	1 "
22 cm	1 dead
	5 Total

TRANSECT 4
(3m x 30m)

Circumference at chest height (cm)	Number of Trees
1 cm	2 live
3 cm	2 "
4 cm	1 "
5 cm	2 "
6 cm	3 "
11 cm	1 "
19 cm	1 "
31 cm	1 "
35 cm	1 "
	14 Total

Two immediate patterns were demonstrated by the data in Table 1. First, there was a discontinuity in the grassland vegetation on either side of the road. On the eastward side, Pennisetum polystachyon predominated; Miscanthus floridulus dominated the west side. Secondly, the substrate in the live Casuarina patch in the eastern plot is mainly exposed red clay (an erosion scar) with little undergrowth, while the western clays were covered by undergrowth. Very few Casuarina trees, living or dead, occurred in the Pennisetum vegetation. In addition, there was little qualitative difference in the floras of the two sites (Table 2). Observation showed that the floras were quantitatively different, but no quantitative data were recorded.

It seems significant that this healthy Casuarina population has benefited by being established on an erosion scar area; the erosion scar seems to serve as a natural firebreak between the Casuarina and other highly flammable vegetation. It can also be argued that the road acts as a firebreak and is important in protecting these trees from destruction by fire. Perhaps such roads would eventually be colonized by Casuarina if their use were discontinued, as evinced by the seedling populations growing along the road edge. However, the lack of understory is probably the most significant protecting mechanism for the establishment of a Casuarina forest.

It would be of particular interest to see how often this pattern is replicated and if it can be used as community classification. Fosberg (1960) delineates five plant communities in the savanna: (1) the Miscanthus community; (2) the Dimeria community; (3) the erosion scar community; (4) the Phragmites or reed community; and (5) the weed community, which follows disturbance. Perhaps within the erosion scar community one could determine factors that would allow the formation of Casuarina forest islands within the grassland vegetation.

LITERATURE CITED

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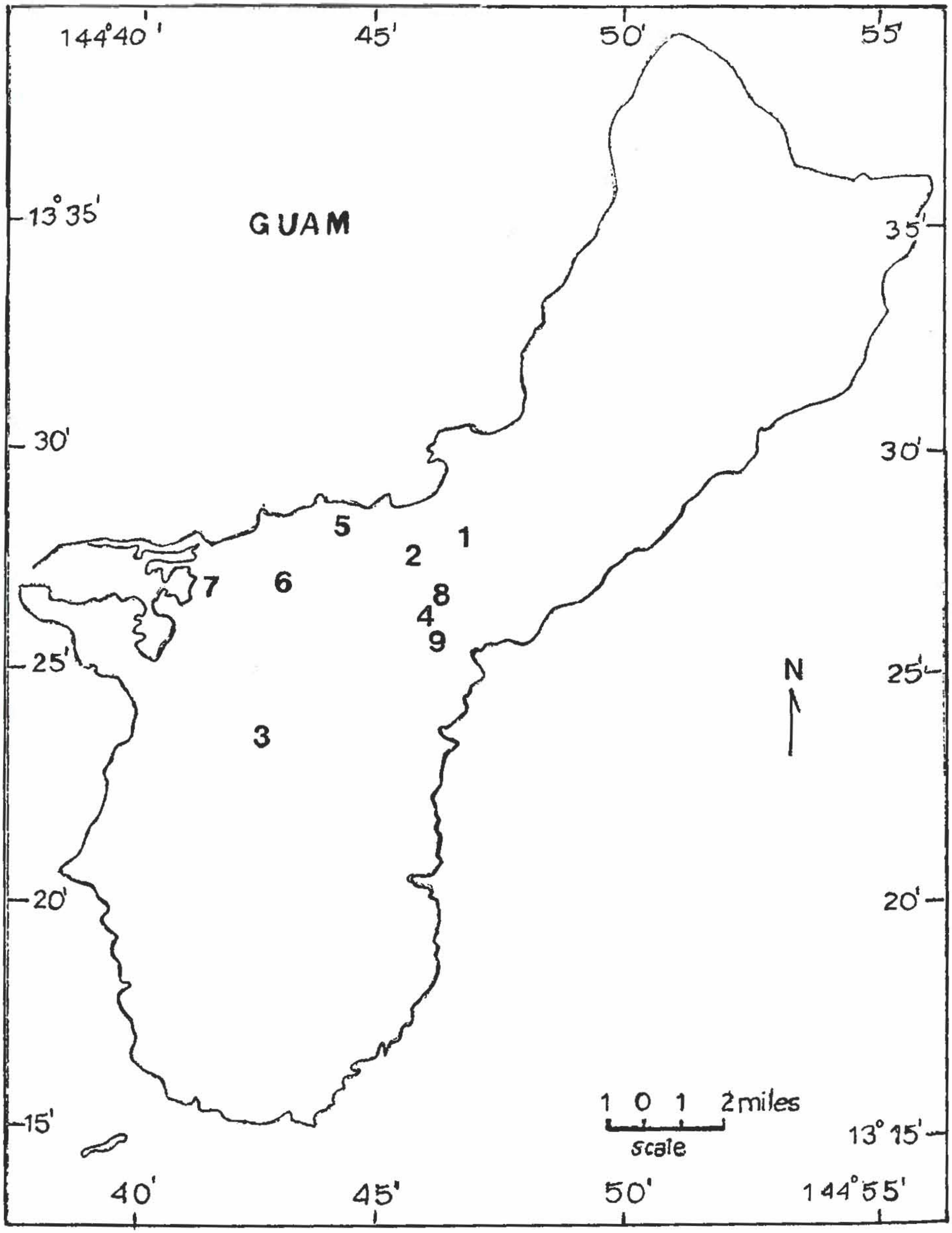

Figure 1. Collection sites. Numbers refer to specific sites listed in text.

A SUPPLEMENT TO THE FLORA OF GUAM: FORESTRY AND FRUIT SPECIES

Brian T. Scully

ABSTRACT

Of thirty four new records for Guam plants included in this study, 22 are economic forest species and 13 are fruit species. Of the forest species 18 were purposely introduced for forestry use while only one of the fruit species was a controlled introduction. The primary sources of these new taxa are Australia, Hawaii, Palau, and the Philippines. Additionally, three species included in the Flora of Guam (Stone, 1970) have been further described.

INTRODUCTION

The first major floristic study of Guam, Useful Plants of Guam, was done by W. G. Safford and published in 1905. Subsequent major studies were published by E. D. Merrill (1914), F. R. Fosberg (1960), and B. C. Stone (1970). The last endeavor presently stands as the definitive botanical work done for the island. Nearly ten years have elapsed since that study, and during this period numerous species have been introduced and have become established on the island. Some of these taxa, mostly the economic forest species, were controlled introductions which have been planted in experimental plots where growth rates, physiognomy and phenological characteristic could be observed easily. The fruit species, however, were introduced for the most part by migrants to the island, who is an effort to retain traiditional dietary habitas brought propagules with them. It is probable that most of the fruit species included here were brought to Guam from either Hawaii, Palau or the Philippines. In fact, only one fruit tree of the included list, the Litchi (Litchi chinensis) was a controlled introduction (from Taiwan). A few taxa on the included list were present when the current Flora of Guam was in preparation, but these plants are very rare and so were inadvertently overlooked.

COLLECTION SITES

All plants of this study were collected at the following sites (Fig. 1), although they were not necessarily confined to these areas. One set of voucher specimens individually numbered FF1-FF37 has been sent to the Smithsonian, and another set has been placed in the University of Guam Herbarium.

1) Canada-Barrigada - In the vicinity of San Vicente Church, two taxa were collected: Spondias dulcis (FF11) at the Blas residence, and Spondias purpurea (FF12) on the Santos ranch.

2) Castro's Nursery - This nursery, located in Toto, has a collection of many ornamentals as well as the following fruit and forestry species: Ficus lyrata (FF3), Clusia rosea (FF17) and Citrofortunella mitis (FF7).

Table 2. UNESTABLISHED SPECIES. The following species have been introduced to Guam and planted at different field sites. At present it seems unlikely that these species will persist in Guam's environment, so they have not been included in the list of described species.

	NAME	COMMON NAME	ORIGIN	YEAR INTRODUCED	PLANTING SITE
1)	Araucaria cunninghamii	Hoop Pine	Australia	1979	C.I.R.
2)	Cedrela toona toona australis	---	Himalayas	1972	Ag. Sta.
3)	Eucalyptus cloeziana	Queensland messmate	Australia	1978	C.I.R.
4)	Eucalyptus tesselaris	Carbeen	Australia	1978	C.I.R.
5)	Gmelina sp.	---	Paleotropic	1971	C.I.R.
6)	Podocarpus neriifolius	Podocarp	Malay Pen.	1978	C.I.R.
7)	Serianthes kenahirae (?)	Ukall	Palau Islands	1978	C.I.R.
8)	Solanum hyporhodium	Cocona	W. Amazon	1979	Ag. Sta.
9)	Solanum quitonese	Naranjilla	N. Andes	1979	Ag. Sta.
10)	Solanum sp.	Trong Dayak	Malay Pen.	1979	Ag. Sta.

Table 1. Continued.

	SPECIES	REPRODUCTIVE PARTS OBSERVED	FRUIT OBSERVED
32)	*Chrysophyllum cainito*	Intermittently	Rarely sets
33)	*Pouteria campechina*	--	June
34)	*Gmelina arborea*	--	--
35)	*Crescentia cujete*	June	June
36)	*Jacaranda mimosaefolia*	--	--
37)	*Anthocephalus cadamba*	--	--

Table 1. Continued.

SPECIES	REPRODUCTIVE PARTS OBSERVED	FRUIT OBSERVED
17) *Clusia rosea*	--	June-July
18) *Garcinia livingstonei*	--	June-July
19) *Passiflora edulis f. flavicarpa*	--	--
20) *Eucalyptus alba*	--	--
21) *E. brassiana*	--	--
22) *E. camaldulensis*	--	--
23) *E. citriodora*	--	Sept.-Oct.
24) *E. deglupta*	July-Aug.	--
25) *E. grandis*	--	--
26) *E. pelleta*	--	--
27) *E. tereticornis*	July	--
28) *E. urophylla*	--	--
29) *Malaleuca leucadendron*	Intermittently	Continuously
30) *Psidium cattleianum f. lucidum*	Oct.-Dec.	May-Aug.
31) *Psidium cattleianum* f. *cattleianum*	Oct.-Dec.	May-Aug.

Wadsworth (1964), Menninger (1962), Morthensen and Bullard (1970), Neal (1965), Popenoe (1920), Purseglove (1974), Ridley (1925), Stone (1970), and Worthington (1959). An anonymous publication (1979) and Hortus III (1976; prepared by the staff of the Bailey Hartorium) were also utilized. The phenology of these taxa, when known, is listed in Table 1.

Other economic forest and fruit trees brought to Guam are listed in Table 2, but are not discussed in this paper. Positive identifications of these species have been difficult to obtain because fruits and/or flowers have not been observed on them.

This paper is not a comprehensive addendum to Stone's 1970 flora, but should still provide additional information. Two studies should be done to further add to Stone's flora: one which identifies and outlines the extent of dispersion of newly-introduced weed species; and one which itemizes the many ornamental species which have been introduced for home plantings and landscaping. In addition, there are various reports of specimens which have not been seen by trained taxonomists, much less described. The presence of such plants should be verified.

GYMNOSPERMAE

ARAUCARIACEAE

ARAUCARIA

Trees with spirally arranged evergreen leaves that are needle-like to scale-like and overlapping. Branches are without internodes. Seed cones massive, each scale being long and pointed with one large seed on its upper side. There are about 12 species which occur naturally in the Southern Hemisphere. Because of their moderately fast growth rates, good form, highly usable wood, and unique appearance, several species have been introduced to Guam for either forest plantings or ornamental purposes. Of those introduced only two, A. columnaris, and A. heterophylla, can be considered established. It is proposed that Stone (1970) wrongly identified the Araucaria taxon growing on Guam as A. excelsa, or Norfolk Island Pine, and that most, if not all of the Araucarias growing on Guam ten or more years ago were A. columnaris, or Cook Pine. Norfolk Island Pine (A. hetrophylla) was not introduced to any appreciable extent until the mid-1970's; the first large-scale distribution of this species took place in 1976 when some 1000 seedlings were released.

The two species are nearly indistinguishable, especially when young; neither their shapes nor foliage are very different and both appear artificial in their near-perfect symmetry. Neither staminate nor pistillate cones have been observed on either species so the identification below is made on vegetative and physiognomic characteristics.

3) Cross Island Road - Plants collected from this area are maintained in an experimental garden on the Cotal Conservation Reserve (CIR). The vegetation of the CIR is dominated by Miscanthus floridulus, and is highly susceptable to burning and subsequent erosion. The weathered, lateritic soil is acidic (pH 3.9-5.0), severely eroded, infertile and dominated throughout by a impervious clay which is usually found at depths of 15-20 cm but occasionally occurs closer to the surface. A number of species have been introduced for watershed management purposes, including: Araucaria hetrophylla (FF2), Acacia auriculiformis (FF4), Acacia mangium (FF5), Swietenia macrophylla (FF9), Colubrina arborescens (FF15), Eucalyptus alba (FF20), E. brassiana (FF21), E. camaldulensis (FF22), E. citriodora (FF23), E. deglupta (FF24), E. grandis (FF25), E. pelleta (FF26), E. tereticornis (FF27), E. urophylla (FF28), Melaleuca leucadendron (FF29), Jacaranda mimosaefolia (FF36), Anthocephalus cadamba (FF37).

4) Department of Agriculture (Ag. Sta.), Mangilao - Specimens have been planted on the grounds of the Agriculture Department for observation and demonstration. The clay loam soil has a pH of 7.0-7.4, and overlies a argilaceous limestone parent material. The taxa of this site are: Araucaria columnaris (FF1), A. hetrophylla (FF2), Enterolobium cyclocarpum (FF6), Aleurites trisperma (FF10), Litchi chinensis (FF14), Colubrina arborescens (FF15), Eucalyptus tereticornis (FF27), Chrysophyllum cainito (FF32), Gmelina arbores (FF34).

5) Downtown Agana - Cedrela odorata (FF8) was collected at the police station and Crescentia cujete (FF35) at Julale Shopping Center.

6) Naval Hospital - On the limestone cliff area of the residential section the following were collected: Cedrela odorata (FF8), and Pachira aquatica (FF16).

7) Piti Forest - Circa 1910 the Department of the Navy established an Agriculture station in Piti for the purpose of developing the island's economy. Little remains of this station with the exception of a few economic species in the village and a two acre forest on the hills behind the village. In this forest are two new records: Swietenia macrophylla (FF9), which is dominant and was planted in 1917 according to reports of local residents (W. S. Null, unpublished data); and Aleurites trisperma (FF10). Only three specimens of Aleurites occur in this planting.

8) Sequenza residence - On this property in Barrigada were collected three specimens: Garcinia livingstonei (FF18), Chrysophyllum cainito (FF32), Pouteria campechina (FF33).

9) University of Guam - Within the vicinity of the college Psidium cattleianum, f. lucidum (FF30) was collected.

The following pages list the above taxa, along with descriptions of plants that are either not currently included, or are only sparingly described in the Flora of Guam (Stone, 1970). References used for these descriptions include Backer (1965), Bailey (1974), Blakely (1965), Burkill (1966), Corner (1940), Hooker (1897), Kelly (1978), LI (1963), Little and

COOK PINE ; NEW CALEDONIA PINE

1) Araucaria columnaris (Forst.) Hook.

A. cookii R. Br.

A tall columnar tree to 60 m (in Guam to 24 m). Bark moderately rough and dark gray to black in color. Branches in whorls of 4-6 and each whorl 25-50 cm apart. Branchlets or leafy twigs set in 2 rows along the branches, usually pointing upward. Leaves scale-like, imbricate, oval, blunt, 60-80 mm long and incurved which gives an appressed appearance. Because of this appressed appearance the leafy twigs resemble a neat, tightly braided cord.

This tree is native to New Caledonia and the Isle of Pines. It is widely planted as a forest tree because its wood makes excellent lumber and boat spars. It was planted throughout Guam as an ornamental tree before the mid-60's, but very few have been planted since then. It was estimated, visually, that about 50% of the trees were topped by Typhoon Pamela in 1976. The tree appears to have a potential for forestry on Guam, but it has yet to be used.

NORFOLK ISLAND PINE

2) Araucaria heterophylla (Salisb.) Franco.

A. excelsa (Lamb.) R. Br.

A tall cone-to-pyramid-shaped tree to 60 m in its natural environment. The tallest on Guam is probably no more than 4 m, but the trees will probably be at least 20 m when mature, as they are in Hawaii. Bark is light brown on new growth but turns much darker with age. Branches in whorls very similar to those of A. columnaris, but the tiers can be set apart some 10 cm further. Branchlets or leafy twigs set in 2 rows along the branches, usually pointing outward in a horizontal plane or drooping, especially when older. Leaves scale-like, imbricate, narrowly triangular, sharp-pointed, 80-125 mm long and pointing outward to 40-60 degrees. Because of this outward projection of foliage the leafy twigs appear feathery and thus can be distinguished from A. columnaris.

This species is indigenous to Norfolk Island but has become very popular throughout the world. It is used for lumber, ornamental plantings (including indoor potted plants), and Christmas trees. It has been used each of these ways on Guam ever since the seedlings became available in 1976.

ANGIOSPERMAE

MORACEAE

FIDDLE LEAF FIG

3) Ficus lyrata Warb.

F. pandurata Hance

An evergreen tree up to 12 m with somewhat ascending branches. Bark medium brown, peeling longitudinally, curling and persistant throughout. Leaves large, 35 cm long, 15-25 cm wide, fiddle-shaped, acute, overlapping, cordate, entire, with wavy margins and prominent veins, dark green above, light green below; petioles stout, 3-4 cm long; stipules lanceolate, 2-3 cm long, persistant and drying brown. Flowers minute, axillary, sessile, solitary or paired, globose, green with dimpled surface, 3-5 cm diameter; with ostiole.

This fig has been introduced to Guam and may be observed in Toto and Tumon Bay; it is native to the tropical regions of Africa.

LEGUMINOSAE

ACACIA TREE

4) Acacia auriculiformis A. Gunn, ex Benth.

An evergreen tree up to 15 m with a thin, rounded crown. Tree appears dull green in color with light gray fissured bark and green twigs. Seedling leaves pinnate with phyllodes; mature leaves phyllodes, narrowly oblong with tapered ends 10-20 cm long, 2-6 cm wide, sickle-shaped, leathery textured and dull green colored with faint longitudinal veins. Flowers tiny, sessile, yellow, fragrant, and crowded on 8 cm axillary racemose spikes. Fruit pods brown and woody when ripe, 1 cm wide, flat and irregularly twisted or curled; seeds black and shiny.

This species is indigenous to Thursday Island in the Torres Strait of north Australia and was planted in the Cotal Conservation Reserve on Guam. The tree has grown rapidly (27 m in two years) on good soils in protected sites, and has shown poor to fair growth on harsh eroded sites; it has some potential for site rehabilitation. Flowering occurred after two years and seed has been collected. More extensive planting of this species for reforestation is being planned.

ACACIA TREE

5) Acacia mangium A. Cunn.

An evergreen tree with ridged triangular ascending branches. Bark thin, greenish-gray, with lenticels. Leaves alternate in a spiral, and modified into phyllodes, 10-20 cm long, 5-13 cm wide, glossy, light green with four prominent longitudinal veins that are visible on both surfaces;

petioles short, thickened, and reddish brown.

This species was introduced from Australia and was planted in an attempt to find additional trees that will flourish on Guam's improverished sites. It has been observed for two years and appears to have a promising future as an introduced forest tree. It is reputed to have a wide tolerance of site conditions like its close relative, A. auriculiformis, but with a better growth form.

ELEPHANTS EAR, EARPOD, GUANACASTE

6) Enterolobium cyclocarpum (Jacq.) Griseb.

A very large semi-deciduous tree with wide spreading canopy and immense gray trunk and huge branches; in Guam, 18-24 m tall with trunk diameter 1-2 m. Bark light gray and thin for tree size. Leaves alternate, twice pinnately compound with 4-9 pairs of pinnae, each pinna with 10-30 pairs of asymmetrical, white-backed leaflets, about 1 cm long. Flowers white, small (1 cm diameter), round, in clustered heads. Fruit a dark brown, shiny, circular, strongly asymmetric, flat or coiled pod, 8-10 cm in diameter. Seeds dark brown, cylindrical, to 1 cm long. Uses: Wood is excellent for craftwood and cabinetry; it also withstands water and is good for canoes and water troughs. The fruit and bark yield tannin, and pods serve as cattle feed in tropical America; bark also yields a cold medicine. A huge specimen can be found in the Plaza de España; it was blown over during a typhoon and is presently intertwined with a large Monkey-pod tree. Other large specimens may be found adjacent to the old bell tower in Merizo.

RUTACEAE

KALAMANSIT, CALAMONDIN

7) Citrofortunella mitis (Blanco). J. Ingram, H. E. Moore

Citrus mitis (Blanco)

A small (5-6 m) evergreen tree with upright habit and dense bright green crown. Branches somewhat angular. Bark brown with gray mottles, rough but not fissured. Twigs green, spineless or with short, sharp spines at the leaf axils. Leaves glossy, bright green, smooth, elliptic with acute apex and cuneate base, 5-10 cm long. Flowers 1-2 cm, borne in axils, white fragrant, bisexual, with penducle; calyx 5-lobed, cuplike; petals 5, slightly overlapping, glossy, reflexed at maturity; stamens usually 20-30, filaments more or less united at the base. Fruit aromatic, leathery-skin hesperidium, bright orange, thin skinned (2-3 mm) depressed globose, 3 cm diameter, with acid pulp, 7-10 segments; skin loose, oil glands present; pulp and skin edible.

A cold-hardy species indigenous to China but now widely cultivated throughout the tropics and subtropics. The Calamondin is believed to be a natural hybrid between Citrus reticulata and Fortunella sp., possibly F. margarita. It is polyembryonic and tends to bear more heavily in alternating years.

This plant is widely cultivated economically on Guam for fruit and juice; because of the bright foliage and fruit it also makes an attractive ornamental.

MELIACEAE

SPANISH CEDAR

8) Cedrela odorata L.

A large deciduous tree 12-30 m tall, slightly buttressed with a trunk diameter of 1-2 m. Crown rounded and large; bark gray, nearly smooth when young but becoming fissured with age. Leaves alternate and pinnate; leaflets paired, 12-20, opposite or subopposite, acuminate, ovate-lanceolate, entire, 5-10 cm long, 2-5 cm wide, smooth and stalked. Flowers many, clustered in panicles 15-40 cm long. Calyx 4-5 lobed, cupped, irregularly toothed, and glabrous; corolla yellow-green with 5 oblong petals. Fruit 4 cm long; seeds winged in the lower part.

This species is indigenous to the West Indies and tropical South America. It produces a light, durable, aromatic timber suitable for tropical uses because of its insect repellent properties. Both bark and leaves emit a fetid odor when freshly cut, hence the name. In Guam, the tree flourishes much better on the coral or limestone soils than on the volcanic derived soils.

BIG LEAF MAHOGANY, HONDURAS MAHOGANY

9) Swietenia macrophylla King.

A large semi-deciduous tree 27 m tall with straight, erect, slightly buttressed trunk; crown dense with dark green foliage. Bark ridged, fissured, and dark gray in color. Leaves alternate, evenly pinnate, 15-35 cm long, glabrous, shiny, petiolate; leaflets opposite, 4-6 pairs on short stalks, lanceolate, 10-18 cm long, 4-8 cm wide, entire, oblique at base, drooping with pale yellowish midrib. Inflorescences 10-15 cm long, axillary panicles; flowers urceolate, greenish yellow, 1 cm across, on short pedicels; calyx 5-10 lobed; petals 5, oblong, 7 mm long, slightly concave; stamens 10; ovary 5-celled. Fruit an oblong woody capsule 13 cm long on stout 8 cm long stalks, cleaving into 5 longitudinal sections with numerous seeds. Seeds flat, winged, 8-10 cm long and reddish brown in color.

This excellent timber species is native to central America but has been planted throughout the tropics for both lumber and shade. A two acre planting was established by the Department of Agriculture in 1917 on a hill behind Piti Village where this species has become naturalized. The tree grows well in both basic and acidic soils provided internal drainage is not impeded. It is one of the major species used in reforestation on the island.

EUPHORBIACEAE

SOFT LUMBANG

10) Aleurites trisperma Blanco

A tall evergreen tree to 18 m with a dense, deep green foliage and rounded crown. Bark dark gray to brown, slightly fissured, with lenticels. Leaves alternate, spirally arranged, simple, entire with margins somewhat sinuate, broadly ovate to cordate, 12-20 cm long, 8-15 cm wide, palmately veined. Petioles 25-35 cm long with two distal glands. Flowers in terminal panicled cymes, monoecious; petals 5, yellowish white to flushed pink, and longer than the sepals. Fruit dry, drupaceous, 5-8 cm diameter, globose, with 3 longitudinal grooves, green changing to medium brown, densely velutinous-pubescent, 3 seeded. Seeds brown, 2 cm diameter with woody testa.

One of five economically important species of Aleurites, it is indigenous to eastern Asia and the western Pacific area. Only A. trisperma and A. moluccana are suited to tropical conditions. Oil is extraced from the seeds of all species and used for various purposes. In the Philippines Lumbang oil is used as a lamp oil. This species flowers in March and April with fruits ripening in September and October; some fruits may adhere to the tree but most are dropped.

This species is rare on Guam but seems to do fairly well where it is grown. Stone (1970) reported that Rodin observed and made collections from a single specimen on Northwest Field in 1945. Presently, a 15 m specimen exists on the grounds of the Department of Agriculture, and other individuals in the Piti Forest. It is a recommended species for further planting both as an ornamental shade tree and an economic species. It is mildly damaged by insects.

ANACARDIACEAE

WI TREE, OTAHEITE APPLE

11) Spondias cytherea Sonn.

A deciduous tree 20 m tall with an erect growth habit, sparingly buttressed. Crown thin and irregular; branches slightly ascending. Bark grayish brown, smooth, with lenticels and longitudinal splits. Leaves alternate, odd-pinnately compound and crowded at branch ends; leaflets 11-23, more or less opposite, elliptic to obling, 9-12 cm long, acuminate with crenulate margin, glabrous. Inflroescence 15-20 cm long, terminal panicle with many small, whitish, bisexual, and pediceled flowers; calyx 4-5 cleft; petals; styles 5, erect. Fruit ovoid to obovoid, drupe with tough orange-yellow skin, 3-8 cm long; flesh pale yellow, firm, very juicy, nearly acid. Seeds 1-5 imbedded in a woody pyrene.

This species is only occasionally cultivated on Guam and mostly in Barrigada. It is called lychee by Chamorros but should not be confused with Litchi chinensis, which is totally different. This species is native to the Society Islands and may have come to Guam from Hawaii, where it is widely cultivated.

It is suited to almost any soil conditions and propagates easily by cuttings. Flowering occurs in February with fruit ripening in August or September. Trees bear consistently, and it is recommended for planting.

SINIGUELAS, SPANISH PLUM

12) Spondias purpurea L.

A deciduous tree 10 m tall with a somewhat open, spreading growth habit. Crown thin, irregular. Bark light gray, smooth, becoming fissured. Leaves alternate, odd-pinnately compound, 10-25 cm long; leaflets 7-23, opposite to sub-opposite, oblong, 2-5 cm long, acute, entire or slightly toothed, glabrous. Inflorescence large, both terminal and axillary panicles; flowers small, purplish or greenish, perfect, on short pedicels; calyx 4-5 cleft; petals 4-5, imbricate; stamens 10, shorter than petals; styles 5, erect. Fruit red or purple drupe, obovoid to globose, 2-5 cm long, spicy, juicy, subacid flesh, tough rind, single-seeded. Seed large, brown, ridged.

Siniguelas is a species commonly cultivated on Guam. The fruit is highly prized by the Filipino community and many specimens may be seen in the villages of Dededo and Yigo. Plants lose their leaves early in the dry season and flowering begins in mid-March with foliage following. Fruits are often eaten while still unripe; however, ripe fruits may be obtained in May and June. This species is easily propagated by taking cuttings just prior to and during bud burst; it bears consistently and is suited to most soils on Guam.

ICACINACEAE

FANIOK

13) Merrilliodendrom magacarpum (Hemsley) Sleumer.

A tall evergreen erect tree, single stemmed and slightly buttressed. Branches, high and somewhat ascending. Bark, medium brown, slightly fissured, becomes dissected into plates with many lenticels.

The above description is provided as a supplement to the description in Stone (1970).

SAPINDACEAE

LYCHEE, LEECHEE

14) Litchi chinensis Sonn.

A medium sized evergreen tree up to 15 m with a dense, dark green, rounded crown, and glossy foliage. Bark brown with fine scales, dimpled. Leaves alternate, even-pinnately compound, 25 cm long; leaflets 2-6 pairs, 8-15 cm long, 3-5 cm wide, oblong-elliptic to lanceolate, acute, base cuneate, leathery, drooping, shining green, glaucous beneath. Flowers polygamous, many borne on terminal panicles 30 cm long, greenish white to yellowish;

calyx five-lobed; petals none; stamens 6-10, exserted. Fruit edible, acid, tuberculed, 3-5 cm in diameter, globose, red to crimson, single-seeded, with white juicy flesh; seeds brown.

The lychee is native to southern China where it is extensively cultivated for fruit production. In 1977 several hundred seedlings were imported to Guam from Taiwan; these have since been released. However, because chilling is required for flower initiation, it is doubtful that this species will ever bear fruit on Guam, although it bears well in Hawaii. The wi tree (Spondias cytherea) is called lychee in the Chamorro language and people will say that they have seen or eaten L. chinensis when, in fact, they have not.

This species thrives best in deep loamy soils where moisture is plentiful and there is a cool season to stimulate flowering. Plantation trees are set on 9-12 m spacings. Propagation is by either seed or air layering. The tree is not recommended for planting on Guam if fruit is the sole objective.

RHAMNACEAE

WILD COFFEE

15) Colubrina arborescens (Mill.) Sarg.

C. ferruginosa Brongn.

A small tree up to 6 m, evergreen, with an open crown. Bark moderately smooth, thin, light gray. Twigs with red-brown pubescence. Leaves alternate, elliptical to ovate-lanceolate, 5-15 cm long, 2.5-8 cm wide, entire, simple, slightly thickened, with apex and obtuse-to-cordate base; upper surfaces dark green, slightly shiny, lower surfaces paler than above; veins present and prolonged near the margins. Petioles 1 cm; flowers white, small with reddish-pubescence, in axillary racemes. Sepals cuplike, 4-5, spreading, pointed; petals 5, smaller than sepals, yellow, folded around 6 stamens.

Fruit a capsule, globose to slightly 3-lobed, 9 mm diameter, with cuplike base. Seeds black, shiny, flattened, 2-3 mm long.

This is used principally as a forest and shade tree; its heavy, hard wood is ideal for posts and pilings.

BOMBACACEAE

PALAU NUT, GUYANA CHESTNUT

16) Pachira aquatica Aubl.

P. macrocarpa (Schlecht.) Walp

A medium size pyramidal shaped tree 7-13 m tall with an open growth habit. Branches horizontal, sparse, in tiers of 4 or 5. Bark smooth, green to gray with some lenticels. Leaves alternate, palmately compound; leaflets 5-9, oblong to elliptic, leathery, and 8-20 cm long; petiole 10-15 cm long, swollen at the base. Flowers axillary, very large, solitary, on peduncles; calyx short, unlobed, campanulate to tubular, 2 cm long, narrow; stamens 200-500, white at base, united into a long tube; anthers yellow. Fruit a brown, woody capsule 15-30 cm long, 13 cm wide with seeds embedded in the pulp.

This species is rare on Guam and is grown for the edible nut. The tree may have been introduced to Guam by Palauans who make a candy from the seeds. It is propagated by either seed or cuttings and is reputed to bear fruit in 3 to 4 years. Flowering appears to be heaviest from June to August.

GUTTIFERAE

CUPEY, BALSAM APPLE

17) Clusia rosea Jacq.

An evergreen tree 5-15 m tall with light brown to gray bark and moderately smooth; branches somewhat ascending. Leaves opposite, short petiolate, thick, leathery, blunt obovate, cuneate, 8-20 cm long, nearly as wide. Flowers (axillary and terminal) stalked, solitary, perfect or monoecious, 5 cm in diameter; petals 6, white to pink, with 4-6 persistent sepals; stamens many. Fruit a greenish capsule, globose, 8 cm in diameter, with 8-12 thick valves having yellow interiors; dehiscent, revealing equal number of cells, with scarlet or purple sticky seeds.

This neotropical species is an epiphyte until it strangles its host; it then becomes self supporting. The fruit is inedible, but seeds contain a sticky gum used as a birdlime or chalking for boats. The gum, which is a purgative, may also be extracted from leaves or bark and used to treat wounds. The timber from this plant is hard, strong and compact, but is rarely used.

Plants are occasionally cultivated as ornamentals on Guam and specimens may be found in Toto and along Tumon Bay. This tree has been confused with the mangosteen (Gracinia mangostana).

GARCINIA

18) Garcinia livingstonei T. Anders

A tree up to 12 m tall with hard and heavy wood. Bark light gray to ashy, rough, slightly fissured. Branches somewhat ascending and arching, bearing whorls of branchlets in tiers of three. Leaves whorled, simple, coriaceous, entire to crenulate, oblong with rounded-obtuse apex and rounded base, 8-12 cm long, 3-4 cm wide, veins visible above, obscure beneath, prominent midrib below; petiole 1 cm. Flowers axillary; fruit yellow-orange to reddish, globose, 5 cm, 1-2 seeded; pedicel 3 cm; seeds light brown surrounded by fleshly orange aril.

This species is indigenous to tropical Africa where the fruit is consumed occasionally. The plant was introduced to Guam in 1950 and cultivated in

Barrigada. The fruit is sweet and fairly tasty but not presently consumed on Guam. The flowers were reported to be creamy yellow, but these have not yet been observed.

PASSIFLORACEAE

PASSIONFRUIT

19) Passiflora edulis f. flavicarpa Dencger

A perennial, evergreen, climbing herbaceous vine. Stems obtusely angled, glabrous. Leaves alternate, 5-10 cm long, 3-lobed, serrate-dentate, glabrous, glossy above, stipulate; petioles 1-10 cm long with two glands near apex; tendrils axillary, simple. Bracts 1 cm long, green, glabrous. Flowers solitary, regular, perfect, 5-8 cm wide; calyx tubular, with 5 sepals and 5 white petals; united filaments purple at base; firm-walled berry many-seeded, 7.5 cm long. Seeds 3-4 mm, black, flattened, pitted and surrounded by the yellow-orange edible pulp.

This species is indigenous to Brazil and the variety (form) flavicarpa originated in Australia. Passionfruit is cultivated extensively for juice production in Hawaii, Australia, and other islands of the Pacific. It is occasionally cultivated on Guam. Plants were probably started on Guam from fruits purchased in stores or by seeds brought from Hawaii. More effort should be given to planting this particular species of Passiflora.

MYRTACEAE

TIMOR WHITE GUM

20) Eucalyptus alba Reinw. ex Blume.

A medium size tree up to 18 m in height and 60 cm in diameter with an open crown, sparsely branched. Bark smooth, pale pink to greenish-white, more or less mottled or blotched; deciduous. Timber reddish-brown, somewhat soft but durable. Juvenile leaves sub-opposite, ovate-lanceolate to broadly eliptical and petiolate. Mature leaves mostly alternate, broadly lanceolate to deltoid, 10-13 cm long, 3-4 cm wide, acute and petiolate. Petioles subterete and 2-3.5 cm long. Umbels axillary, 3-7 flowered. Penduncles somewhat terete or compressed, 10-20 mm long. Buds pedicellate, clavate to ovoid, 9-10 mm wide. Operculum hemispherical, apiculate, shorter than the calyx tube. Pedicels 5-8 mm long. Anthers versatile, obovate, opening in parallel slits; glands globular. Fruit pedicellate, hemispherical to campanulate, 8 x 8 mm. Disc rather thin, somewhat truncate; valves usually 4-5, rather broad, slightly exserted.

Indigenous to the northern Australian tropics, and extends north to the eastern Indonesian archipelago. Plants introduced to Fiji have grown to 5-7 m in 3 years. This species thrives in monsoonal climates with rainfall of 80-160 cm and at elevations up to 425 m. Specimens develop best on flat to gently undulating land and close to watercourses where soil may be waterlogged in the rainy season. Because the bark yields 30-32% tannins it has economic use in forestry.

This species was introduced from Australia and planted on Guam in 1978. There is a well established block planting on eroded acid clay soil in the Cotal Conservation Reserve, and numerous landscape specimens are scattered around the island. It grows moderately fast, 5 m in the first year, under proper management. The growth habit is poor for timber uses, but this species has excellent potential for soil conservation.

EUCALYPTUS

21) Eucalyptus brassiana Brass.

A medium to large tree (20 m) with a sparse, crooked crown and pendulous branchlets. Bark rough, gray, persistent on trunk; and smooth and dull white on branches. Juvenile leaves opposite to sub-opposite, petiolate, slightly glaucous, slightly falcate, 6-9 cm long, 2.5-4 cm wide. Mature leaves alternate, petiolate, linear-lanceolate, slightly falcate, 12-16 cm long, 1-2 cm wide.

This species is similar to E. camaldulensis in the above characters, as well as in the growth habit and general appearance. It does, however, develop a noticeable swelling of the root crown (lignotuber) in Guam plantings. The trees were planted in 1978 and have not yet flowered but appear to be worthy of additional planting as a forest tree.

RIVER RED GUM, MURRAY RED GUM

22) Eucalyptus camaldulensis Dehn.

E. rostrata Schlecht.

A medium to large tree up to 30 m, with diameter 1-2 m. Open crown; bark smooth, commonly dull white or ash. Twigs reddish; juvenile leaves opposite to sub-opposite, petiolate, slightly glaucous, slightly falcate, lanceolate, 6-9 cm long, 2.5-4 cm wide. Mature leaves alternate, petiolate, lanceolate, acuminate, 12-22 cm long, 0.8-2.0 cm wide, venulose and pale green on both sides. Umbels axillary with 5-10 flowers. Peduncles terete, 10-15 mm long. Buds ovoid to horn-shaped, pedicellate, 6-10 mm long. 4-5 mm wide. Operculum conical to rostrate, 1.5-2.5 times longer than the goblet-shaped calyx-tube. Anthers versatile, obovate, opening in parallel stils; dorsal gland small, globular. Fruit hemispherical to broadly turbinate, 7-8 mm by 5-6 mm; disc sharp and domed; valves exsert, acutely deltoid and incurved.

Widely distributed throughout the Australian continent around river banks, perennial streams and alluvial flats. It is tolerant of wet conditions and periodic inundation but is also drought resistant. Occurring mainly in semi-arid areas (25-65 cm rainfall per year), it can rapidly attain suitable harvest size (20 m in ten years). Ecologically, it is adapted to a wide range of soil types, and is moderately salt tolerant. This species is one of the most widely planted eucalyptus in the world, and is used for forestry, ornamental, conservation and apiary purposes.

Several block plantings were established in 1978 in the Cotal Conservation Reserve. The growth rate is fast (5 m per year), and of good form. It has proven to be somewhat typhoon resistant and adaptable to various site conditions. There presently are two species of leaf roller that cause some minor damage. This species appears to have excellent potential as a tree for forestry and conservation purposes on Guam.

LEMON SCENTED GUM

23) Eucalyptus citridora Hook.

A moderately tall (12-25 m) slender tree with an open crown. Bark smooth, white, powdery and deciduous throughout; timber durable and pale-colored. Juvenile leaves opposite for 4-5 pairs, becoming sub-opposite, petiolate, oblong to oblong-lanceolate, rough, setose, 7-15 cm long, 3-6 cm wide. Mature leaves alternate, petiolate, lanceolate, lemon-scented, 10-16 cm long, 1-2 cm wide. Inflorescence a terminal corymb with 3-5 flowers on terete peduncles 0.5 cm long. Buds ovoid and pedicellate; flower operculum hemispherical and shorter than the calyx-tube; anthers obovate. Fruit urceolate, 1 cm x 1 cm, pedicellate and contracted to a short thick neck. Disc thin, oblique; valves enclosed.

This species is native to the sub-tropical regions of Queensland where it thrives in heavy soils with moderate rainfall. A planting of this species was established at the Cotal Conservation Reserve in 1978. The plants have established more slowly when compared to other species but this may result from a greater susceptibility to insect damage. Because this plant has more open crown and only produces a light shade, understory vegetation is not inhibited. The charcteristic lemon scent is derived from citronella oil; in some areas this has been distilled from the leaves for commercial purposes.

MINDANAO GUM, KAMARERE

24) Eucalyptus deglupta Bl.

E. naudiniana F. Muell.

A medium to very large tree from 15-60 m tall and up to 2 m in diameter. Bark smooth, green to reddish, glaucous, deciduous. Branchlets angular; timber reddish and moderately durable. Juvenile leaves opposite on 1-3 year old trees, petiolate, ovate to oblong-lanceolate, 5 cm long by 4 cm wide, acuminate, and thin. Mature leaves alternate, petiolate, pale green, ovate-lanceolate, acuminate, 5-14 cm long by 2-7 cm wide. Inflorescence paniculate, terminal, and rather large. Compound umbels with 3-7 flowers. Buds clavate to cylindroid, acute, pedicellate, 5 x 4 mm; flower operculum acutely conical, as long as the calyx-tube. Anthers reniform, with a small terminal gland. Fruit pedicellate, ovoid-clavate or globose, 5 x 5 mm. Disc thin, valves as long as the calycine portion, protruding.

Distributed indigenously from Mindanao in the north to New Guinea in the south including the Celebes, Moluccas, and Irian, it is called "Bagras" in Tagalog. This tree grows best on moderately fertile, sandy loams of the riverflats; rainfall commonly ranges from 250-300 cm per year within the natural distribution area. It is one of the fastest growing species in the world and is used for both timber and pulp.

Several block plantings were established in the Cotal Conservation Reserve in 1978; plants have grown moderately fast with good form on protected sites. Typhoons have caused problems with sapling to pole-sized trees because they are somewhat top-heavy. This species has, on one site, produced flowers and set seed within one year following germination.

TOOLUR, ROSE GUM, FLOODED GUM

25) *Eucalyptus grandis* Hill ex Maiden

A tall tree up to 46 m, with diameter of 1-2 m and a moderately dense crown. Bark smooth and deciduous, white or subglaucous; timber red and durable, but may warp in curing. Juvenile leaves sub-opposite, shortly petiolate, oblong-lanceolate, thin, undulate, 3-6 cm long and 1-2.5 cm wide. Mature leaves alternate, petiolate, lanceolate to broadly lanceolate, acuminate and undulate, 13-20 cm long and 2.0-3.5 cm wide, dark green, and faintly veined. Umbels axillary, 3-10 flowers or more; peduncles compressed, 10-12 mm long. Buds pyriform, usually constricted in the middle, pedicellate, glaucous, 10 mm long and 5 mm wide. Operculum conical to shortly rostrate, shorter than the calyx-tube. Anthers versatile, rather large. Fruit pedicellate, glaucous, pyriform, rather thin, slightly contracted at the orifice, 7 mm long, 6-8 mm wide. Valves 4-6, thin and usually incurved.

This tree is native to the north coast of New South Wales and southeastern Queensland bordering the rain-forest areas. Stands on moist basaltic derived loams of the valley areas do best. Reputedly an excellent tree for use in subtropical coastal forestry, it yields .26% oil and produces good all-around lumber. Australia reports 8 m of growth in the first year with intensive plantation management.

Two plantings were established in 1978 within the Cotal Conservation Reserve. Growth has been moderately fast with good form, but typhoon winds and some insect species have damaged younger trees. It has not grown as fast on Guam as other eucalypt species.

LARGE FRUITED RED MAHOGANY

26) *Eucalyptus pellita* F. Muell.

A tree 12-30 m tall and 1-2 m in diameter, with a heavily branched crown. Bark rough, fibrous, becoming fissured, persistent throughout; twigs smooth, brownish orange; timber durable and red in color. Juvenile leaves subopposite for 3 to 4 pairs, narrow to broadly lanceolate, 3-9 cm long by 3-5 cm wide, rather thick petiolate. Mature leaves alternate, ovate to broadly lanceolate, 10-16 cm long, 3 cm wide, coriaceous, smooth and shining, finely veined, and petiolate. Umbels axillary, with 3-8 flowers; peduncles compressed to strap-shaped, 10-25 mm long and 4-6 mm broad. Buds pedicellate, cylindroid-urceolate to broadly turbinate, 15-22 mm long by 10-15 mm wide. Operculum conical to subglobose, much inflated, broader and longer than the bicostate calyx-tube. Anthers versatile, obovate, opening in parallel slits; dorsal gland ovate, rather small. Fruit shortly pedicellate, subglobose to turbinate, bicostate, 15-18 mm long by 16-20 mm wide; discs large, domed, up to 5 mm in diameter; valves strong, usually exserted.

In its native habitat this species is distributed discontinously along the coast in both Queensland and New South Wales, where rainfall ranges from 90-229 cm a year. It is used for conservation purposes on coastal sandy soils. The wood is persistent in the soil when used for fence posts, support and landscaping. This species yields .37% oil, and is known to have an extended flowering period of 9 months in its natural range.

The tree should be considered for future plantings on Guam. Its growth rate is slower than that of some eucalypts, but because of tree form and wind resistance the tree has potential as a conservation species. Growth is best, however, in those areas with deep soils which are protected from wind.

FOREST RED GUM

27) Eucalyptus tereticornis S.

E. umbrellata (Gaertn.) Domin.

A tree tall to 40 m with a thick trunk and somewhat open crown. Bark smooth and irregularly blotched throughout, or (sometimes) with rough flaky plates persistent at the base. Timber durable and colored red. Juvenile leaves sub-opposite for 2-3 pairs, elliptical to broadly lanceolate, 6-16 cm long, 5-6 cm wide and petiolate. Mature leaves alternate, narrow-lanceolate, 10-21 cm long by 1.2-2.5 cm wide, slightly falcate, petiolate. Umbels axillary with 5-12 flowers; penduncles almost terete, 5-12 mm long. Buds horn-shaped to conical pedicellate, and 12-16 mm long. Operculum conical, usually 2-3 x longer than the cupular calyx tube, and sometimes broader at the base than the latter. Anthers versatile, opening in long, narrow cells; dorsal gland rather small and globular. Fruit hemispherical to turbinate, pedicellate and 6-9 cm long, 8-10 mm wide; the calycine rim is often sharp; discs are broad, domed and fused to rather thick, broad, strongly exserted valves.

This species occurs naturally over a wide range of latitude from Victoria to Papua, New Guinea along the eastern coast of Australia. Over this range it remains fairly consistent in growth habit and size, and is usually found in open formations or as single specimens scattered on alluvial plains and stream banks. It tolerates heavy soil and water-logged conditions, and yields 0.5% oil, which makes it a useful and economic tree for tropical and subtropical forestry.

Guam records show that is was first planted in 1977; after nearly three years of growth, the tree appears to be one of the most promising exotics ever introduced for reforestation. It appears to tolerate winds-even typhoons-as well as rain and drought. Insect damage is evident but it appears to have little effect on the tree. During their second years some specimens developed longitudinal fissures from 30-60 cm long and 1 cm wide, which exposed the cambium tissue. The fissures callused within a few months, and it is now thought that they may have resulted from periods of rapid diameter growth.

TIMOR MOUNTAIN GUM

28) Eucalyptus urophylla Blake.

Very large trees up to 55 m with diameters up to 2 m; shows apical dominance. Bark persistant to branches and red-brown to brown in color; twigs smooth and generally red; timber pinkish brown to red-brown. Juvenile leaves suboposite, petiolate, broadly lanceolate, 10-15 cm long, 5-8 cm wide. Mature leaves subopposite to alternate, acuminate, broadly lanceolate to linear, 12-20 cm long, 2-5 cm wide, moderately thin, petiolate. Umbels axillary with 7-11 flowers; peduncles somewhat flattened, 1-2 cm long; pedicels angular. Buds globular to ovoid; operculum rounded conical, slightly apiculate; length equal to width. Fruit obconical to cupular. Disc moderately wide, almost flat to obliquely depressed; valves 3-5.

An excellent tropical forestry species native to Timor and surrounding islands; it is grown extensively in Brazil. Usually found naturally in association with E. alba and Casuarina. It develops best on deep, moist, well-drained soils derived from igneous and metamorphic rock; growth is much poorer on limestone soils. Naturally distributed in monsoonal climates with 127-240 cm annual rainfall occurring during 6-7 months of the year, it was introduced to Guam in 1978.

RIVER TEA TREE, PAPERBARK

29) Melaleuca leucadendron L.

M. cajaputi Roxb.

A small to medium evergreen tree with a bushy growth habit. Bark, whitish to very light gray, thick, spongy, papery, multilayered. Leaves alternate, linear to oblong, curved or straight, thinly leathery, 5-10 cm long, 1 cm wide, with 3-7 longitudinally parallel veins. Inflorescence whitish, in cylindrical terminal spikes 10-20 cm long with 20-60 flowers; petals 5; stamens in 5 bundles, 1 cm long. Fruit a spherical or hemispherical capsule 2 mm wide. The inflorescence of this species is terminal but may appear to be axillary because vegetative growth proceeds from the inflorescence tip.

Because of the variation in taxonomic characteristics there are questions regarding the authority of this name, and some botanists classify this plant as M. quinquenervia (Cav.) S. T. Blake. This tree was planted on the Cotal Conservation Reserve in 1970 and 1978; it has flowered and produced seed but grows fairly slowly.

This species is native to Australia, New Guinea and New Caledonia, where it grows in environments ranging from swamps to dry savannas. The timber is brownish, mottled or veined and warps badly upon drying, but is very durable when used as posts in wet soil or in the sea. The papery bark is used for caulking and packing. A tea is made from the leaves in New Caledonia, and the leaves also produce cajeput oil, which is used pharmacologically. The fruit capsules are also used medicinally in the Malay Peninsula.

ABAS, YELLOW CHERRY GUAVA

30) P. littorale f. lucidum Degener.

An evergreen tree up to 7 m tall with a loosely branched habit; branches cylindrical. Bark smooth, grayish brown, peeling. Leaves opposite, simple, entire, pinnately veined, glabrous, glossy deep green, elliptic to obovate, acute, to 7.5 cm long, 2.5-4 cm wide, on short stout petioles. Flowers solitary, white, 2.5 cm across, on axillary peduncles; calyx prolonged above ovary, obscurely lobed; corolla with 4-5 orbicular petals; stamens many, clustered at base of calyx lobes. Fruit round to obovate, inferior, many seeded, sulphur-yellow, 2.5 cm diameter, with white flesh, acid when ripe. Seeds small, hard, and yellowish brown.

ABAS, PURPLE STRAWBERRY GUAVA

31) Psidium cattleianum Sab.

Psidium littorale f. longipes (Berg.) Fosb.

Same as 30) except growth habit is somewhat more dense and fruit is purplish red and sweet rather than sour when ripe.

These two species are widely cultivated in Guam gardens and on family ranches for their edible fruit. Trees usually flower heaviest in November and December; fruits ripen April through August. Fruits are eaten fresh or made into juices and jellies. Plants thrive on well-drained, sandy loan soils, but will produce in a satisfactory manner on clay soils.

The forms of P. cattleianum may be easily distinguished from P. guajava by the branches and bark. P. guajava has quadrangular shaped branches with scaly bark, while P. cattleianum has smooth bark and cylindrical branches.

SAPOTACEAE

CAINITO, STAR APPLE

32) Chrysophyllum cainito L.

An evergreen tree up to 12 m with a diameter up to 60 cm, and a dense crown of dark, glossy, green foliage. Bark brown, rough, scaly and fissured. Leaves alternate, acute, oblanceolate-elliptic, 8-13 cm long, 3-8 cm wide, entire, drooping, with up-curled sides, slightly thickened; upper surfaces deep green, smooth and shining; lower surfaces silky, copper colored and veined; petioles 1-2 cm long, reddish brown and pubescent. Flowers purplish white, small and clustered on pubescent axillary stalks 1 cm long; sepals 6, rounded, brownish green and imbricate; corolla tube opposite the lobes. Fruit a berry 5-8 cm diameter, glabrous, smooth, hard, green when young and reddish gray when ripe. Seeds 3-8, flattened, brown, imbedded in a tasty white pulp.

Star apples are cultivated on Guam as dooryard specimens for ornamental and fresh fruit purposes. They are easily distinguished by the bronze-satin color of the lower leaf surfaces. By halving the fruit transversely the characteristic star-like formation which the source of the English name may be seen.

Fruit bearing is rather variable among specimens. Asexual propagation would appear to be the ideal method of maintaining quality plants. The star apple is indigenuous to the West Indies and is adapted to a wide variety of soils.

CANISTEL, EGGFRUIT

33) Pouteria campechiana (HBK) Baehni

Lucuma nervosa A. DC.

An evergreen tree 9-15 m tall, with erect growth habit. Leaves alternate, bright green, glabrous, leathery, elliptic to narrowly obovate, 10-25 cm long, 5-10 cm wide, rounded to acuminate apex, shortly petiolate, 12-20 pairs of veins. Flowers small, 4-5 parted, greenish-white with 4-5 imbricate sepals; corolla campanulate, five-lobed, imbricate, stamens inserted, attached to the base of corolla lobes. Fruit 1-3 seeded, globose to obovid, 10-15 cm long, greenish brown to yellow; skin membranous; pulp sweet and orange-yellow. Seeds 3 cm long, dark brown and shiny.

Eggfruit is rare in cultivation, but is being planted more often on Guam. It tolerates poor soil conditions but does best on clay or clay loan soils. It is usually propagated by seed, but superior lines may be propogated vegetatively.

VERBENACEAE

MELYNA

34) Gmelina arborea Roxb.

A 13-20 m semi-deciduous tree with few, thornless branches. Bark sandy gray, speckled, smooth. Leaves opposite, simple, entire, broadly ovate, 15-30 cm long, 10-20 cm wide, smooth above, pubescent beneath; apex acuminate, base somewhat cordate; petioles 5-15 cm long with two distal glands. Inflorescence cymose, arranged in drooping panicles 30 cm long that are both terminal and axillary. Calyx 4-5 toothed, or entire; flowers 2-3 cm across, brownish yellow, on short pedicels; corolla with short narrow tube, five-lobed, wide mouth, bell shaped; stamens 4. Fruit drupaceous, roundish to ovoid, 2-3 cm long, yellow, juicy, 1-4 seeded, pyrene hard.

This species is native to India but is now grown throughout tropical east Asia as a fast growing forest and/or ornamental tree. The timber is white, glossy, and resistant to warping, not wholly unlike that of teak. Because of these wood qualities, it has been primarily used for crafts and carpentry work. The trees thrive on Guam's limestone soils but the plantings on the acid soils of the Cotal Conservation Reserve have done very poorly.

BIGNONIACEAE

CALABASH

35) Crescentia cujete L.

A medium sized tree up to 12 m with a short trunk and thin gray bark; branches outspread and arching. Leaves alternate but spirally arranged and clustered at nodes, nearly sessile, oblanceolate, simple, entire, with obtuse apex, cuneate, 5-15 cm long, smooth or downy beneath. Flowers solitary or clustered on main branches or trunk, 5 cm long. corolla campanulate with five irregular lobes, somewhat lacerated, yellowish with red or purple veins. Fruits globose, 15-30 cm long, green to yellow, hard-shelled, smooth; pulp white, juicy, with many seeds. Seeds dark brown, flat, 8 mm long.

This species is native to tropical America where the fruit is used to store water, and also for household utensils. The flesh of the fruit may be poisonous but seeds are edible and oil bearing. Specimens may be seen on O'Brien Drive near Bank of Hawaii in the shopping center.

JACARANDA, GREEN EBONY

36) Jacaranda mimosaefolia D. Don.

J. acutifolia R. Br.

A semi-deciduous, spreading tree with a thin, open, light green crown, up to 15 m tall. Bark smooth, pale grayish and flaky; twigs brittle. Leaves opposite, oblong-rhomboid, 1 cm long, shortly acuminate. Flowers many, in terminal panicles, 20 cm long. Corolla bluish, funnel-form to campanulate, 5 cm long, 5-lobed, 2-lipped; calyx 5-toothed, truncate; stamens 4. Fruit 5 cm in diameter; capsules brown, 2-seeded, flattened, rounded apex, with somewhat waxy edges; seeds with flat wings.

This species is native to northwest Argentina. Probably planted on Guam prior to 1979, when it was introduced for small trial plantings. The tree is known for its colorful violet flowers and hence is more useful in urban plantings than for timber.

RUBIACEAE

KADAM TREE

37) Anthocephalus cadamba (Roxb.) Mig.

A. morindifolia Korth

A tall, deciduous, monopodial, symmetrical tree with a slightly buttressed trunk, to 24 m. Branches sparse, horizontal and drooping slightly at the ends. Bark gray, smooth, somewhat fissured and sometimes with coarse flakes. Leaves opposite, petiolate, prominently veined, ovate to oblong, 22 cm long, drooping, upper surface glabrous and coriaceous; lower veins tomentose; stipules lanceolate, caudacious. Flowers yellow to orange, solitary heads, 5 cm diameter, united by confluent calyx tubes; coralla tubular, 5 lobes with 5 stamens borne at the throat; filaments short. Edible fruits confluent into a fleshy globose mass 5 cm in diameter; seeds minute.

This is a fast growing species native to the Indo-Malesian region (extending from India to New Guinea). It was planted in the Cotal Conservation Reserve but only two trees remain. The tree has done well in Puerto Rico where it is very popular in reforestation projects. Efforts will be undertaken to establish a few more plantings with Kadam when plant material is available.

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