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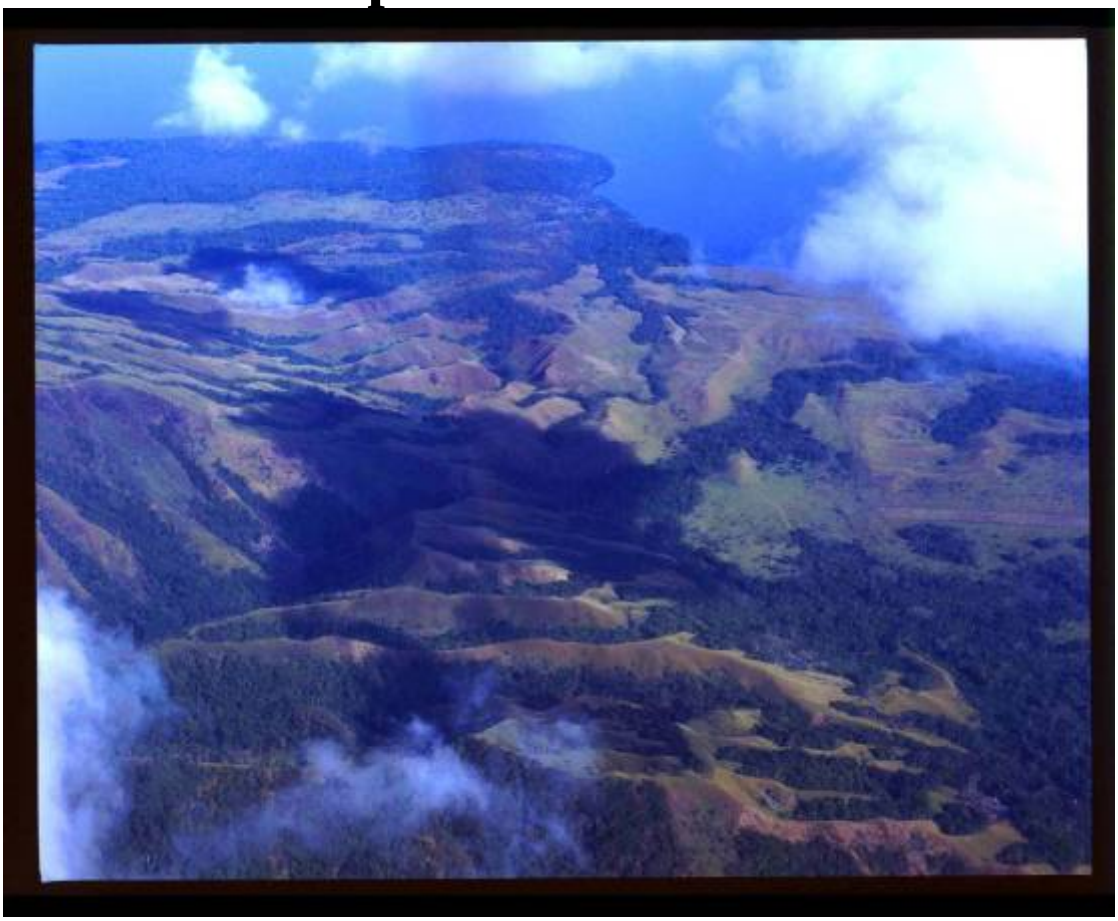
June 1989[1]

An urgent need for conservation action:

Toward monitoring and protection of the biological diversity of the rainforest and coral habitats of off-shore New Guinea islands -

Fergusson Island, Milne Bay Province, Papua New Guinea



Aerial view of south-western Fergusson Island, March 1989, photograph by Gordon Brent Ingram

A report to the Office of Environment and Conservation, Government of Papua New Guinea; the Biology Department of The University of Papua New Guinea; and World Wildlife Fund - Australia

fishing rocks west of the village of Nade, on the south coast of Fergusson Island, March 1989, photograph by Gordon Brent Ingram

table of contents

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An urgent need for conservation action: Toward monitoring and protection of the biological diversity of the rainforest and coral habitats of off-shore New Guinea islands - Fergusson Island, Milne Bay Province, Papua New Guinea

Executive Summary

shore west of Nade, on the southern shore of Fergusson Island, Papua New Guinea with Normanby Island in the distance, March 1989, photograph by Gordon Brent Ingram

A report to the Office of Environment and Conservation, Government of Papua New Guinea; Biology Department of the University of Papua New Guinea; and World Wildlife Fund - Australia

Some of the most spectacular combinations of unique and vulnerable plants and animals in the entire South Pacific - Australasian region are in and around the off-shore islands of New Guinea. This combination of coral, shore areas and various types of rainforest make these islands some of richest in "biological diversity" on Earth. Islands relatively close to the New Guinea mainland are particularly rich and vulnerable and are often so "super-saturated" with species that any kind of addition of human-induced disturbance can "tip the scales" to cause the loss of some unique species. Such is the case of the D'Entrecasteaux Islands and of Fergusson Island in particular.

This study was conducted from 1986 through to 1989 under the auspices of the Biology Department of the University of Papua New Guinea and the Government of Papua New Guinea's Office of Environment and Conservation. The goal of the project was to study the situation of these off-shore islands in terms of threats to the continued existence of representative, vulnerable, unique and valuable species and habitats from proposed logging and mining and in combination with expansion of traditional agriculture, gathering and hunting. Fergusson Island was chosen because of its relatively high degree of endemism and the fact that there has been little assessment of the possible threats to local biological diversity by the logging which began in 1986 and the mining which is currently proposed.

This research is intended to provide the basis for a proposal from the government of Papua New Guinea, in cooperation with national and international non-government organization, for a network of protected areas - both rainforest and marine - and eventually for a community-managed conservation district or national park with international recognition under UNESCO's Man and the Biosphere Programme.

This report identifies eight alternative strategies for development of a programme for the conservation of the terrestrial and marine biological diversity of Fergusson Island. Strategy 8 is most preferable with Strategy 1 least preferable. The methodology for choice of alternative combinations of conservation measures is based on minimum requirements of focal species within the Fergusson Island biotic district.

Recommendations

1. Fergusson Island is one of the most biologically rich and least disturbed islands in the entire Pacific region. Given its remarkable combination of rainforest and

coral reef ecosystems, it is one of the most biological diverse areas on Earth. It merits special attention by national and international conservation agencies.

2. So far, there has been no comprehensive planning of development and habitat conservation on Fergusson Island and pressures for resource extraction are now severe. Without the establishment of a networks of large rainforest and marine reserves, unique species and ecosystems may well go extinct over the next ten years. Given that provincial officials are intent on selling off the remaining logging and mining rights for the island to foreign companies in the next 12 to 18 months, it will be necessary to quickly develop a plan with the support of the local communities and in cooperation with the Research Committee of the Government of Milne Bay Province and the Biology Department of the University of Papua New Guinea. Such a plan will need to be under the auspices of the Government of Papua New Guinea's Office of Environment and Conservation and involve the support of the Melanesian Environment Foundation and international conservation organizations such as World Wildlife Fund.

3. There is one protected area which is currently in existence on the island and it was initiated and is currently managed by local communities in the area.The Lake Lavu Wildlife Management Area is a remarkable example of a community controlled conservation area but since its establishment about 10 years ago, there has been little resources, education and renumeration provided to these remarkable "conservationists." A first step in establishment of Fergusson Island as a "conservation district" or a national park should be to provide an on-going liaison and dependable support to these communities.
The area has accessible to "flying boats' ("float planes") and is worthy of a research hut and guest house for bird watchers and rainforest enthusiasts. The area is remarkable in its diversity of bird species, notably tropical raptors, and in the pristine state of its adjacent lowland rainforest.

4. Given the logging that is progressing rapidly in the eastern part of Fergusson Island, the mountains above the village of Nade and extending north into the Salakahadi District are strategic for the survival of a number of forest birds on the island. Nade already has two tour groups visiting it a year as it is one of the most accessible areas for viewing Fergusson (and adjacent Normanby Island) Island's endemic Bird of Paradise. Given the rugged nature of the terrain, the area is under less pressure for logging and will probably only be of interest to the companies after the mid-1990s. This should allow enough time for the establishment and entrenchment of community oriented conservation programmes centred on a tourist guesthouse, a research station, trail maintenance and marking, and community education. Given the local enthusiasm, easy access through the airstrip at Salamo, the beaches and the "charm" of Nade and the coast to the west

of it, the area would be an excellent choice for a wilderness tourism-oriented national park.

5. The most vulnerable and diverse coral reef system that we could identify was off of the southwest coast between Mapamoiwa and Iaupolo to the northeast. The area to the north is being considered for logging. Subsequent sedimentation from the Fagalulu watersheds and the off-shore booms could destroy the shallow corals. The marine area and adjacent shores merit protection along with a research station in the one village between Mapamoiwa and Iaupolo that exists along the shore.

6. One other central portion of Fergusson Island will be crucial for the maintenance of the area's biological diversity (particularly its forest birds) and this extents from the lowlands around the Salamo River beginning about 8 kilometres above the settlement of Salamo and extending to the east and west several kilometres and up to the summit of Mount Kilkerran. This could be protected in some kind of local use zone as long as roads and logging were prohibited.

7. With a such a remarkable amount of plant and animal endemism, vulnerable reefs and traditional exploitation, the others parts of the islands will require a network of smaller (100 to 1,000 hectare) reserves which could be managed as areas of traditional gathering and hunting. A prerequisite for establishment of these will need to be a vigorous programme of conservation education, for which some local enthusiasm has already been expressed, and which involves the local councils and the two major Christian denominations in the area: the United Church in Salamo and the smaller Catholic mission.

8. Given the island's isolation and the patterns of development, it will be necessary to work very closely with the United Church of Christ Mission in Salamo and to base administration in the village of Salamo.

9. The terrestrial and marine areas in and around Fergusson Island would comprise an excellent candidate for Papua New Guinea's first Biosphere Reserve under UNESCO’s MAB programme.

10. Given the growing international and national (through the Melanesian Environment Foundation) interest in the preservation of primary rainforest and coral reefs, a number of venues for financial and technical support are available for community initiatives including:

a. support for basic research (especially inventories and taxonomic identification),

b. geographic information systems for a range of stakeholder groups from local to national;

c. a network of research stations through a number a foreign universities

d. coordinated through the Biology Department of the University of Papua New Guinea;

e. establishment of modest, nature-tourism facilities for example through the World Bank and the Canadian High Commission (in Canberra); and

f. technical support for education and monitoring through bilateral programmes such as CUSO, VIA and the Peace Corps as well as United Nations technical agencies such as UNEP and the Man and the Biosphere Programme (MAB) of UNESCO.

a sketch map of the East Papuan Peninsula and the D'Entrecasteaux Islands to the north

Lake Lavu and the surrounding forest that is in the Lake Lavu Wildlife Management Area looking north into the interior mountains of Fergusson Island, March, 1989, photograph by Gordon Brent Ingram

Introduction

The preservation of Local Biological diversity *in situ*:
A growing concern in land use planning

"Biological diversity" is both something real, in the environment, and is a representation from a body of scientific concepts under-laid by an array of socially related concerns. How we perceive the biological diversity, on Earth, and in our respective communities, is a reflection of the nature of science in the late Twentieth Century and the cultural, ethical, economic and political ties which certain groups perceive in terms of particular species, communities and resources. These relationships are highly dynamic and have become more prominent as more elements of biological diversity have been threatened with disappearance.

Concerns for the persistence of biological diversity are based on a fluid set of scientific notions which have begun to take on policy dimensions as natural habitats throughout the world have become jeopardized. The implications of the subsequent losses of biological resources have begun to be felt in the political and economic spheres.The scientific concepts, embodied in concerns for habitat conservation, are grounded in Nineteenth Century biology and geography. This can only provide a partial basis for coping with the pervasive threats to natural habitat which have emerged in the latter part of the Twentieth Century.

There are a number of factors which make for the fluidity of scientific concepts which currently exists in biological conservation. Societal interest, controversy and practical need have created increased demand for certain research. Current paradigms can not satisfactorily solve certain problems. Rapid infusions of information can initiate scientific revolutions which provide partial solutions to such problems.

The current conceptions of biological diversity are dominated by notions of three levels within any given area:

- ecosystems and landscapes;
- species; and
- intra-specific variation as best measured through genotypes and alleles.

Modern biology has provided the basis for a more comprehensive understanding of the loss of biological diversity and the respective causes than could have been possible in earlier times. In the new field of ecology, the Nineteenth Century pre-occupation with the climax, successional phase allowed for an appreciation of the requirements of organisms for certain biophysical conditions. The development of a universal system of taxonomy and the emergence of the science of genetics laid the basis for consideration of intra-specific variation.

At the species level, two conditions have usually been considered in descriptions of biological diversity: the numbers of species and the relative abundance of species. In considering a particular spatial unit, these two abstract properties can be quantified by various types of indices and measures. It was Whittaker who laid the theoretical basis for consideration of more than simple species counts, alpha diversity, such as including regional landscape diversity, sometimes referred to as gamma diversity. The elements of this latter concept of biological diversity lay the basis for the policy concern. As well as the differing perceptions of the three levels of biological diversity (community, species and intra-specific), there are contrasting views of the spatial nature of the resource and its loss. Much of the concern for species has emphasized the absolute, planetary count and the uniqueness of life forms. But perceptions which have motivated localized conservation efforts have had a regional orientation.

While extinctions of species and other forms of loss of biological diversity are natural phenomena, scientists in recent decades have come to recognize that a new wave, derived from expansion of land use and general environmental degradation, threatens a higher magnitude of the biota of Earth. Over the last decade, media coverage on the demise of species has helped to make broad sections of the public, particularly in the affluent countries, aware of the crisis of accelerated losses.

Often linked to species loss, especially in the popular media, is the loss of unique types of natural communities and mosaics of complete sets of successional phases. Destruction of a few of the more spectacular categories of community types, such as primary forest of the humid tropics, has gained public attention. Since the early 1970s, there has been growing international concern over irreversible destruction of these communities. In other regions of the world, concern for loss of community types has been related to the regional loss of natural habitat and the links between diminishing and disintegrating ecosystems and the disappearance of

associated species. It has been an understatement when it was first suggested that with every endangered species, there is also an "endangered ecosystem."

The loss of intra-specific variation when it occurs in populations of wild species can be termed genetic erosion. This is a result of the loss of populations and genotypes which can come with loss of habitat. The loss of this heritable variation can have detrimental consequences for both the survival of some species and will diminish the range of genetic material available for introductions and improvement of cultivars and livestock.

Contemporary recognition of the need for *in situ* conservation of biological diversity has involved four overlapping categories of concerns. There are the economic needs for maintenance of current resources and amenities, associated with natural ecosystems and wild species, which are prone to degradation with the loss of certain elements of biological diversity. There are the economic advantages of certain technological options which are precluded when certain biological resources disappear.

There is the dimension of time and the moral issues of intergeneration distributive justice. A loss which is insignificant, today, might be a contributing factor to the impoverishment of future societies. There is a host of other moral issues involved with the extent of the sanctity of species and natural habitat and the evolutionary responsibility which human beings have to allow for the continuing adaptation and survival of the species with which we share the Earth. Biological diversity as a land use policy concern has spread from the North America and Europe to numerous countries in the last decade. There were a number of international efforts which have been concerned with aspects of the conservation of biological diversity and with protection of habitat. The need to maintain "genetic diversity" was a major topic in the initiation of UNESCO's Man and Biosphere Programme in 1968.

The World Conservation Strategy emerged as a remarkably influential policy guide and lists three major objectives in conservation. After "maintenance of essential ecological process", "preservation of genetic diversity" is critical for both "insurance and investment." By the mid-1980s, concerns for the conservation of biological diversity were being worked into broader projects for environmental management. Genetic diversity is now often mentioned, in vague terms, by international organisations.

In order to transform the conservation of biological diversity from a vague policy concern into a viable objective in land use planning, it is necessary to critique the contemporary approaches to habitat protection and to build a framework for a pool of more effective methods. One possible set of innovations in conservation planning, which could better consider biological resources, is through maintenance of minimum conditions and requirements of key species in protected habitat in districts delineated through natural factors.

There are three ways in which elements of the biological diversity of a region are lost. Habitat conversion, such as from primary forest to pasture, usually precludes the survival of the original species on respective sites. If all of the sites with a particular set of biophysical conditions are converted, unique habitat types, some species and populations may disappear. Habitat alteration can make it impossible for certain aspects of the regional biota to persist. If such change is sufficiently pervasive, elements can disappear. Fragmentation is the process whereby the total area of a single undisturbed tract of habitat is sufficiently diminished or a tract is broken down

into smaller units of habitat. Disintegration of niche architecture progresses to the point where only a subset of elements of local biological diversity persists within certain tracts of vestigial natural habitat.

Land use-induced disturbance can degrade ecosystems and diminish the biological diversity of an area but such relationships are never automatic. In order to understand the threats to biological diversity and to formulate viable programmes for conservation, it is necessary to identify cause-effect linkages between the intensity of certain regimens of practices on certain sites and the requirements of certain organisms and complexes and their vulnerability to certain kinds of change.

Well-defined geographic boundaries based on "natural territorial complexes" are often desirable for environmental planning. But most planning units are results of historical, political and cultural factors. Their boundaries rarely reflect natural factors and distinct biogeographical units. This poses problems for determination of the regional scope of efforts for programmes of *in situ* conservation of local biological diversity. The size of planning units has often been too large or small to respond to the conservation requirements of some organisms and communities. Boundaries which cut across topographic and geomorphic formations and distributions of species, which are small and localized, are the most problematic.

Biotic districts of bioregions could be employed to represent, "variously sized ecosystem units that have significance both for development of resources and for conservation of the environment". Biotic districts are not so much intrinsic, natural entities as aggregations of landscape units relative to concerns for certain resources and threats from expansion of land use. The biosphere is comprised of a well-integrated set of organisms. Few discreet units exist. However, there are areas which are more homogeneous and areas where differences are more pronounced. Linking these points of difference along with barriers between geomorphic barriers can highlight rough boundaries for biotic districts can highlight rough boundaries for biotic districts can highlight rough boundaries for biotic districts. The biotic district concept may offer a partial solution to a dilemma involved with formulation of standards of biological conservation as related to can highlight rough boundaries for biotic districts.
In cases where elements of diversity are not threatened with total extinction, there is the question of the extent of protected habitat which is necessary at the present time. A series of biotic districts could function as a rough guide with each functioning to provide a minimum level of protection. This approach also has strategic advantages in that it is the unnoticed extirpations of species, at the district level, which eventually lead to extinctions. Maintenance of local presence of full sets of elements, throughout a biogeographic province, could slow or control losses. Perhaps the opportunities for and limitations to planning networks of protected areas for conservation of biological diversity, which are embodied in the bioregion ideal, will only be appreciated after application in a number of land use planning settings. The following is a description of one of the few areas where the concept has become a cornerstone in nature conservation.

"New Zealand has established a Protected Natural Areas programme which aims to ensure that the full range of natural diversity is protected in each 'ecological district' in New Zealand. An ecological district is defined as a local part of New Zealand in which geological, topographical, climatic and biological features and processes - including the broad cultural pattern – inter-relate to produce a characteristic landscape and range of natural biological

communities. There are currently 268 ecological districts and 1,500 protected natural areas in New Zealand. The protected areas cover 4.5 million hectares or 16% of New Zealand's land area."[2]

The focal taxa concept involves a jumble of notions. Keystone species are those which exert influences over other members of their ecological communities out of proportion to abundance Soule and Salwasser of the United State Department of Agriculture Forest Service began to consider the possibilities for employment of management indicator species in the National Forests of the United States. In earlier and related approaches in Europe, plant studies were used to locate rare and vulnerable elements in the landscape. To locate ancient woodland in Britain, as part of site choice for protection, used a number of plant indicators.

There are a number of uses of focal taxa in land use planning. The use of such species for planning habitat protection programmes for the in situ conservation of local biological diversity can lay the basis for:

1. choice of sites for protected natural areas;
2. organisation of priorities for analysis of habitat quality;
3. monitoring the effectiveness of established networks of protected areas ;
4. prescriptions for land management within protected areas; and
5. regulation of potentially damaging land use activities in areas adjacent to protected habitat.

The choices for subsets of species, as a basis for habitat conservation, have often resulted from a hodgepodge of interests and perceptions. If the focal species concept is to be a viable cornerstone of programmes for the conservation of biological diversity and, in turn, be integrated into comprehensive land use planning, the intended functions of the tool must be clearly delineated and described for each application.

There are three types of indications which focal taxa can provide in environmental planning for the *in situ* conservation of biological diversity. There are species which are representative of complexes of organisms and associated environmental factors. Some taxa are more vulnerable to extirpation because of environmental and ecological changes which result from land use practices. A third type of indicator is not so much derived from natural factors as a number of pressures for and from human exploitation. A single organism can qualify for more than one category of indicator.

Minimum requirements for habitat and populations are a form of prediction for the persistence of indicator species and of the complexes of organisms of which they are a part. If the full set of minimum requirements of all of the focal species of a district were maintained within protected habitat, the local biological diversity can be assumed to be adequately conserved.

The minimum requirements concept, as a technique in environmental planning, emerged from the "safe minimum standards" approach to public decision-making involving endangered species. The deterioration of certain populations and habitat requirements can provide foci for more intensive monitoring and management.

The compilation of the minimum requirements, for local focal species, becomes the sampling frame for ecosystem and site analysis. Possible conservation interventions such as choice of sites as protected areas and management and regulation of external land use would be based on subsequent analyses. Minimum requirements are the measures in a three-tiered analysis of the natural habitats within biotic districts:

step 1. determination of the particular focal taxa which are present;

step 2. determination of the types of minimum requirements for each focal taxon which is present; and

step 3. assessment of both quantitative and qualitative requirements, as related to the numbers and densities of each requirement, for each focal taxon.

The dimensions of a set of requirements for focal species can be complex. Requirements can fall into the following categories:

- population size;
- number of populations;
- area;
- environmental gradients;
- habitat features and associated species; and
- successional phases with disturbance factors.

dipterocarp tree in primary forest above the village of Nade on the south coast of Fergusson Island, March 1989, photograph by Gordon Brent Ingram

Fergusson Island, D'Entrecasteaux Islands:
The biotic region and district

"However various may be the effects of climate, however unequal the means of distribution, these will never altogether obliterate the radical effects of long-continued isolation"
[*Natural History of the Papuan Islands*] (Wallace 1869)

Because of its ecological richness and large tracts of primary rainforest, Beehler (1985) proposed a 4 x 8 kilometre reserve in the Mount Kilkerran area of Fergusson Island as part of a network for the protection of rare New Guinea birds and, in particular, for the Goldie's Bird of Paradise, the curl-crested manucode, and the trumpetbird. He noted that,

"More space, and greater expanses of undisturbed forest are needed to support 'extinction-proof' populations."

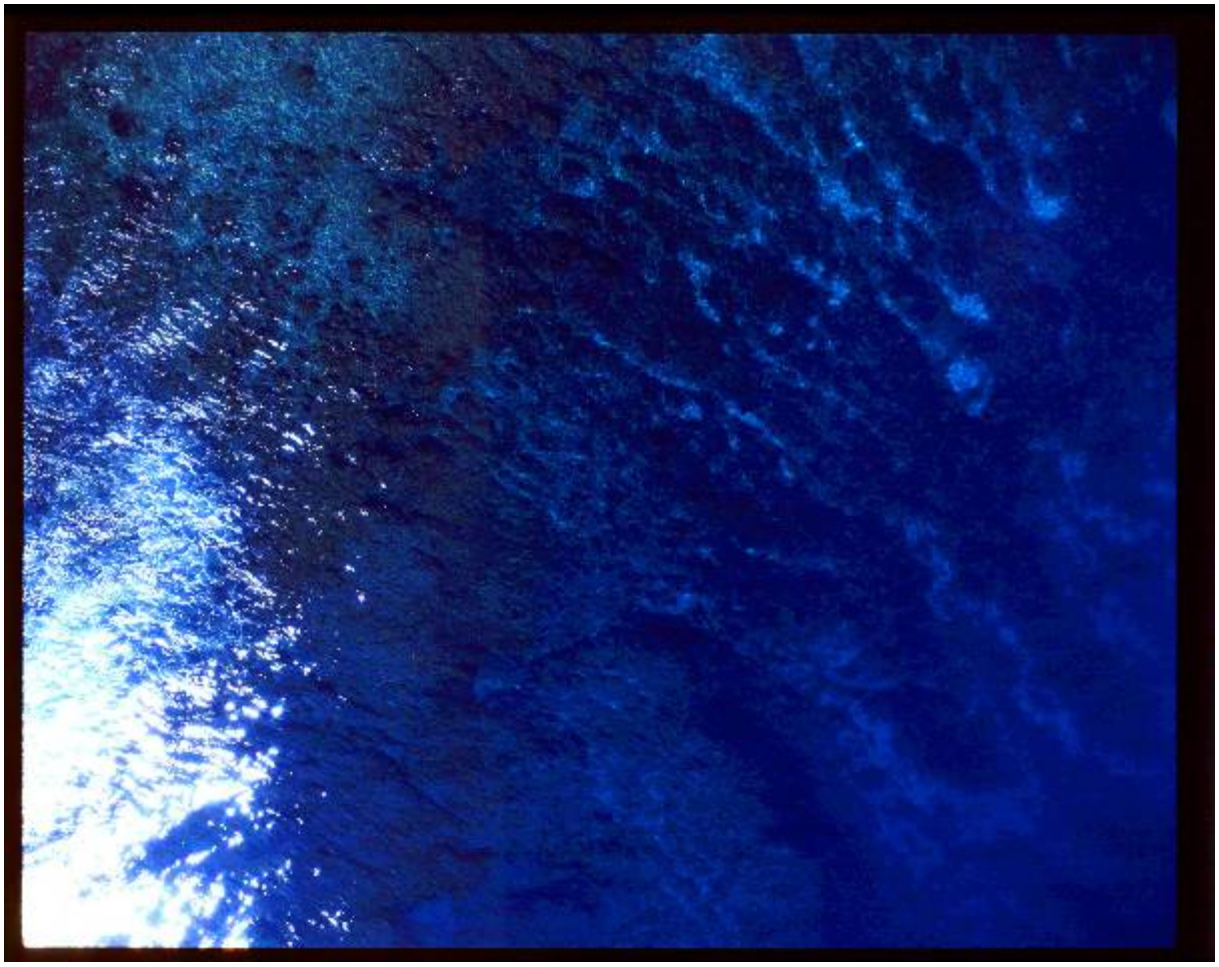
Logging began on Fergusson Island in 1987 with little environmental planning or recognition of sensitive biota and habitat. Mineral exploration began in the same period and a gold mine has been proposed for the northwest coast of the island.

The situation on Fergusson Island would, at first, seem optimal for development of habitat conservation programmes which are compatible with the needs of indigenous people. Land is held by local household units, the subsistence economy is still viable, there is reliance on a wide array of wild species, population pressures are still low and political power is decentralized. There is even a locally initiated wildlife management area. But in this favourable context, it has been possible, still, for foreign logging operations to establish without any kind of comprehensive land use plan, without any decisions on habitat protection nor mechanisms for channelling economic benefits back to the local community.

There is not a popular sense of the loss of biological diversity because people have no frame of reference for this having ever happened. There is little anticipation of the externalization of environmental costs from logging and mining companies on to local people because these communities have limited class formations and the other people with whom they have had contact have been mainly similar, neighbouring groups and missionaries. There is a deep mistrust between the different language groups of the island which impedes the political cohesion which is necessary to make counter-proposals for more sustainable development as well as for conservation.

The D'Entrecasteaux Islands lie off the south-eastern peninsula of New Guinea comprise an area of 1340 square kilometres of land with elevations which rise to 1830 metres and lie between 9°S and 150°E, 9° S and 151° E, 9°30’ S and 151°E, 9°30’S and 151°30’ E, and 10°30’S and 151°30’E. Fergusson Island is the largest island in the D'Entrecasteaux Archipelago and one of the largest islands off of eastern New Guinea. Fergusson island has an area of 1340 square kilometres with elevations which rise to 1830 metres and lies between 9°18’S and 150°23’E in the north-west, 9°22’S and 150°58’E in the north-east, 9°45’S and 151° E in the south-east, and 9°40’S and 150°25’E in the north-east.

In his review of the protected areas and needs for additional habitat conservation in Oceania, Dahl (IUCN/UNEP 1986) lists Fergusson Island as as a priority island ecosystem for conservation after New Guinea, itself, New Britain, adjacent Goodenough (Morata) and Bougainville. The same study rates Fergusson Island as the 22nd island and the 17th volcanic island and the 10th island with altitudes over 400 metres, in Oceania, in "conservation importance." Fergusson Island was given a low rating of human impact on natural ecosystems and is one of the few large islands so little disturbed to remain in Oceania. This island is particularly important as it has or rather had one of the most pristine mosaics of primary rainforest, on a relatively large, mountainous island, of anywhere in the world.



coral reef and sea grass beds between Fergusson and Normanby Islands, March 1989, photograph by Gordon Brent Ingram

The bioregion: The D'Entrecasteaux Archipelago

Within the D'Entrecasteaux Islands archipelago, there are three large islands: Fergusson, Normanby and Goodenough along with a number of small, low islands such as Dobu. The D'Entrecasteaux Islands are highly diverse, geologically, and are most remarkable for the dormant volcanism on Fergusson and Goodenough Islands. Outside of the volcanic areas, are metamorphic materials of undetermined age.

There are divergent conclusions on the geological history of the D'Entrecasteaux group. The islands may have been connected to the Australasian mainland and may simply be "a line of granite intrusions that would line up with the line of intrusions along the mountains axis" of New Guinea (Cliff Ollier personal communication[3]). In a contrasting perspective, the work of Pigram and Davies (1987) suggests that the islands may be part of "amalgamation formed composite terranes" from "sites in ocean basins far removed from the edge of the Australian craton" which have recently collided with the continental land mass. Pilgram (1988) elaborated in stating that,

"The rocks that make up these islands owe their presences to two major events. The first was the docking of the East Papuan Composite terrane about 2 - 3 millions years ago as a consequence of uplift and doming caused by extension related to the opening of the Woodlark

Basin. The islands are separated from the mainland by a large half graben that formed a depocentre from the Late Miocene. I therefore consider it unlikely that the islands and the mainland were ever connected. The most likely time for a land connection would have been during a major sea level lowstand in the Quaternary."

By contrast, Wood (1981) suggested that the island have been connected to the mainland as late as the Pleistocene. Based on nautical charts, Diamond (1986 page 495 and 1987 personal communication) suggested that the D'Entrecasteaux Islands were probably never closer than 800 metres to the mainland of Australasia. The D'Entrecasteaux Archipelago has been one land mass at various points. Much of the D'Entrecasteaux Island are uplifting. However, there has been relatively rapid subsidence in some of the southern, shore areas.

The dominant soils in the D'Entrecasteaux group are inceptisols, particularly eurtandepts and dystrandepts. These soils occur up to elevations of 1500 metres and are often on the moderate slopes. There are also entosols, particularly tropofluvents, on the north coasts of Fergusson and Goodenough. All of the D'Entrecasteaux area is classified as "moderate" under the Universal Soil Loss equation (Bleeker 1983).

The D'Entrecasteaux archipelago is remarkable, even within the region, for its moderate seasonal range of temperatures and precipitation. The mean maximum temperature at sea level in January is from 30°C to 32°C and in July is 24°C to 28°C. The Koppen system classifies all of the D'Entrecasteaux group *tropical rainy - no dry season*. This is in contrast to the adjacent mainland of New Guinea, directly south, which is classified as *tropical rainy - short dry season.*

The islands are classified by McAlpine and Keig (1983) as having moderate seasonality and a rainfall regimen which is "continuously heavy." Soil moisture deficiencies, except in a few shore as on the southern side of the islands, are rare. Humidity in January is >90% and in July is 85-90%. There are strong winds, from the southwest, from May through September.

New Guinea is placed in the Indo-Malesian region for flora and the Australasian region for vertebrates. Much of the flora of Gondwanaland, of which Papua New Guinea is a part, was temperate and was decimated as New Guinea pushed into the tropics 25 million years ago. Asian tropical rainforest and temperate flora invaded as the Australasian plate neared the Sahul shelf. The older New Guinea flora persisted in drier areas and in the mountains (van Balgooy 1976). The forests of New Guinea are generally as rich in plant species as those of the mixed dipterocarp forests of the Sunda Shelf islands.

The Pacific Ocean coast of New Guinea is on the eastern fringe of one of the world's most diverse marine biota, particularly in terms of coral species (Vernon 1986). The reefs of the D'Entrecasteax Islands have not been inventoried but may well represent a contact point between central Pacific, marine biota of a highly insular character and more continental, Australasian species.

The vegetation of the D'Entrecasteaux Islands has been transformed at a number of times by climatic fluctuations. Between 30,000 and 12,000 years before present, conditions were more arid and large portions of what is today rainforest were dry forest and savannah. Lowland rainforest became the dominant physiognomic type in southern New Guinea, including the

D'Entrecasteaux Islands, only 8,500 to 5,000 before present. It was at the end of this period, that human-induced vegetation change, related to burning, became evident (van Balgooy 1976). The remarkable diversity of the region "may be attributed to survival in New Guinea of older groups which have become extinct or relictual on the continent" [of Australia] (Pratt 1981). There has been a biogeographical "confrontation" (Beehler 1981) between Australian and New Guinean species, due to the cool/dry and hot/humid climatic fluctuations, which has allowed for a great mix of biotic elements. As with other Australasian islands, there is an exceptionally high level of diversity of bird species (Mayr 1941, Beehler 1986). Beehler (1985) notes that,

"Of New Guinea's 570 species of nonmarine breeding birds, 445 dwell in rainforest...The source of richness of New Guinea's avifauna is primarily Australia and only secondarily Asia."

The foothill forests of New Guinea, up to 500 metres, may have some of the greatest levels of avifaunal diversity outside of the Amazon Basin and the south-east Asian mainland (Bell 1984). In addition, frugivores from the lowlands can survive up to 1500 metres elevation. The areas with higher and more consistent rainfall, with relatively high temperatures, encourage a high and reliable source of arthropods. A substantial portion of the area of Fergusson Island is in this elevational band. And it is these areas which are under increasing pressures for logging, mining and expansion of gardens.

While New Guinea is something of an enriched zone of overlap for avifaunas there are only four orders of native mammals: Monotremata, Marsupialia, Rodentia and Chiroptera (Laurie 1952). The D'Entrecasteaux archipelago is distinctive, ecologically, because of the large number of niches, which are usually occupied by mammals, which instead are dominated by birds.

The paleoecological implications of the evolution of the endemic *Rattus* species are intriguing but inconclusive. Taylor et al. (1983) suggest a strategy where in the Pleistocene the mammals evolved on an archipelago less fragmented and closer to the New Guinea mainland. Conditions were less humid and there was probably colonization by Australian savannah species.

In his review of the distribution of bat species in the region, Koopman (1982) noted that,

"the East Papuan peninsula bat fauna is largely a depauperate sample of the main New Guinea fauna and the East Papuan island bat fauna largely a depauperate sample of the East Papuan peninsula bat fauna."

To complicate the uniqueness of the conservation setting on Fergusson Island, review by Diamond (personal communication) suggests that the biogeography of the islands is more similar to New Guinea islands which were never connected to the New Guinea mainland. Both Fergusson and Goodenough have avifaunas which may have declined (Diamond 1972) from landscape fragmentation since the breakup of the single D'Entrecasteaux land mass in the late Pleistocene but which are still "supersaturated" with bird species.

"Thus, the avifauna of Fergusson has decayed, by an excess of extinction over immigration from the 108 species it presumably supported when it was part of a larger island, but has not yet decayed to the equilibrium values for its contracted post-Pleistocene size." (Diamond 1972)

But in a contrasting perspective, Simberloff and Abele (1976) suggested that the total number of species, which might be able to occupy such a fractionated area, could actually increase. Both processes may be occurring, simultaneously, as certain species disappear from fragmentation while others become established through the expanded terrestrial / marine niches. An alternative explanation for the distinctness of D'Entrecasteaux biota from that of the mainland can be derived from the climatic shifts over the last 10,000 years (Beehler et al. 1988, page 21) and, to a lesser degree, the much longer period of volcanism. The D'Entrecasteaux Islands may have been a peninsula of New Guinea but, biologically, an "island" of drier, seasonal forest and savannah.

The lowland rainforest probably only became established over the last 10,000 years with the considerably older mountain forests evolving more like oceanic islands. The more recent, lowland forest would have acted like a land bridge to these older areas with island endemism. But roughly at the same time that this lowland forest began to be established, the islands began to breakup and the links may have always been tenuous. The remarkable diversity of the D'Entrecasteaux Islands is derived less from their large stands of insular rainforest than rather from the dynamic between these habitats and the drier savannah biota.

Human societies

The prehistory of these islands is poorly known. Human presence in the area may well extend beyond 50,000 years. The area is notable for its highly diverse set of language groups and social structures. There are both matrilineal and patrilineal societies. There was and continues to be a distinctive system of trading and intra-village contact called the Kula which extended north to the Trobriand Islands and to the Woodlark Basin (Malinowski 1922).

The first European presence in the D'Entrecasteaux Islands was in 1793. There was sporadic missionary and trading contact in the Nineteenth Century. The British took official control of the area in 1884. The first missionary settlement was at Dobu in 1891. It was Methodist and later become the United Church of Christ. The Roman Catholic Church is now active in the area as are a number of smaller Protestant groups.

Normanby Island looking south from Fergusson Island, March 1989, photograph by Gordon Brent Ingram

Fergusson Island as a biotic district within the D'Entrecasteaux Islands

The islands of Fergusson and Dobu, with a few off-shore islands[4], are treated as a biotic district on the basis of: geology, landforms and biogeography. Goodenough and Fergusson Islands are separated by a fault line. Fergusson and all but the northern tip of Normanby Island are separated by another fault (Ollier and Pain 1980) and it is probably here that part of one of the Pacific plates, to the north, abuts the Australian Plate. The fragmentation of the D'Entrecasteaux land mass, though relatively recent, has created at least five different contexts for habitat conservation of which Fergusson and Dobu comprise one area.

There are some key differences in biotic composition between the three largest islands in the D'Entrecasteaux Islands which have been most explored, so far, through the bird lists (Lecroy et al. 1983). I have treated Sanaroa and Tewana Islands, to the east of Fergusson Island, as a separate biotic district as the conditions there are more similar to the Amphlett Group to the north. These two biotic districts are more oceanic in nature and unfortunately have already been heavily degraded by intensive gardening on relatively dry slopes.

The marine boundaries of this biotic district are less discrete. The 20 fathom line is a convenient boundary and when these extend to other terrestrial areas, boundaries can be tentatively set through equidistance. Where there are reef formations which extend below 20 fathoms but which are closer to Dobu and Fergusson than to the other larger, D'Entrecasteaux

Islands, these reefs are also included in the Fergusson Island biotic district. Unfortunately, the marine depths in the area are poorly known (Defense Mapping Center 1974).

Biophysical variation within the Fergusson Island biotic district

Geology and geomorphology

Goodenough and Fergusson Island "consist largely of gneiss domes intruded by granites" (Pain et al. 1981). There are two large gneiss domes on Fergusson: the Morima-Oitabu comprises much of the central portion of the island while the Mailolo occurs over the northwestern area of the island (Ollier and Pain 1980, 1981). In the centre of Fergusson Island is a large block of Omara Granodiorite which underlies the Morima-Oitabu gneiss dome. This is relatively youthful, Pliocene granite with an active tectonic position and a remarkable rate of uplift (at a rate 1.5 m per 1,000 years). There are high rates of erosion which roughly equal that of the uplift. It has been suggested that Fergusson Island has one of the rare "steady state" landscapes.

There are two volcanic cones on the island, Oiau or Deidei and Lamonai, and two areas of geothermal activity, Deidei (Mackay 1976) and Iamelele / Fagalulu. There are "well-preserved strato volcanoes" (Loffler 1977) and while there have been no eruptions in historical times, they may still be active. The lowlands on the northern side of the island are alluvial in origin. Gold sediments are found around the Salakadi and Basima areas (Davies and Ives 1965).

There are several rivers draining the central portions of the island notably the Salamo in the south, the Ato Ato and the Bunai River in the north and the Asapoi to the east. There are numerous streams coming off the steep slopes directly to the sea. There is only one large lake, Lake Lavu, which is in the swampy, central part of the island.

Climate

The only climate data for Fergusson Island is taken at Salamo. Based on limited recording in the 1950s, Brass (1959) noted total annual rainfall as 2,570 millimetres with the month with the highest rainfall being June and the lowest being February. Other parts of Fergusson, particularly at higher elevations, receive well over 3,500 mm of rainfall. The higher elevations of the mountains are sub-tropical and temperate in character though there is no indication of frosts.

There are drier pockets at lower elevations probably because of orographic uplift along the shore. Both the southwest and southeast of Fergusson as well as Dobu is considerably drier than the slopes of the steep mountains

Soil

Virtually, all of the soils of Fergusson and Dobu are latosols and related brown soils which are associated with hill and mountainous terrain (Wood 1981).

Vegetation

In their reconnaissance of Fergusson and Goodenough Islands, Davies and Ives (1965) noted five different physiognomic types of vegetation:

- rainforest,
- grassland,
- secondary forest,
- alpine grassland on the highest elevations of Goodenough, and
- mosaics of open forest and Eucalypt savannah with grassland.

There are isolated patches of oaks and conifers on the highest elevations of Fergusson Island.

The crude map of the vegetation of Papua New Guinea by Paijmans (1975) indicates that Fergusson Island has a number of the following categories of vegetation plus a number of others.

1. *FHs* - Small-crowned lowland hill forest - The forest is either mixed or poorly developed, due to adverse conditions of climate and soils, or is dominated by one tree species which is naturally small-crowned. There are some pure stands of *Casurina* spp. and *Hopea* spp. There are a number of areas on the south side of the island of a mixture of the dominant forest type and grassland which are "largely man-made and maintained by burning."

2. There are bands of *FL* - Lower montane forest in the mountains above 1400 metres. The forest is small-crowned, dense and the height and girth of trees decreases with altitude. A number of trees have temperate affinities such as *Araucaria cunninghamii* as well as the oaks.

3. In the lowlands, west of where the logging operations were begun at Sebutuia Bay, is a pocket of *FHS* - small-crowned trees on plains and fans. There is gently undulating to flat and locally swampy terrain with soils often stony or gravelly. The forest is dense but with a thin-stemmed canopy of over 25 metres in height and is dominated by dipterocarps and *Intsia* spp., *Casuarina* spp. and *Campnosperma* spp.

4. There is a dry, hill scrub on the slopes of the southern volcanoes. This is a vestigial Eucalyptus community which has been modified by human-ignited fire.

5. Ther are extensive areas of freshwater swamp around Lake Lavu.

6. There are pockets of mangrove around Fergusson Island.

Cultures

Fergusson Island supports a diversity of human cultures and one indication of this is the extraordinary number of languages. As well as the Dobu language, which became the *linga franca* of the area[5] with its favouring by the missionaries at Salamo (Lithgow and Staalsen 1965), the following languages are spoken on various parts of the island and involve less than 50 % shared cognates (L. Lovell personal communication 1989): Morima, Kalokolo, Salakedi, Minaveha, Iaupolo, Galea, Basima and Maiodom.

It was not until 1920 that the Galia and Ebadidi tribes, in the interior of Fergusson Island, were pacified. A hospital at Salamo was opened by the United Church of Christ in 1925. A police post was established in Mapamoiwa in 1927. In the pre-World War II period, there were also sporadic cargo cults centred at Basima. The World War II review of Fergusson Island (Allied Forces Southwest Pacific Area 1942) lamented that,

"In the North-West of the island, there are some people quite uncivilized and ungoverned."

The island may have had highly variable population densities. In one of the few records from the Nineteenth Century, Moresby (1876) noted that there was no habitation on the northern side of Fergusson Island and little fish. He suggested that this was because of undersea hotsprings though such widespread depopulation if such was really the case was more likely due to warfare. Until local conflicts subsided, early in the Twentieth Century, population densities were highest in the foothills in areas least vulnerable to raids.The many small villages, which are now in the lowland areas, are mostly less than a century old.

The 1980 census (Papua New Guinea Bureau of Statistics 1981) gave a total population for Fergusson Island of 14,587. The population of the island 38 years before was thought to have been 10,000 (Allied Force Southwest Pacific Area 1942). This rate of population growth is low especially for developing countries but may be gradually increasing. Through improved medical care, infant mortality is declining and life expectancy is increasing. Informal, council sources suggest that the population of Dobu is roughly 2,000 though many residents live away from the island for much of the year.

primary lowland forest below with a recent clearing for swidden agriculture in the distance, south central Fergusson Is, March 1989, photograph by Gordon Brent Ingram (small)

A framework for designing and managing protected habitat for the preservation of the biological diversity of Fergusson Island: Focal species

Review of the data

The list of the vertebrates of the island is largely based on the Rothschild bird expeditions of Fergusson and Goodenough Islands (Rothschild and Hartert 1896 and 1914) and the Fourth and Fifth Archbold Expeditions of 1953 and 1956-1957 (Brass 1959). The first collecting of mammals was in the late nineteenth century with 12 species initially identified (Thomas 1895). Before the Fifth Archbold Expedition, the island was "virtually unknown botanically" (Brass 1959) though subsequently there has been collecting by the National Herbarium in Lae.
The most extensive biological and broader environmental research in the area has been on the avifauna (Frith 1979). A list was compiled by Lecroy (et al. 1983), based on 1978 and 1979 field work in the area. Diamond (1987) compiled a list of bird sightings in the area as based on the literature.

There are, therefore, some severe gaps in the knowledge of the biota of Fergusson Island. Most of the endemic plants have neither been collected nor identified. Virtually nothing is known on the endemic invertebrates including the corals and the butterflies. Zweifel (personal communication 1987) noted that his list of the frogs and reptiles of the D'Entrecasteaux Islands probably only includes about half of those species present. And even the list of mammals is probably not complete especially for the bats though Koopman (1982) did make a thorough review of the literature. Such a poor state of knowledge makes the utility of focal taxa, as conservation planning techniques, at best, marginal. Yet, even with these limitations, it is still possible to compile a compelling and somewhat diverse list of species.

Local criteria for identification of focal taxa

A "course mesh" approach to choice of species must be pursued especially for plants. If only because of the slightly greater pool of data on birds, and their extraordinary diversity on the island, this group becomes the metaphorical indicators for most assemblages of forest organisms. But this is risky especially for the survival on non-avian endemics and freshwater organisms. And information on endemism in some groups, such as butterflies and fish (Munro 1967) is lacking for the D'Entrecasteaux Islands.

The exploited species are problematic, here. The area has been heavily serviced by missions over the last century and traditional plant use, such as for medicinal species, has declined. In contrast to the two previous island case studies, the anthropological research has tended to focus on social structures and at the expense of ethnobiology.

There has been such unsustainable commercial exploitation of wild species, beginning with the birds of paradise, and extending to the current logging, of the modest and easily exhaustable pockets of dipterocarp forest, that this category is barely employed. The genetic resource category is similarly limited by the small number of gene-pools, principally of citrus, mango and possibly cane, which have been recognized from the region.

Representative species

Marine ecosystems

Some types of "indicator organisms" (Gomez and Yap 1984) for coral reefs such as dominant coral species have yet to be identified and fish which are obligate coral predators have yet to be identified. The giant clam, *Tridacna* sp. (Roswater 1965), is a partial indicator of deeper communities within coral reefs. The dugong, *Dugong dugon*, is dependent upon sea-grass beds and is therefore a reliable indicator of the grazing food web (Heinsohn et al. 1986) of this community type.

Terrestrial / marine interface

The two major zones of the mangrove communities are dominated by *Rhizophora* spp. and *Bruguiera* spp. respectively. The Brahminy kite, *Haliastur indus*, may be a viable indicator for a range of shore ecosystems especially those involving mangroves.

Marine / estuarine interface

There is also a tidal stream community dominated by *Nypa fruticans* (Percival and Womersley 1975). The saltwater crocodile, *Crocodylus porosus*, may have some utility as an animal indicator of the integrity of the mouth of rivers and adjacent swamps.

Freshwater ecosystems

The freshwater crocodile, *Crocodylus novaeguineae*, may have some utility for indicating the maintenance of a range of lake and stream conditions. Similarly, the requirements of the rare, Great-billed heron, *lulumoio* (Ebadidi), *Ardea sumatrana*, (Lecroy et al. 1983) might be a viable representation of a range of stream and lake conditions.

Terrestrial communities

FHS - small-crowned trees on plains and fans - These communities have various dominants including a number of poorly identified dipterocarp species, as well as *Intsia* sp., *Casuarina* sp. and *Campnosperma* sp.

sclerophyll scrub - These drier areas can be represented by the dominant eucalypt species.

FHs - small-crowned lowland hill forest - There are a series of pure stands of *Casurina* sp., *Castanopsis* sp. and *Hopea* sp. and these are reliable dominants. However, the dominants of more mixed forest have not yet been determined.

FL - lower montane forest - There are pockets of the relatively rare conifer, *Araucaria cunninghamii* and some oak species which extend to the lower elevations. These are representative of some rarer types of lower montane forest.However, the dominants of the more mixed forest types have not yet been determined. There is a type of forest in the upper elevations of the hill forest which can be termed, cloud forest, and one of the dominants is a *Castanopsis* sp.

Keystone mutualists and mobile links

Certainly all of the larger *Ficus* spp., though not yet identified should be considered keystone mutualists. Other mutualists have not yet been identified.

A key group of mobile links, which are particularly sensitive to regional environmental change, are nomadic fruit-eating birds – especially bird species that migrate closer to the ground rather than fly long distances. These species require a number of different habitat types over wide environmental and ecological gradients. Their survival would be a significant indicator of the conservation of district-wide mosaics particularly in the highly diverse foothill forests. Three such species are the
pink-spotted fruit dove, *Ptilinopus perlatus*;
Nicobar pigeon, *Caloenas nicobarica*;
and the Pied imperial pigeon, *Ducula bicolor*.
Perhaps less sensitive but just as much mobile links are the other pigeons,
Ducula pinon and *D. zoeae*,
and the other fruit doves, *Ptilinopus viridis*, P. *aurantifrons*, and P. *superbus*.

The following species of fruit bats have been recorded on the island (Koopman 1982):
flying fox, *Pteropus hypomelanus*;
Dobsonia pannietensis pannietensis (syn. D. *moluccensis*)*;
Nyctimene major (syn. N. *geminus*);
Macroglossus lagochilus;
Syconycteris australis (syn. S. *crassa crassa*)*;
leaf-nosed bat, *Hipposideros galeritus*;

*Pipistrellus tenuis**;
Chalinolobus nigrogriseus;
Kerivoula (Kerivoula) agnella; and
free-tailed bat, *Tadarida (Mormopterus) beccarii*.
Some of these bat species have been recorded from above 1,000 metres and may be useful for representing montane diversity especially *Dobsonia pannietensis pannietensis* (syn. D. *moluccensis*), *Syconycteris australis* (syn. S. *crassa crassa*), and *Pipistrellus tenuis.*

The arboreal marsupial, *Dactylopsila tatei*, is a mobile link which is thought to spread the seeds of large, fruit-bearing forest trees. The black Dorcopsis wallaby, *Dorcopsis atrata*, is thought by local informants to be dependent on the fruit of a fig (*Ficus* spp.). There are birds which are primarily nectarivores such as the eastern black-capped lory, *Lorius hypoinochrous* (syn. *Domicella hypoinochrous*).

High level predators

The freshwater crocodile, *Crocodylus novaeguineae*, is near the apex of the food chain in river, lake and swamp areas (Whitaker and Mills 1982). The saltwater crocodile, *Crocodylus porosus*, has a similar position in estuarine ecosystems. The forest and shore-dwelling birds of prey recorded for the area include:
crested hawk, *Aviceda subscristata*;
black kite, *Milvus migrans*;
Brahminy kite, *Haliastur indus*;
white-breasted sea eagle, *Haliaeetus leucogaster*;
New Guinea grey-headed goshawk, *Accipiter poliocephalus pallidimas*;
variable goshawk, *Accipiter novaehollandiae pallidimus*;
Gurney's eagle, *Aquila gurneyi*; and
Peregrine falcon, *Falco peregrinus*.

There are as least two large pythons on Fergusson Island and these are key terrestrial predators: Papuan python, *Liasus albertisii*, and Amethystines python, *Python amethistinus* (Whitacker et al. 1982).

Vulnerable species

In his study of avifauna compositions on the New Guinea island of Karkau, Diamond (1971) listed categories of species rarity. He linked these attributes to vulnerability to extinction on continental islands especially the following:

1. narrow habitat requirements;
2. large-sized territory;
3. tendencies to be unsuccessful competitors; and
4. species in only marginally suitable habitat.

For this study, the criteria for vulnerability for all species have been expanded beyond that of simple rarity to include:

1. large-sized, widespread species;
2. species with small geographic ranges;
3. species which are hunted;
4. habitat specialists; and
5. inexplicably rare species (Beehler 1981).

Species vulnerable because of endemism or rarity

There is not sufficient information available on amphibians in the D'Entrecasteaux Islands to identify endemic species (Menzies 1976). The skink, *Emoia tetrataenia*, may be endemic to Fergusson Island. The population of the freshwater crocodile, *Crocodylus novaeguineae*, is the only one which occurs on an off-shore island and is therefore rare and might comprise a separate subspecies. One of the three sea turtles in the area is relatively rare: Hawksbill turtle, *Eretmochelys imbricata*.

Two groups of birds were suggested by Diamond (1987) on the basis of endemism:"the two species of birds of paradise endemic to Fergusson and one or more other southeastern island" which comprise the following three species:
curl-crested manucode, *Manucodia comrii*;
trumpet manucode, *Manucodia keraudrenii*; and
Goldie's bird of paradise, *Paradisaea decora*,

and "subspecies endemic to Fergusson alone...or to Fergusson plus other southeast islands" which are the following species:
variable goshawk, *Accipiter novaehollandiae pallidimus*;
pheasant pigeon, *Otidiphaps nobilis insularis*;
red-breasted fruit dove, *Ptilinopus viridis vicinus*;
double-eyed fig parrot, *Opopsitta diophthalma virago* (syn. *Cyclopsitta* d. v.);
buff-faced pygmy parrot, *Micropsitta pusio harteri*;
Papuan boobook, owl, *Ninox theomacha goldii*;
barred owlet nightjar, *Aegotheles cristatus* cf. A. *bennettii*;
yellow-billed kingfisher, *Halcyon torotoro ochracea*;
blue-breasted pitta, *Pitta erythrogaster finschii*;
varied triller, *Lalage leucomela*;
grey-headed cuckoo-shrike, *Coracina schisticeps vittata*;
large-billed gerygone, *Gerygone magnirostris proxima*;
golden whistler, *Pachycephala pectoralis fergussonis*;
little shrike-thrush, *Colluricincla megarhyncha fortis*; and
Papuan black myzomela, *Myzomela nigrita forbesi*.

There are also particularly rare birds, such as the Great-billed heron, *Ardea sumatrana*, and the Gurney's eagle, *Aquila gurneyi*, which are recorded on Fergusson Island though only are present sporadically. The biogeography and taxonomy of the mammals of the D'Entrecasteaux Islands is far from complete. There are gaps in taxonomic treatments and in collecting.

The taxonomy of New Guinean rodents is far from complete (Menzies and Dennis 1979). The Mayer collections (Laurie 1952) suggests that a species of prehensile tree rat, *Pogonomys fergussoniensis*, (syn. P. *loriae fergussoniensis*) is endemic to Fergusson Island and, so too, is the "*Pteropus* sp." (page 312, Laurie) cf. *Pteropus hypomelanus*. One of the two native rats, Rattus mordax fergussoniensis is endemic to Fergusson, Goodenough and Normanby Islands (Taylor et al. 1982).

There is a arboreal marsupial, *Dactylopsila tatei*, endemic to Fergusson Island (Tyler 1979, Honacki et al. 1982). The black Dorcopsis wallaby, *kelei*, *evaga* (Ebididi), *Dorcopsis atrata* (van Deusen 1957), is one of the rarest and considered one of the most endangered marsupials

(Tayler 1979). This wallaby is confined to small portions of Goodenough (IUCN / UNEP 1989) and Fergusson Islands.

A number of mainland bat species were identified by Koopman (1982) as being restricted in the D'Entrecasteaux Islands to Fergusson Island:
Macroglossus lagochilus;
Chalinolobus nigrogriseus; and
Tadarida beccarii.

There may well be active bat speciation going in the D'Entrecasteaux group. Based on the small number of recordings both the *Chalinolobus* species and the *Kerivoula (Kerivoula) agnella* can also be considered rare.

Plants with limited dispersal capabilities
There has been insufficient botanical surveying in the area to identify the plants with the most limited powers of dispersal.

K-selected species
The size and reproductive requirements of the giant clam, *Tridacna* sp., such K-selection attributes (Yamaguchi 1977). There are social and physiological aspects of the *Dugong dugon* which require maintenance of stationary populations with relatively high rates of reproduction and low rates of adult mortality (Marsh et al. 1984). The freshwater crocodile, *Crocodylus novaeguineae*, and the saltwater crocodile, *Crocodylus porosus*, have also some K-selection characteristics as so do the large snakes, the Amethystines python, *Python amethistinus*, and the Papuan python, *Liasus albertisii*. The three species of sea turtles, the Hawksbill turtle, *Eretmochelys imbricata*; leatherback turtle, *Dermochelys coriacea* (Spring 1981); and green turtle, *Chelonia mydas*.

Species vulnerable to the impacts of logging, mining and related operations
The reptiles and amphibians of Fergusson Island are sometimes vulnerable to the indirect impacts of forest clearing (Zweifel 1987, personal communication) in two ways. The first is through alteration of the hydrological mosaic. Secondly, there is vulnerability to increased rates of siltation from soil erosion. Unfortunately, there is insufficient data to identify these species.

On Fergusson Island, there are a number of bird "species of the forest interior...whose habitat disappears with logging" (Diamond 1987):
blue-breasted pitta, *Pitta erythrogaster finschii*;
common golden whistler, *Pachycephala pectoralis*;
little shrike thrush, *Colluricincla megarhyncha*;
grey crow, *Corvus tristis*;
Papuan black myzomela, *Myzomela nigrita forbesi*;
dwarf honey-eater, *Toxorhamphus ilioliphus* (syn. *Oedistoma iliolophus*);
tawny-breasted honey-eater, *Meliphaga flavescens* (syn. *Xanthotis flaviventer*); and
puff-backed honey-eater, *Meliphaga aruensis*.
Goldie's bird of paradise, *Paradisaea decora*, also requires edges of relatively mature forest for display (Lecroy 1981, Lecroy et al. 1980, personal observations with Kalupi 1989).

There are number of ground-dwelling, fruit-eating birds which are vulnerable to disturbance of the forest floor and the removal of fruit producing, canopy trees:
Papuan black myzomela, *Myzomela nigrita forbesi*;
Nicobar pigeon, *Caloenas nicobarica*;
blue-breasted pitta, *Pitta erythrogaster finschii*;
scrubfowl, *Megapodius freycinet*; and
pheasant pigeon, *Otidiphaps nobilis insularis*.

There are a number of cavity nesting birds which require large, old trees for nesting and these species include:
tawny-breasted honey-eater, *Meliphaga flavescens*;
Blyth's hornbill, *Aceros plicatus*;
sulphur-crested cockatoo, *Cacatua galerita*;
eclectus parrot, *Larius roratus*;
Goldie's bird of paradise, *Paradisaea decora*;
buff-faced pygmy parrot, *Micropsitta pusio harteri*;
Papuan boobook, *Ninox theomacha goldii*;
barred owlet nightjar, *Aegotheles cristatus*; and
yellow-billed kingfisher, *Halcyon torotoro ochracea.*

The cuscus, *Phalanger orientalis intercastellanus* (Laurie and Hill 1954), and the arboreal marsupial, *Dactylopsila tatei* are cavity nesting in large trees associated with primary forest. There are a number of bird species which are only associated with primary forest and large tracts of disturbed forest probably involve psychological barriers which in turn intensifies the influence of fragmentation:
golden whistler, *Pachycephala pectoralis fergussonis*;
little shrike-thrush, *Colluricincla megarhyncha fortis*;
Papuan black myzomela, *Myzomela nigrita forbesi*;
pink-spotted fruit dove, *Ptilinopus perlatus*;
blue-breasted pitta, *Pitta erythrogaster finschii*;
grey crow, *Corvus tristis*;
dwarf honey-eater, *Toxorhamphus ilioliphus*;
tawny-breasted honey-eater, *Meliphaga flavescens*;
Blyth's hornbill, *Aceros plicatus*;
sulphur-crested cockatoo, *Cacatua galerita*;
eastern black-capped lory, *Lorius hypoinochrous*;
trumpet manucode, *Manucodia keraudrenii*;
Goldie's bird of paradise, *Paradisaea decora*; and
pheasant pigeon, *Otidiphaps nobilis insularis*.

On the reefs, there are corals which are vulnerable to suffocation and related maladies as an indirect result of sedimentation from logging. Their physical forms accumulate sediment, and these species are therefore vulnerable. Unfortunately, the species have yet to be identified in terms of Latin binomial labels. The giant clam is also vulnerable to accumulation of sedimentation.

Species vulnerable as targets for hunting and over-exploitation

The giant clam, *Tridacna* sp., is very attractive for harvesting by both local people and foreign operations. The coming of guns has contributed to the vulnerability of some species, particularly birds. In his notes on Fergusson Islands, Diamond (1987) suggested that "big edible birds that are prime targets of shotguns" be included as focal species and listed the following:
black-shouldered fruit pigeon, *Ducula pinon*;
fruit pigeon, *Ducula zoeae*;
pheasant pigeon, *Otidiphaps nobilis*;
Blyth's hornbill, *Aceros plicatus*, (syn. *Rhyticeros* p.); and
scrubfowl, *Megapodius freycinet*.

Species vulnerable through illegal trafficking

All of the sea turtles,
Hawksbill turtle, *Eretmochelys imbricata*;
leatherback turtle, *Dermochelys coriacea*; and
green turtle, *Chelonia mydas*,
are hunted locally and by foreigners and a portion of this is illegally exported. All of the parrots, on the island, be considered vulnerable because of illegal international trade (Diamond 1987) and include:
eastern black-capped lory, *Lorius hypoinochrous*;
double-eyed fig parrot, *Opopsitta diophthalma virago*;
buff-faced pygmy parrot, *Micropsitta pusio harteri*;
sulphur-crested cockatoo, *Cacatua galerita*; and
eclectus parrot, *Larius roratus*.

Exploited species:
Wild species which
have been traditionally utilized by the peoples of the D'Entrecasteaux Islands

The important traditional, local wild food plants include:
the two species of sago, *Metroxylon sagu*, M. *rumphii*;
chestnuts, *ike*;
curry berry, *saido*;
and four species of edible fern, *boboiwa*, *beluwai*, *enoenososo* and *mawgwamawgwa*.

As for sources of animal protein, the giant clam, *Tridacna* sp. and the local oyster species are exploited as regular food sources. The major fish and shellfish species which are exploited in the freshwaters and marine areas of Fergusson Island have not been identified.

There is a rather large freshwater eel, *esipo*, *aefo* (Ebididi), which is fished as a food source in some of the larger streams and in the lake. The freshwater crocodile of Lake Lavu, *Crocodylus novaeguineae*, continues to be exploited and managed for food and skins as is the saltwater crocodile, *waligowa*, *Crocodylus porosus*, though to a lesser degree. All three of the sea turtles, *tameyle*, Hawksbill turtle, *Eretmochelys imbricata*; leatherback turtle, *Dermochelys coriacea*; and green turtle, *Chelonia mydas*, are hunted for food.

The following birds are hunted for food:
Blyth's hornbill, *Aceros plicatus*;
scrubfowl, *Megapodius freycinet*;

sulphur-crested cockatoo, *Cacatua galerita*; and
eclectus parrot, *Larius roratus*.

The following mammals are hunted for food: the dugong, *tomadawa*, *Dugong dugon*; the cuscus, *Phalanger orientalis intercastellanus*; and the black Dorcopsis wallaby, *Dorcopsis atrata*.

There is a wide range of medicinal plants that continues to relied upon for health and community survival. Based on Powell's (1976) list for the area, which included the Trobriand Islands to the north, the following species are thought important for coping with fevers, malaria, colds, infections and sinus and stomach problems:
Ficus septica;
Morinda citrifolia;
Premna integrifolia;
Alstonia scholaris;
Alstonia spectabilis;
Morinda citrifolia; and
Sida acuta.

Unfortunately, there are not enough data on these species to include these species as focal taxa at the present time. There is also a high level of reliance on plants for technology and construction. A number of species are key to house construction such as sago palm, *Metroxylon sagu*, M. *rumphii* ; black palm and giant bamboo. A number of tree species are prized for canoe-making but these have yet to be identified, taxonomically. Black palm wood is also important for spears and axe handles. A finger-shaped coral, *gili*, is gathered for the production of lime which is key in the consumption of betelnut.

There are a number of vertebrate species that are relied upon for ceremony and technology and which are bartered (but which have not been widely traded for currency). The Goldie's Bird of Paradise, *Paradisaea decora*, is a major cultural emblem and the male birds are still hunted for their plumes, for use in traditional dances, in the central part of Fergusson Island. There are a growing number of species which are exploited commercially. Given the rapid rate and unsustainable logging, conservation of some of the pockets of the Dipterocarpaceae species (Ashton 1982), which are the targets of logging, is highly desirable in the event that sustainable timber exploitation becomes viable and there is a decision to reforest. There are also growing pressures for commercial exploitation of the giant clam, *Tridacna* sp. and the sea cucumber.

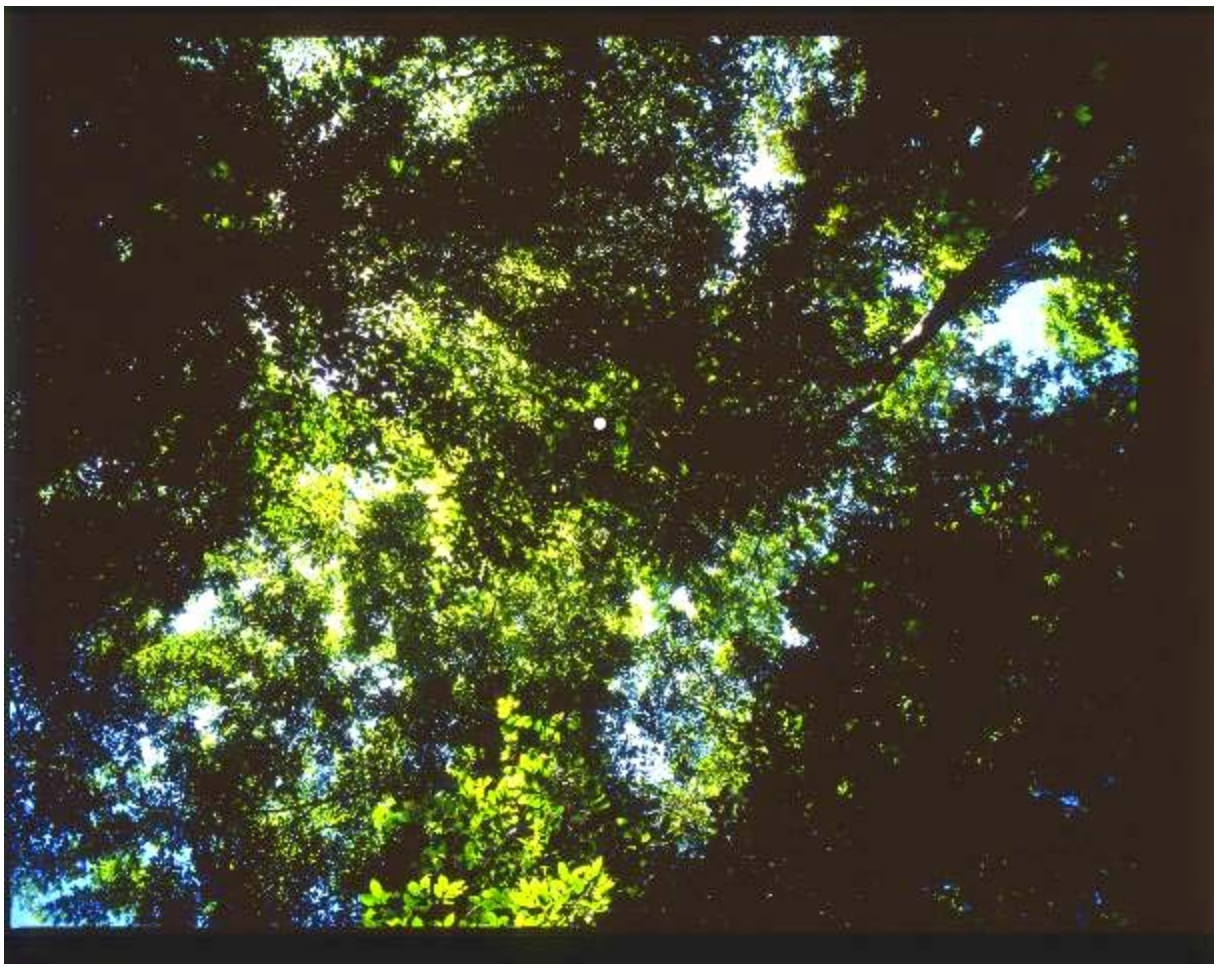
Species with potential genetic resources of regional and national importance
A number of species have genes that can contribute to breeding programmes for crops that in turn are significant for potential improvement of economic activities in Papua New Guinea, the Melanesian Islands, Indonesia and northern Australia:
wild relatives of banana, *Musa* spp.;
Pandanus spp.;
wild mango, *kasawe tomatai*, two species of *Mangifera* spp.;
wild sugar cane, *Saccharum* spp.;
New Guinea wild lime, *Microcitrus warburgiana*;
Melansian papeda, *Citrus macroptera*; *Monanthocritrus cornuta*; *Wenzelia tenuifolia*; *Wenzelia dolichophylla* (Jones 1988);

wild taro, *bolobolo*;
Vaccinium sp. (Van Deusen 1957);
palm, *Archontophoenix* spp.; and
Dipterocarpaceae species (often prized for timber).

Species with potential genetic resources of international importance could provide genes potential improvement of economic activities in similar climatic regions of the world, and with exploitation of some species in the same or closely related genera.

wild relatives of banana, *Musa* spp.;
wild sugar cane, *Saccharum* spp.;
Dipterocarpaceae species;
wild mango, *kasawe tomatai*, two species of *Mangifera* (Jenness and Ballantyne 1920, Mukherjee 1985);
wild taro, *bolobolo*;
wild citrus: Australian finger lime, *Microcitrus australasica*;
New Guinea wild lime, *Microcitrus warburgiana*;
Melansian papeda, *Citrus macroptera*; *Monanthocritrus cornuta*; *Wenzelia tenuifolia*; and *Wenzelia dolichophylla* (Jones 1988).

The endemic rat, *Rattus mordax fergussoniensis*, one day may be useful to medical research.



primary forest canopy, above Nade on the south coast of Fergusson Island, that is the most important local display site for Goldie's Bird of Paradise, March 1989, photograph by Gordon Brent Ingram

A framework for monitoring and managing the biological diversity of the Fergusson Island area: Minimum requirements for habitat and population of the focal species

The following is a review of phylla and categories of focal taxa for determination of relevant categories of minimum requirements as a prerequisite for determination of categories of requirements for each focal taxon.

vascular plants

The requirements of the plant species in the D'Entrecasteaux Islands can include all of the six categories of minimum requirements.

invertebrates

Because of the problems with the rapid turnover of populations and the practical problems of data collection, the requirements for species which are small, numerous or marine are limited to
area,
environmental gradients,
disturbance factors, and
habitat features.

fish

The requirements for the fish are similar to that of for the invertebrates:
area,
environmental gradients,
disturbance factors, and
habitat features.

reptiles, amphibian, birds and mammals

Relatively ubiquitous and sedentary species, can have requirements for area, habitat features, and successional phases. Mobile and relatively ubiquitous species have requirements for population size,
habitat features,
environmental gradients
and
successional phases.

Breakdown of types of calculations of minimum requirements for the D'Entrecasteaux Islands

The qualitative requirements, for environment gradient, habitat and successional factors can be determined in the following modes. If the species is a plant or an invertebrate with well-known and delineated patterns of occurrences, requirements can be limited to the range with known patterns of occurrence.

If the species is a plant and the occurrence within the biotic district has not been satisfactorily confirmed or the extent of occurrences determined, qualitative requirements can be based on the range within the patterns of occurrences in similar environments.

If the species is a plant or an invertebrate which is relatively widespread or a community dominant, postulated requirements can be limited to the extent of that community or communities though less typical occurrences could be added as the basis for additional requirements. If the species is a plant or an invertebrate, the local populations of the species have been significantly disturbed or utilize traditionally and are therefore vulnerable and occurrences are less common or predictable, requirements can involve areas both confirmed and postulated plus habitats on sites which were historically viable and could be restored.

If the invertebrate is relatively sedentary or small invertebrate, and which is known to occur in the area but which has not been well-studied in terms of patterns of occurrences, the range of factors within areas of occurrences can be determined to be the qualitative requirements. If the species is a ubiquitous vertebrate, qualitative requirements can be determined on the basis of the range of factors within community types where there are occurrences. If the vertebrate is obviously limited to a community type or types but is relatively ubiquitous within this or these, qualitative requirements can be based on the range of factors within these communities.

If the vertebrate is not ubiquitous, qualitative requirements can be determined on the basis of general life history data, general habitat modelling and the patterns of local occurrence.

If the vertebrate is rare and mobile or migratory, qualitative requirements are limited to the full range of sites, with habitat features, which might have been exploited in a historical period.

If the species has a recognized potential for holding potential genetic resources, one of the previous categories of determination of qualitative requirements should be chosen. In addition, a finer degree of requirements, within a more comprehensive range of gradients, habitat features and disturbance factors, than are necessary for fitness should be determined.

The quantitative requirements for population size, numbers of populations and minimum area, can be determined in the following modes.

If the species is a plant or invertebrate and has one meta-population throughout the biotic district, but is not limited to the biotic district, number of populations required is 1 and population size is a reflection of species biology. The requirements for area can be determined in terms of the existing, local range and range of densities.

If the species is a plant or an invertebrate and has one or a series of isolated populations with barriers to exchange of reproductive material, either from the boundaries of the biotic district or internally, the number of populations required is the number of separate occurrences which can be argued to be viable, at the present time. Population size can be determined on the basis of species biology. The requirements for area can be determined in terms of the existing, local range and the respective range of densities.

If a plant species is rare or not confirmed within the biotic region and district or depressed at the present time, numbers of populations required is the number of separate occurrences which presently exist or could exist in the potentially viable habitat. Area requirements include all of the space around each occurrence which could support the species and population size (where necessary) can reflect the carrying capacity of the areas which could support populations as well as demography and species biology.

If the species, plant or animal, is also classified as having potential genetic resources, the population sizes, which are required, can be expanded to assure the maintenance of rarer alleles, beyond those necessary for basic resilience, with a corresponding increase in minimum area.

If the species is a vertebrate and has one meta-population, throughout the biotic district, but is not limited to the biotic district, number of populations required is

Population size can be based on species biology and the carrying capacity of the district and minimum area required is related to spatial requirements at *K*. This can be based on pre-existing models for the species.

If the species is a vertebrate and has at least one population, bounded naturally, the number of populations required is the number of such naturally defined areas. Population size can be based on carrying capacity for each area of the district and minimum area is related to spatial requirements at *K*.

If the vertebrate is comparatively rare or highly site-dependent, numbers of populations required will be equal to those which currently exist within the biotic district, and minimum area required will reflect the full extent of those habitat features which are required for protection.

Sebutuia Bay, on the south coast of Fergusson Island east of Nade in October 1988 in the months before it was made a log dump, photograph by Gordon Brent Ingram

Long-term threats to the biological diversity of Fergusson Island & the entire D'Entrecasteaux Archipelago

Pressures for expansion of land use

Virtually all of the population of Fergusson Island, except for the inhabitants of the mission village at Salamo and a small number of teachers, have been dependent on a subsistence economy. There has been a system of intra-regional exchange, the Kula Cycle (Malinowski 1922), which is still in existence. Fergusson Island is key for the supply of betel nut. Intrusions into these subsistence patterns have been erratic: the labour recruitment in the Australian

colonial period (Young 1971), the World War II bases, the establishment of small plantations and now logging and mining.

The logging, the increased agricultural production associated with the planned Sebuotioa – Salamo road and the gold-mining operations may, once-again, bring a few more individuals, primarily males, into the wage economy on a temporary basis. However, for the majority of the young of the island, prospects for access to regular cash and consumer goods are severely limited. Given the richness of natural resources, on the island, and the shift in the local and national economy toward "monetization of resources" (Pernetta and Hill 1982), there is increasing pressure for land use practices which could alter habitats. The increases in the world prices of timber and some minerals compound this trend.

Commercial logging and agricultural expansion

Much of the forest lands of Papua New Guinea have poor quality timber in terms of present commercial value (Lamb 1977). These highly diverse stands produce low volumes of marketable timber in relation to the cost of operations (White 1977). This is the case with much of Fergusson Island except for the pocket of dipterocarps behind Sebutoia Bay.

Much of the current and prospective logging involves selective logging of relatively valuable stands. Some of the logging in the lower elevations on less severe slopes has been done under the guise of forest clearing for agricultural expansion. Unfortunately, the underlying latosols will be productive for crops such as cacao for less than a decade. Large portions of the temporarily cleared areas will revert to seral scrub with limited agricultural productivity over the long-term.

Infrastructure for logging

An additional rationale for logging, and more recently for mining, on Fergusson Island has been to allow for the building of a road into the centre of the island. While this road may have limited utility, over the long-term, especially for people who can not afford mechanized transport, it could hasten some expansion of agricultural in the central parts of the island. The impacts of logging roads have been poorly documented in the Melanesian region. However, there has been some recent interest on the effects of roads on adjacent forest and reef (Craik and Dutton 1987) in Queensland. There has been research on dipterocarp forest in Asia which suggests that the impacts of logging roads on granitic soils like those areas to the west of Sebutoia Bay, could produce "catastrophic erosion" (Burgess 1971).

Mining exploration, mining and associated infrastructure

So far, only mining exploration has taken place on Fergusson Island. This has involved cutting trails, making clearings and drilling. The most lasting impacts involve relatively small landform alterations, soil disturbance and subsequent sedimentation in streams. Mining, however, could be highly detrimental to some elements of local biological diversity. A sub-surface gold mine has been proposed for the northeast coast of Fergusson Island. As of March 1989, the respective environmental impact assessment for that project has yet to be released.

There are four types of disturbances associated with mining operations. First, there are the extraction sites. Secondly, there is the infrastructure particularly roads. There is subsequent sedimentation associated with the extraction and the roads. Finally, there is the distribution of the poisonous tailings and subsequent toxins in freshwater and marine ecosystems.

The fisheries of the area have not been well-inventoried. The diversity of marine fish, crustaceans, turtles and mammals has allowed subsistence exploitation to be relatively light. Intensification of harvesting is related to export markets, particularly that to Japan. The focus tends to be on a small group of marketable species such as the giant clams and the sea cucumber.

marked dipterocarp tree above the village of Nade, on the south coast of Fergusson Island, March 1989, photograph by Gordon Brent Ingram

Cause-effect linkages between land use and loss of biological diversity in protected habitat
The relationships between commercial logging, and to a lesser extent prospective mining, and the loss of biological diversity have been poorly documented for New Guinea. The review of the impacts of commercial forestry by Routley and Routley (1977) noted "massive reduction in numbers of non-human species" from permanent loss of forest.

Much of the debate over the impacts of commercial logging in Papua New Guinea have centred on the few large projects such as the infamous Gogol Valley project which converted large portions of the tree biomass into woodchips. Concerns have also involved the underlying, colonially derived development objectives (Davidson 1983) and insufficient environmental assessment.

In the Gogol Valley debate, Seddon (1984) noted a host of negative impacts most of which were socially related. In terms of biophysical alterations, he stated that there was massive short-term environmental degradation. In an accompanying article, Saulei (1984) documented substantial regrowth in the logged areas, but noted that the vegetation which followed was "less diverse." He also suggested that there will be long-term impacts on some cut areas in the form of water logging, soil erosion and leaching, reduction of phosphorous levels, changes in floristic composition and establishment of grassland in formerly forested sites.

Changes in and intensification of traditional patterns of exploitation

Except for the mangrove areas, much of Fergusson Island below 200 m elevation and within 2 km of shore is in some form of culturally maintained landscape type. This disturbance regimen may be relatively recent as before a century ago, villages were situated at higher elevations in order to avoid raids involving marine craft. Besides village areas there are:

- swidden gardens with cultivated yams, bananas and tree crops;
- planted or intensively managed sago swamps;
- coconut plantations of recent origins;
- intensively managed forest with managed patches of perennials such as the chestnut and the giant bamboo; and
- grasslands on north-facing slopes which are the products of repeated burning associated with hunting.

All six categories preclude primary lowland rainforest habitat though former swidden and gathered areas, older than 50 years, have many ecological attributes of primary forest. Because of population growth, all of these cultural landscapes are increasing in area with associated human-related disturbance tending to intensify with greater human population and gardeners.

Loss of habitat on reserve edges

Habitat on the edges of roads, logged areas, mining operations and gardens, is often subsequently degraded over time. Primary rainforest is particularly sensitive to blowdown and penetration by seral and invasive species. The major variables involve slope, aspect and landform. Such edges can function as buffers for protected areas but for numerous species with requirements for primary rainforest, margins as wide as several hundred metres from disturbed zones must be considered inviable.

Degradation of the soil mantle

Soil disturbance usually involves heavy equipment associated with logging, mining exploration, mining and roads. As well as precluding the on-site impact areas from ever being significant for the in situ conservation of many sensitive species, downstream, freshwater habitat is jeopardized from risks of mass wasting and sedimentation.

Degradation of estuarine, tidal and marine habitat

Sedimentation from mining, logging and roads can contribute to the degradation of estuarine, beach and marine habitat. The coral reefs in the more sheltered off-shore areas, such as those in Seymour Bay, are particularly vulnerable. Another significant factor for shore degradation is that of transport dumps for logs and tailings. As well as inevitable contamination by tree bark and mining tailings in bays, there is the risk of pollution by petroleum products and other industrial chemicals.

The most insidious threat is from mine tailings to off-shore coral reef ecosystems. Generally poisonous tailings in settings like coastal New Guinea are barged and dumped off-shore. However, the areas off Fergusson Island are often relatively shallow and extremely rich, biotically. For the mine proposed at Wapolu Point, in the northwest of Fergusson Island, the shortest marine route to water sufficiently deep as to not destroy corals is at least 50 km to the west or 80 km to the east.

Degradation of freshwater habitat

Virtually all of the degradation of freshwater habitat would be due to sedimentation and, in those cases involving mining tailings, subsequent poisoning. Virtually all of the significant sedimentation is a secondary and tertiary impact of logging, mining and roads. Sedimentation can alter stream morphology which has a direct impact on stream organisms. It often depresses oxygen levels which diminishes the viability of some populations.

Obtrusive technology, trampling and other presence-related factors

The noise from and visual contact with extractive operations will probably render some adjacent protected habitats unviable for some rainforest vertebrates. Similarly the shore dump and transport areas will probably render large margins of adjacent areas unviable for certain raptors and mammals like the dugong.

Tourism at the present time does not pose any threats to either marine or terrestrial species. If the area were ever to become a Mecca for marine tourism, and the area is certainly impressive in terms of corals, the presence of numerous speed boats would be detrimental to the dugong.

Disruption of food webs

There are a number of types of food web disruptions which expanded land use could set into motion. Removal of even a small percentage of large fruiting trees, in a particular area, could be catastrophic for dependent birds and bats. Raptors are vulnerable to contamination of freshwater and estuarine ecosystems particularly from mining tailings. The smothering of beds of corral from logging sediment could cause the loss of many vertebrates and would damage certain fisheries. Certainly, the over-exploitation of certain marine food resources could disturb marine food webs.

Fragmentation

Fragmentation is also a secondary and tertiary impact of habitat alteration, resource extraction, roads and possibly mismanagement of the marine zone. In the case of terrestrial ecosystems, it is largely a problem for the larger vertebrates which require aspects of primary rainforest such as large perches, canopy, cavities for nesting, large fruit bearing trees and undisturbed understory. In addition, there may be a group of rainforest vertebrates, mainly birds, which are unable, psychologically, to cross roads and clearings and which are doubly sensitive to logging and mining. These factors would have a major bearing on reserve design especially for those reserves which will be relatively small.

Fragmentation in coral reefs has some intriguing implications for biological conservation. However, it has been poorly documented because disturbances there have been more general than site specific and most reefs, by their nature, involve a heterogeneous mosaic. Certainly any sedimentation or mechanically related disturbance which diminishes the size of an isolated reef

could cause a secondary loss of species as a result of an isolate having been shrunken or broken down.

Further introduction of alien species

The drier parts of Fergusson and much of Dobu are particularly vulnerable to establishment of weeds such as elephant grass, Pennisetum sp., which was introduced in association with cattle grazing at Salamo in the 1960s. Such exotics in areas of disturbed soils are inevitable. However, in the drier areas, these species could invade the scrub-grassland and become permanently established.

The typical domesticated animals have not faired well aside from the pig which established many thousands of years ago. As with many off-shore New Guinea islands, early Melanesian societies are assumed to have introduced the sand wallaby, *Protemnodon agilis papuanus*. These populations have naturalized in drier areas and this species' presence may have a deleterious impact on the endemic wallaby.
Domestic cats and dogs could pose a modest threat to birds and mammals around villages. Areas with logging, mining and agriculture could become sources of invasive exotics, and guidelines are necessary to limit the introduction of new species.

Father and daughter, south-western Fergusson Island, February 1989 photograph by Gordon Brent Ingram

Analysis of the institutional framework for habitat conservation and environmental planning in the D'Entrecasteaux Islands

The State: Legislative and executive measures

The D'Entrecasteaux Islands were part of the former British Colony which become Papua under the post-World War I, Australian administration. The institutional setting for habitat conservation in Papua New Guinea evolved under the colonial, Legislative Council which was formed in 1951. It was replaced by a House of Assembly which became the government in 1973. The country became fully independent in 1975.

Because of low population densities in many areas, and the modest exploitation of natural areas, habitat protection has been less the focus of concerns for conservation than over-exploitation of certain species such as orchids, butterflies, crocodiles, birds of paradise, marsupials and marine fauna. As the old customs, practices and taboos have broken down, with social change, and the technologies for killing have become more sophisticated, the focus for conservation has often been on markedly declining populations. The government of Papua New Guinea has been active in the conservation of certain types of primary forest since the 1950s (Eaton 1984). A modest national park movement started within the government in 1966.

There are three levels of government working on Fergusson Island:

a. national - the Independent State of Papua New Guinea;
b. provincial - Milne Bay Province with the capital at Alotau; and
c. local - with two councils, one for the eastern two thirds of Fergusson Island plus Dobu and the other for western Fergusson Island and extending to adjacent Goodenough Island.

The local government council began meeting in the Dobu area in the early 1960s. The national legislature began meeting in the mid-1960s and became the national parliament in the mid 1970s. The government of Milne Bay Province was established in 1978.

Since independence, there has been some devolution of power to the provincial legislatures and executive councils but responsibilities for environmental protection have stayed largely federal. Provincial governments are key for the implementation of federal regulations. This has contributed to non-enforcement of contentious environmental regulations especially when they conflict with land use which generates royalties for the provinces. Most of the efforts for habitat conservation in Papua New Guinea have involved the national level of government. Proposals for conservation can be made and implemented through local councils but usually involve the national government.

There is something of a mandate within the 1975 Constitution of the Independent State of Papua New Guinea for the conservation of biological diversity. The fourth goal is that natural resources and environment be conserved and used for the, "collective benefit of us all" and its second and third points call for, "conservation and replenishment...of the environment and its sacred, scenic, and historical qualities" and "adequate protection to our valued birds, animals, fish, insects, plants and trees" (Constitutional Planning Committee 1974). Fortunately, for the cause of conservation of biological diversity, "valued species", in most of the subsistence communities of the country, include a substantial portion of the local biota.

The fourth point of the Constitution of Milne Bay Province (Papua New Guinea Department of the Milne Bay Province 1978) states that,

"We intend to have a major say in the development of all our resources SO THAT the healthy state of our surroundings can be preserved for generations to come."

There are three important statutes for the conservation of wildlife and the establishment of protected areas (Eaton 1986). The *National Parks Act* of 1982 was established:

"to provide for the preservation of the environment and of the national culture inheritance by - (1) the conservation of sites and areas having particular biological, topographical, geographical, historical, scientific and social importance." In the 1982 Act, There are provisions for a large number of categories of protected areas:

1. national parks;
2. provincial parks;
3. nature reserves;
4. sanctuaries;
5. marine parks;
6. historical parks;
7. historical sites;

8. city parks;
9. national;
10. walking tracks; and
11. international memorial parks.

But these categories are not clearly defined. The Act does not provide much guidance in the formulation of objectives for the management of protected areas.

The *Conservation Areas Act* was intended to remedy the deficiencies of the *National Parks Act*. It allowed for the establishment of a National Conservation Council to advise on the selection and management of conservation areas, a registry of sites, and a management committee. Protection can be on private land with the main safeguard the requirement for a management plan. Alterations to the prescribed status quo would require permission from the Minister of Environment and Conservation.

The *Fauna (Protection and Control) Act* of 1966 provides for the protection of a number of species and their habitats. The species of the Fergusson Island area which are protected under the Act include the dugong and the Goldie's Bird of Paradise. The 1978 *Environmental Planning Act* allows for review of larger development proposals.

The orthodox approaches to control of protected areas have not often been workable in this country where 97 % of the land is under customary tenure. The institutional and legal category of conservation, the wildlife management area, involves more land in the country than do national parks.
This category of protected area is enabled through Part III of

The *Fauna (Protection and Control) Act* which dates back to 1966. There are three categories of possible protected areas which are available, but the first two of "sanctuaries" and "protected areas" are rarely applied. The wildlife management areas are formed on communally owned land where a committee of owners is formed for protection and management of certain wildlife resources (Eaton 1986).

Often regulation involves adjustment of the traditional rules and taboos.The factors which have been behind initiatives for wildlife management areas include:

1. worry that important species will become extinct;
2. worry of traditional rules being ignored; and
3. recognition of the need to regulate the behaviour of outsiders.

For the conservation of biological diversity, in areas where there are pressures for logging, the *Forestry Act (Amalgamated)* 1973 is a potential tool for conservation planning. The Act enables the government to purchase rights to exploit certain aspects of the land from customary owners, such as timber. The royalties, which are usually much higher than the costs of the purchase of the rights, go to the government. The *Forestry Act* is explicit about environmental restrictions. Logging is prohibited 20 metres from permanent water courses and 50 metres from major rivers. Selective logging is prohibited on slopes over 25 degrees and clear-felling is prohibited on slopes over 30 degrees.

In areas with logging, customary landowners always have the right of access, gardening and hunting. Fruit trees and other economically important plants are excluded from timber

agreements. Logging is supposed to be excluded from sacred areas – but controversies and conflicts have been generated in interpreting this vague proscription. Large-scaled timber projects may be required to have an environmental statement filed under the *Environmental Planning Act*.

Papua New Guinea is a signator of the 1976 *Convention on Conservation of Nature in the South Pacific*[6] which has yet to be fully implemented. This convention works to "safeguard representative samples of the natural ecosystems", in each country, and gives special attention to endangered species. The Convention includes guidelines for the management and expansion of national systems of protected areas.

Papua New Guinea has signed and ratified CITES and has the *International Trade (Flora and Fauna) Act* of 1979. Implementation of habitat conservation measures in Papua New Guinea involves an unwieldy number of government offices.
The Office of Environment and Conservation of the Department of Lands Survey and Environment has responsibility, at the national level, for environmental planning, national parks, and wildlife and environmental protection. It determines when environmental assessments are necessary. The Office of Forests of the Ministry of Forests has responsibility for negotiation and enforcement of environmental safeguards in forestry agreements as well as for forest land use planning. The Papua New Guinea Ministry of Justice is responsible for drafting environmental legislation and environmental litigation. The Department of Lands and Surveys, of the Ministry of Lands and Surveys,is responsible for acquisition, reservation and allocation of land for government-controlled habitat conservation. The National Planning Office of the National Investment Development Authority of the Ministry of National Planning is responsible for land use components in national and regional planning. The Constabulary of the Ministry of Police is responsible for enforcement of environmental legislation as is the Department of Provincial Affairs of the Ministry of Provincial Affairs.

Lake Lavu Wildlife Management Area

This is the only formally protected area on Fergusson Island and the legal basis for this kind of habitat protection, in Papua New Guinea, is incomplete. The reserve was proposed in 1975 by Alfred Kalupi of the Department of Environment and Conservation and was supported by the West Fergusson Island Local Government Council. The lake has freshwater crocodiles were being carelessly exploited by foreign hunters. The reserve was a response to the need to limit exploitation to local communities. The wildlife management area was finally gazetted in 1981 with a total area of 2,640 hectares. Rules are set by a committee of seven representatives of the surrounding villages of Lapapai, Niubowo, Masimasi, Ebedidi, Sobakadi and Yamalele No. 1 and 2.

Rules prohibit the use of shot-guns. Only landowners, using traditional methods, can hunt in the area (Eaton 1986). Collection of crocodile eggs is forbidden. Wildfowl eggs can only be collected every 6 months. No bush fires can be lit during dry seasons. No wallabies can be killed. People caught breaking the rules can be fined up to K 20. (about US$ 25) (Gidu 1978).

In his 1986 report on the area, Eaton noted that the major threat to habitat, in the management area, is from proposed, commercial logging. The legal powers of this wildlife management area, to exclude logging and the impacts of logging, have not been precisely determined.

In the March 1989 reconnaissance of the area, with Alfred Kalupi, we found that the local Committee have not met formally since 1980. Over the last ten years, there has been little contact with the government wildlife conservation officers, many of whom were laid off in 1982, though one did visit the area in 1988. However, there still is a chair of this Committee, from a village within the area, who monitors the lake for infractions of the rules.

The State: Patterns of implementation and administration

As in many developing countries, concerns for the environment and conservation of wildlife and habitat, in particular, have not often translated into effective programmes. Of the 8 strategic objectives of the government, environmental management has had the lowest allocation of government resources (Eaton 1986). This is due, in part, to the pressures for expanded social services. Some of the "constraints" which are working on the Department of Environment and Conservation were brought up at the Third South Pacific Parks and Reserves Conference in 1985 (South Pacific Regional Environment Programme / Government of Papua New Guinea 1986). The current problems listed were shortage of personnel and skills, organisational instability, ineptness and "ineffective planning mechanisms." The last three points are particularly significant for considering present limitations on land use planning for the *in situ* conservation of local biological diversity.

The rapid succession of government programmes, over the last decade, have not contributed to "stability and harmony" in this respect. The "incompetence", is related to,

"Alteration and rejection of...decisions by less qualified personnel higher in the bureaucratic structure."

In other words, the Office of Environment and Conservation is sometimes obstructed from pursuing its legislative mandate by more powerful government offices.

The Secretary of the Department of Lands Survey and Environment has effective control over the Director of the Department of Environment and Conservation which has only "policy control." The third type of constraint, ineffective planning mechanisms, is typical of resource frontiers and "The lack of a multi-disciplinary approach to planning and decision-making frequently leads to the (Department of Environment and Conservation) being totally overlooked in areas which fall within its responsibility."

The environmental legislation of Papua New Guinea is based on overseas models, particularly Australian, and this is problematic since the country does not have the administrative, judicial and professional resources for implementation. The legislation has not always supported customary frameworks for conservation though the country is remarkable in the degree to which traditionally based tenure and beliefs are still respected.

Patterns of implementation: Allocation and management of protected natural habitat

There have been difficulties in implementation of the categories of protected areas, under the National Parks Act, because of lack of funding for field surveying and personnel. Like other countries in the south Pacific, it has been difficult to gain acceptance for the concept of the national park (Reti 1986). The National Conservation Council mentioned under the *Conservation Areas Act* has not been formed because of "shortage of staff" (Eaton 1984).

The wildlife management area category of habitat protection may often be the most viable for conservation of local biological diversity. In his review of the wildlife management area programme, Eaton (1986) suggested that it might provide alternative models of conservation for, "developing countries where customary or cognitive systems of tenure are still important." There are a number of advantages of the wildlife management area category of protected area for Papua New Guinea at the present time. The establishment of a wildlife management area is relatively simple. A proposal goes to the Office of Environment and Conservation of the national government. Formal establishment only requires the listing of the title of the area, its legal boundaries and the names of the management committee members.

Wildlife management areas can be established without costs of government acquisition. This is particularly important, in the present political climate, where real government funding for conservation is well below that which was available at its peak in 1982. The landowners are responsible for management of their areas and for making rules. Conservation is not imposed from the outside. Rule-making is flexible and adaptive for changing situations.

The disadvantage of the wildlife management area is that rules may become so flexible that little real conservation is accomplished. There is a bias for protection of certain fauna rather than on habitat or plants. It may be difficult to extend implementation of this Act to situations with pressures for intensifying, traditional exploitation.

In Papua New Guinea, a number of wildlife management areas have been set aside to protect forest habitat from commercial logging (Eaton 1986). Some shifting cultivation has been allowed. Cutting has been restricted to areas where cultivation has already taken place. Given the economic disadvantages from lost revenue from preclusion of logging, it has been suggested that a portion of the cutting royalties go for compensation and incentives for conservation.

Another problem is with local support from individuals who are literate and who can deal with governments. At the time of the establishment of the management area at Lake Lavu, an area with Goldie's Bird of Paradise was identified on the mountain slopes above Nade. A proposal was made but was never implemented because the local contact was never able to complete the required reports.

Enforcement of any conservation regulation in Papua New Guinea, at the present time, is difficult because of the severe cutbacks in the number of wildlife officers. The fines, for breaking the rules in wildlife management areas, have usually gone to compensate land owners and not back to the budgets of local wildlife officers.

Patterns of land use planning

The *Environmental Planning Act* has been applied to timber projects but concerns, so far, have not included biological diversity. Planning exercises, in most cases, have not been effective at inclusion of concerns for the conservation of primary forest and Lamb (1977) noted that "not only are there strong incentives for converting or destroying rain-forests, but there are a number of disincentives actually hindering long-term planning and sustained-yield forestry in Papua New Guinea."

In recent years, the Act was invoked to require an environmental assessment and plan for the proposed gold mining on the northwest coast of the island. However, the plan was required after extensive exploration had already caused substantial negative impacts. In recent years, there are visions of New Guinea-wide system of protected areas (Diamond 1986). The national government of Indonesia, with the cooperation of the province of Irian Jaya has accepted proposals for an initial network of over 50 reserves. However, there have been no such initiative, for such a review or comprehensive programme, in Papua New Guinea.

The private sector and non-governmental organisations

The government has the key role in virtually all of the natural resource exploitation in Papua New Guinea. The capital which is necessary to establish modern logging and mining operations can only be found outside of the country. There are now two such logging companies working on Fergusson Island. In order to have foreign-based investment, the federal and provincial governments act as entrepreneurs. Given the incentives, with the bulk of the royalties going to the provincial government, distinctions between government and private industry are sometimes blurred. While there has been a small saw mill established at Esa'ala, virtually all of the timber taken from Fergusson Island is exported, as unfinished logs, to Japan and Korea.

SPAN Industries is owned and operated by the United Church of Christ mission at Salamo. Commercial activities involve those which are considered badly needed for community development such as transportation services, boat building and a store.

There are few nationally based environmental organisations which have support at the local level in Papua New Guinea. In 1989, the two environmental organisations which met regularly were the Melanesian Environment Foundation, which recently was initiated with the help of the national council of churches, and Friends of the Earth which mostly involved non-nationals.

There have been environmental and subsequent social problems related to logging and mining development that have involved conflicting approaches to the distribution of costs and benefits of the development. Landowners are given modest payments for the logging of their land and can make demands for the building of schools and other facilities. However, local families are under severe pressure from district officials to sign over the rights to logging and exploration for minerals because the province receives the bulk of the royalties.

In other parts of south-eastern New Guinea, there has been significant local resistance to extractive operations. In his essay on logging, Waiko (1977) suggested that much of the commercial logging in Papua New Guinea at that time was a form of neo-colonialism and saw a contradiction in the contrasting priorities for development between localized subsistence economies and international capital. In their chronicle of conflict around the intrusion of a foreign logging company in Northern Province, Waiko and Jiregari (1982) note that the environmental damage inflicted by the company was an assault on the autonomy of that community and "their capital resource."

In that local struggle, Waiko and Jiregari stated that

"advocates of development create a situation in which a false consciousness emerges...is false partly because the people are not aware of the degree of destruction of the environment"

and link this with the process of cultural disintegration where,

"tradition and custom, as a means of understanding and relating to the village environment and the mechanisms to incorporate change in it, lose their capacity to convey meaning."

In these situations, local Melanesian concerns for the conservation of biological diversity may well be most articulated through efforts for the protection of the full range of subsistence resources and religious values.

The communal patterns of land tenure on Fergusson Island

In Papua New Guinea, conservation programmes must be compatible with traditional, though changing, patterns of land tenure. The key variables in land tenure systems (Crocombe 1974) involve biophysical, economic and cultural factors. There are a number of types of territorial relationships which influence the nature of the environmental management measures which might be viable:

- rights to direct use;
- rights for indirect economic gain;
- rights of control;
- rights of transfer; and
- residual and symbolic rights.

Rights to near-shore marine resources are usually linked to ownership of adjacent land and particular species (Wright 1985).

Within Fergusson Island there are a diverse set of territorial arrangements. There are claims along clan lines which tend to be amalgamated for villages. Claims are often not vigorously enforced until the resource is perceived as being scarce. There are still numerous confrontations and legal conflicts related to competition over communal resources in the area.

Particularly rich areas, such as reefs, have well-defined and demarcated claims. Remote mountain slopes are at the opposite extreme of this continuum with infrequent pressures for hunting and gathering and respective claims which are correspondingly vague.

Cultural factors which contribute to conservation

The peoples of Fergusson Island were organised into totemic, exogomous clans called *susu* in Dobuan. The Dobuan areas of the southeast of Fergusson are matrilineal while most other communities in the area are patrilineal. Most of the social research that has been conducted in the area has been on the Dobu. In the 1920s,

"Each village has a set of linked totems, a bird ancestry, a fish, and a tree" (Fortune 1932).

There were no regular chieftainships, no rank and no castes (Benedict 1934). Women were and continue to be active in the decisions of local communities though Malinowski (1922) noted that this was more so in southern Fergusson Island than in surrounding societies.

Most of the cultural factors among the Dobuans, related to conservation, are similar to most of the people of Fergusson Island and there are similarities with the Trobriand Islanders. The Christian missions have been active on Fergusson Island since 1890 and it is difficult to disentangle their impacts on attitudes and activities as they pertain to the exploitation and conservation of biological resources. In some areas, such as around the mission village of Salamo, belief systems have been altered. But this is probably not the case in more remote areas, such as in the centre of the island, where the Dobuan language is less commonly spoken.

Like the potlatch of the Haida in Pacific Canada, the people of Fergusson Island have ritually-regulated means for redistributing surplus and maintaining communal ties. The *sagari* of the Dobuan communities still goes on after a death and involves redistribution of local food items in response to familial reorganisation.

In terms of beliefs which governed resource use, LeCroy et al. (1980) make a general comment about the Dobuans of Nade, Fergusson Island.

“Traditionally, the people believe that there is an almighty ruler of all creation. Each living thing, flora or fauna, has a human and spiritual component, the harmony of relationships being determined by the spiritual components of the totality of living things. If the spiritual component is upset, then disorder results and confusion and disharmony in the human world is the inevitable consequence."

In his study of acrimony in modern Massim society, an ethic group occupying all of Goodenough and the northwest of Fergusson Island, Young (1971) noted some contradictions between the old ways and the new.

"An often incongruous syncretism has resulted in which Christian values are commonly expressed in word, though less commonly in deed, when an older stratum of values is still dominant...The sharp edges of the pagan culture have been worn down by the ubiquitous Methodism, but the indigenous growths of materialism, pragmatism and individualism remain firmly rooted in the people's subsistence and society."

The distribution of local, biological knowledge on a small island with nine language groups is problematic. Dividing this nine over the total population of less than 20,000, it becomes obvious that the number of specialists, people who might be experts on particular areas, communities and species, is tiny and perhaps prohibitively so in terms of the development of a knowledge base. My initial impressions are that the knowledge of each local expert, often respected older individuals, is limited to such small village areas that it is too fragmentary for more holistic perspectives which allow for understanding of ecosystem types and habitat requirements of particular species.

Throughout New Guinea, there are a number of traditional practices which contributed to forest conservation. There was *de facto* forest conservation where human population densities were low and fire was not used too freely (De'ath 1982). Taboos have tended to allow the protection of sacred areas, referred to in Pigeon as *ples masalai* (Eaton no date). In his early description of Fergusson Island, Malinowski noted that Mt. Kilkerran, which he referred to as Koyatabu, was taboo to visit. Similar beliefs limited the exploitation of certain species. Similar restraints have

been documented by Henley (1977), for exploitation of a Bird of Paradise species, *Paradisaea minor*, in another part of New Guinea.

"The belief that forest spirits will be angered and send sickness on those who kill large numbers..in a short time tends to limit the bag of hunters."

Such a view of the forest tends to allow for the conservation of certain species which are related to forest use. However, this does not necessarily support a holistic view nor workable approaches to ecosystem management. In Carrier's (1982) case study of the Panam of Manus Province, wildlife conservation ideals won little acceptance because there was not a cultural appreciation for ecological principles.

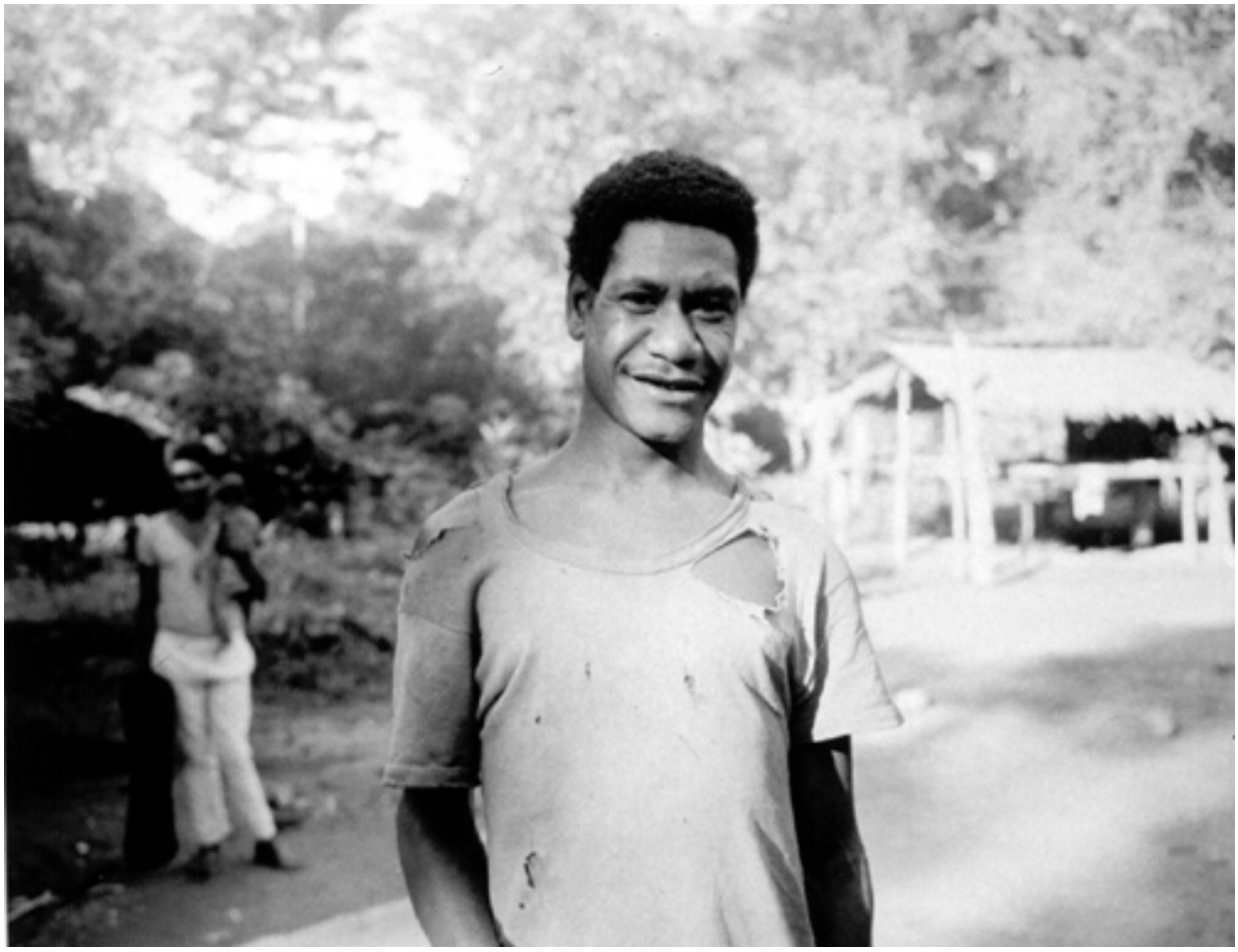
Perhaps a more fundamental obstacle on Fergusson Island to the cooperative relationships which under-lay habitat protection, is the small, isolated nature of the language groups, the cultural fabric dominated by sorcery and,

"a thorough absence of trust in neighbours and the practice of treachery beneath a show of friendliness" (Fortune 1932).

In her seminal comparison of societies, Benedict (1934) notes that Dobuan culture was extreme in that,

"The Dobuan lives out without repression man's worst nightmares of the ill-will of the universe, and according to his view of life virtue consists in selecting a victim upon whom he can vent the malignancy he attributes alike to human society and to the powers of nature."

In such a heavy atmosphere, the consensus and solidarity, which fosters local conservation practices, was often lacking. In much of this area, it has been the United Church of Christ, and more recently Roman Catholic and other Protestant missionaries, as well as the local government councils, often organized along language lines, which have provided the basis for the higher levels of cohesion necessary to make counter-proposals for more sustainable development.



protection officer, Lake Lavu Conservation Area, Fergusson Island, 15 November, 1988, photograph by Gordon Brent Ingram

Alternative configurations of conservation measures for protection of local biological diversity in the Fergusson Island area

The eight strategies

Strategy 1 maximum management option: minimum portion of the Fergusson and Dobu Islands area in protected habitat with high levels of regulation - random and often poor quality of sites - regulation largely within boundaries of protected areas

This situation has often resulted with national park establishment and is the most common manifestation of the island metaphor in nature conservation. This could result if the resources of conservation agencies and organisations become focused on Lake Lavu wildlife management area, particularly if it were up-graded to a national park. One other area, involving a mountain - shore - coral reef constellation, would be necessary.

This reflects a situation where pressures for expansion of land use are great, the total area of the protected habitat is minimal, the quality of most of these sites is poor, networks of reserves are left with an on-going burden of requirements for heavy regulation and manipulation. This is the maximum management option which foists the costs of biological conservation on future generations. The advantages of this approach is that few new organisations and administrative frameworks are necessary though those currently in place would be expensive to up-grade.

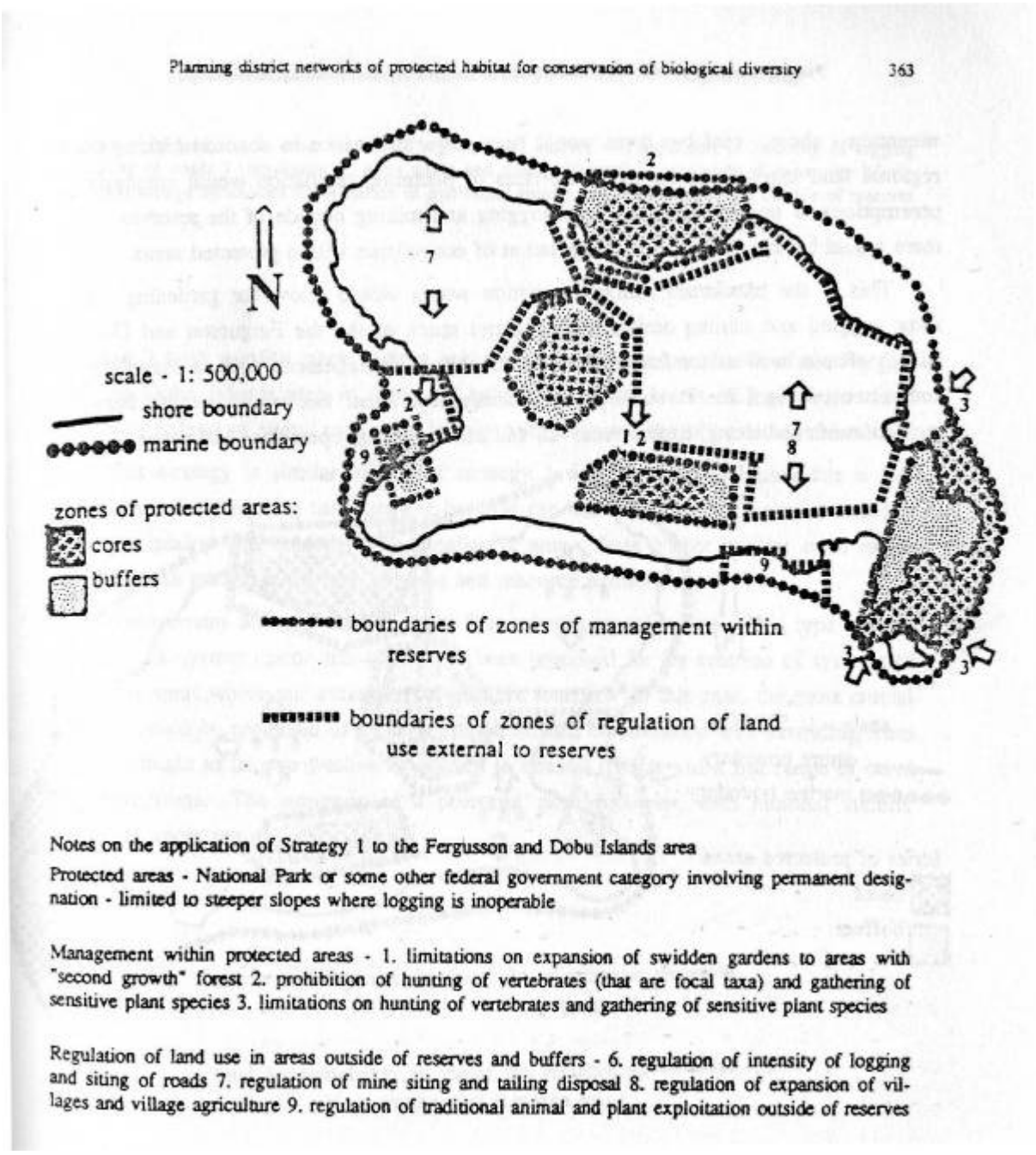
Notes on the application of Strategy 1 to the Fergusson and Dobu Islands area

Protected areas -National Park or some other federal government category involving permanent designation - limited to steeper slopes where logging is inoperable

Management within protected areas:
1. limitations on expansion of swidden gardens to areas with "second growth" forest;
2. prohibition of hunting of vertebrates (that are focal taxa) and gathering of sensitive plant species; and
3. limitations on hunting of vertebrates and gathering of sensitive plant species.

Regulation of land use in areas outside of reserves and buffers -

1. regulation of intensity of logging and siting of roads
2. regulation of mine siting and tailing disposal
3. regulation of expansion of villages and village agriculture
4. regulation of traditional animal and plant exploitation outside of reserves



from Gordon Brent Ingram 1989 Planning district networks of protected habitat conservation of biological diversity, page 363

Strategy 2 maximum mitigation option: minimum portion of area of the Fergusson and Dobu Islands area in protected habitat and with high levels of regulation - poor site quality - regulation largely of external land use

The configurations of protected areas in this strategy might be similar to that in strategy 1 emphasizing the Lake Lavu area plus another area with a constellation of mountain - shore - reef but there would be a major difference in decision-making for regional land use. From the earliest phases of planning, regulation would emphasize pre-emptions of negative impacts from logging and mining outside of the reserves and there would be minimal, direct manipulation of ecosystems within protected areas.

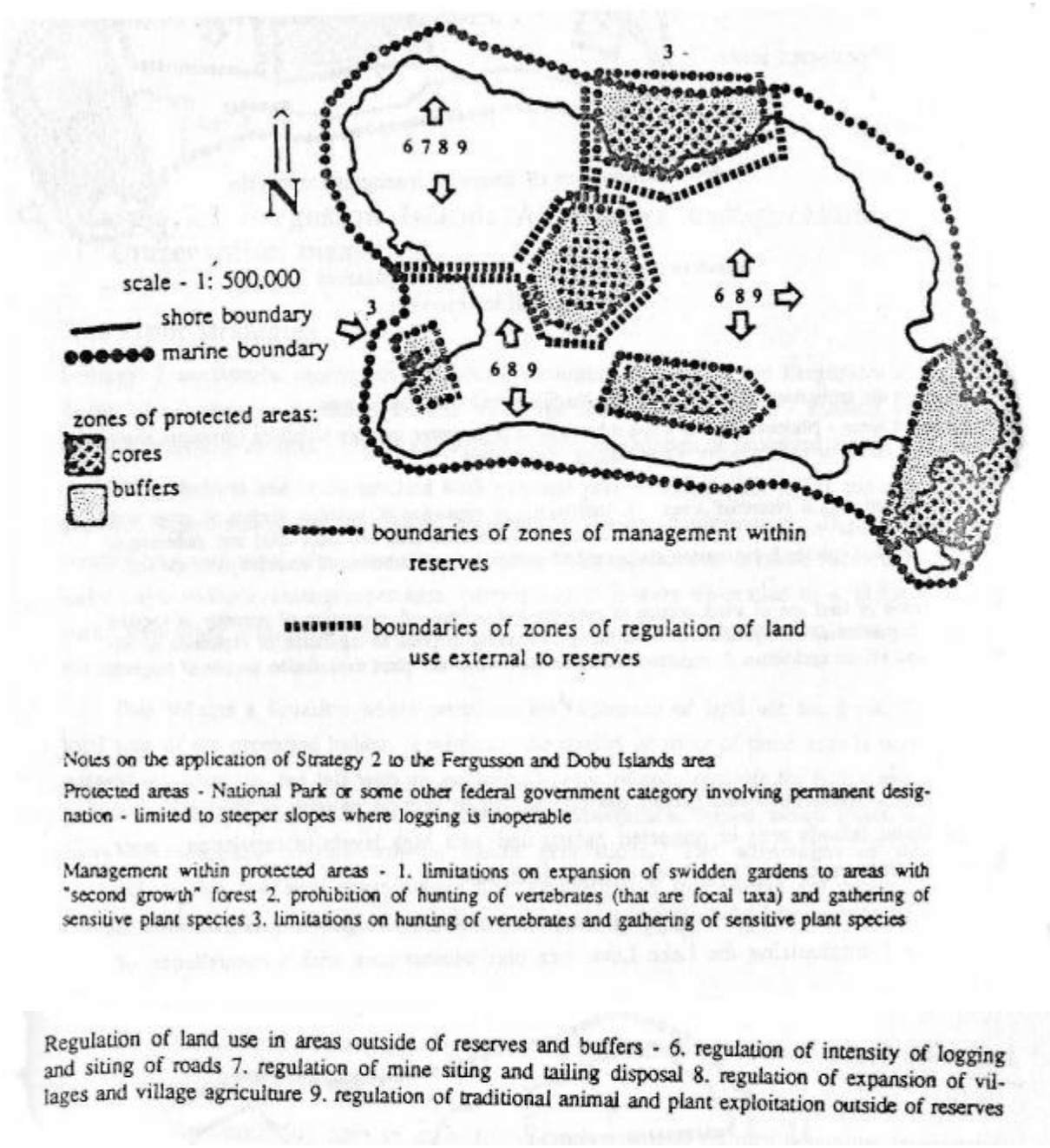
This is the maximum mitigation option which would allow for gardening and some logging and mining activities throughout much of the Fergusson and Dobu Islands area as well as for laissez-faire approaches to management, such as the village committee of the Lake Lavu Wildlife Management Area, but would require heavy regulation of road siting, timber removal, and mining siting, operations and waste.

Notes on the application of Strategy 2 to the Fergusson and Dobu Islands area

Protected areas - National Park or some other federal government category involving permanent designation - limited to steeper slopes where logging is inoperable

Management within protected areas:
1. limitations on expansion of swidden gardens to areas with "second growth" forest;
2. prohibition of hunting of vertebrates (that are focal taxa) and gathering of sensitive plant species; and
3. limitations on hunting of vertebrates and gathering of sensitive plant species

Regulation of land use in areas outside of reserves and buffers:
1. regulation of intensity of logging and siting of roads;
2. regulation of mine siting and tailing disposal ;
3. regulation of expansion of villages and village agriculture; and
4. regulation of traditional animal and plant exploitation outside of reserves.



Notes on the application of Strategy 2 to the Fergusson and Dobu Islands area

Protected areas - National Park or some other federal government category involving permanent designation - limited to steeper slopes where logging is inoperable

Management within protected areas - 1. limitations on expansion of swidden gardens to areas with "second growth" forest 2. prohibition of hunting of vertebrates (that are focal taxa) and gathering of sensitive plant species 3. limitations on hunting of vertebrates and gathering of sensitive plant species

Regulation of land use in areas outside of reserves and buffers - 6. regulation of intensity of logging and siting of roads 7. regulation of mine siting and tailing disposal 8. regulation of expansion of villages and village agriculture 9. regulation of traditional animal and plant exploitation outside of reserves

from Gordon Brent Ingram 1989 Planning district networks of protected habitat conservation of biological diversity, page 364

Strategy 3 high quality park system option: minimum portion of area of the Fergusson and Dobu Islands area in protected habitat with high levels of regulation - high quality of habitat of sites – regulation largely within boundaries of protected areas

This strategy is similar to that of strategy 1 and its island metaphor but is less problematic for on-going management because the habitat which has been allocated is of better quality and tending to be smaller in area. These higher quality areas might involve areas attractive for new gardens and resource extraction. Management activities can be more focused on particular sites. This type of high quality park system option has sometimes been proposed for the creation of systems of protected areas which are attractive for wildlife tourism. In this case, the most

crucial corridor could be protected in order to have a unified conservation area extending from high mountain to lake to freshwater swamp to coastal habitat and a full range of coral reef conditions. The presence of a powerful park authority, with national stature, would be necessary.

Notes on the application of Strategy 3 to the Fergusson and Dobu Islands area

Protected areas:

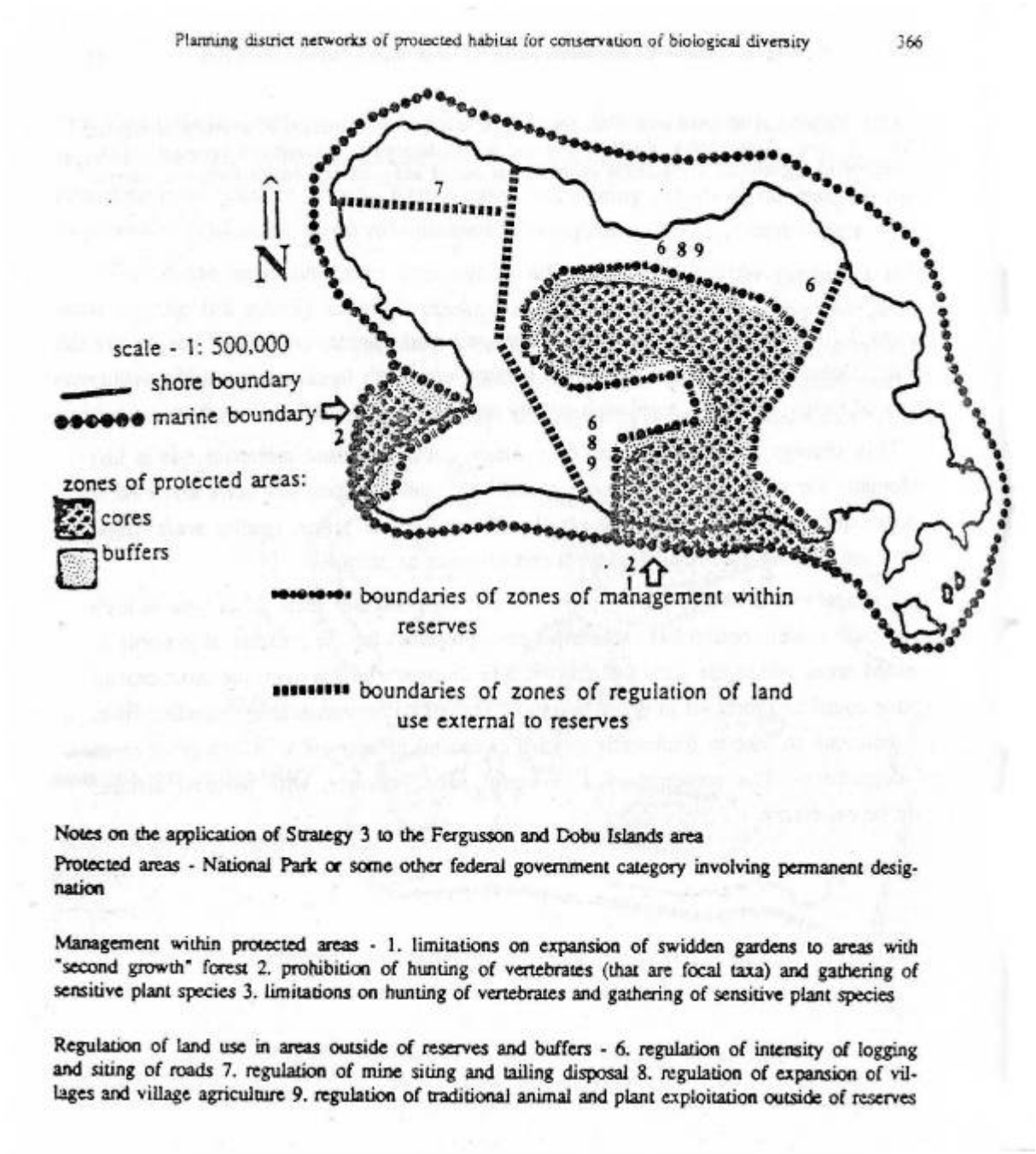
National Park or some other federal government category involving permanent designation

Management within protected areas:

1. limitations on expansion of swidden gardens to areas with "second growth" forest;
2. prohibition of hunting of vertebrates (that are focal taxa) and gathering of sensitive plant species; and
3. limitations on hunting of vertebrates and gathering of sensitive plant species.

Regulation of land use in areas outside of reserves and buffers:

1. regulation of intensity of logging and siting of roads;
2. regulation of mine siting and tailing disposal;
3. regulation of expansion of villages and village agriculture; and
4. regulation of traditional animal and plant exploitation outside of reserves.



from Gordon Brent Ingram 1989 Planning district networks of protected habitat conservation of biological diversity, page 366

Strategy 4 maximum area in mitigation option: minimum portion of area of the Fergusson and Dobu Islands area in protected habitat with high levels of regulation - high quality of habitat of sites - regulation is largely in areas outside of protected areas

This strategy is similar to that of strategy 2 but the requirements for mitigations might be more workable as the sites which are protected are less problematic. Land use expansion could be relatively pervasive but regulatory measures for land use would be precise and well-monitored.

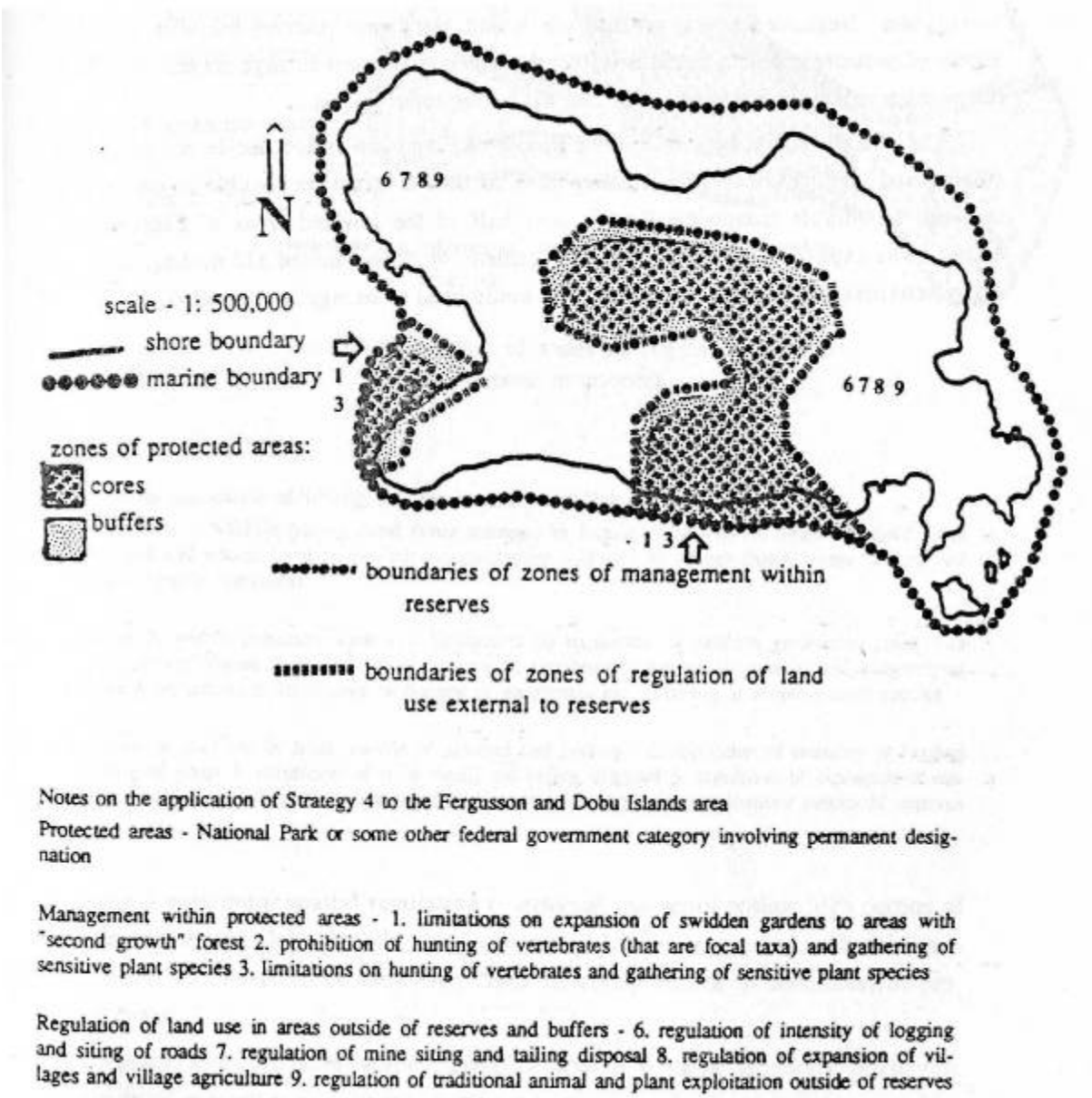
This, the maximum area in mitigations option would require planning apparatuses which could maintain tight controls for an indefinite period.
Relatively sophisticated and on-going scientific monitoring, linked to planning powers to up-grade regulatory measures, for the siting of adjacent roads, gardens, logging and mining, would be necessary.

Notes on the application of Strategy 4 to the Fergusson and Dobu Islands area

Protected areas:
National Park or some other federal government category involving permanent designation

Management within protected areas:
1. limitations on expansion of swidden gardens to areas with "second growth" forest;
2. prohibition of hunting of vertebrates (that are focal taxa) and gathering of sensitive plant species; and
3. limitations on hunting of vertebrates and gathering of sensitive plant species.

Regulation of land use in areas outside of reserves and buffers:
1. regulation of intensity of logging and siting of roads;
2. regulation of mine siting and tailing disposal;
3. regulation of expansion of villages and village agriculture; and
4. regulation of traditional animal and plant exploitation outside of reserves.



Notes on the application of Strategy 4 to the Fergusson and Dobu Islands area

Protected areas - National Park or some other federal government category involving permanent designation

Management within protected areas - 1. limitations on expansion of swidden gardens to areas with "second growth" forest 2. prohibition of hunting of vertebrates (that are focal taxa) and gathering of sensitive plant species 3. limitations on hunting of vertebrates and gathering of sensitive plant species

Regulation of land use in areas outside of reserves and buffers - 6. regulation of intensity of logging and siting of roads 7. regulation of mine siting and tailing disposal 8. regulation of expansion of villages and village agriculture 9. regulation of traditional animal and plant exploitation outside of reserves

from Gordon Brent Ingram 1989 Planning district networks of protected habitat conservation of biological diversity, page 367

Strategy 5 maximum spatial management of internal buffer zones option: high portion of the Fergusson and Dobu Islands area in protected habitat as required with minimum regulation – poor quality of habitat of sites - regulation largely within boundaries of protected areas

In contrast to strategies 1 through 4, the ones which follow are viable in settings where pressures for expansion of consumptive land use are less severe. Highly site-specific land use expansion is envisioned as in the case of mining and infrastructure installation. Negative impacts of land use would bleed into reserves but, due to the extent of protected habitat, could be offset through management in edge zones. This is the maximum spatial management of internal buffer zones option. The strategy might be viable if the people of Fergusson Island

decide not to give mining and logging concessions as they have so far. It might be possible to create a network of wildlife management areas over half of the lowland areas of Fergusson Island. The expansion of logging and new gardens would be limited and mining, especially activities with major off-site impacts, would need to be tightly controlled.

Notes on the application of Strategy 5 to the Fergusson and Dobu Islands area

Protected areas:

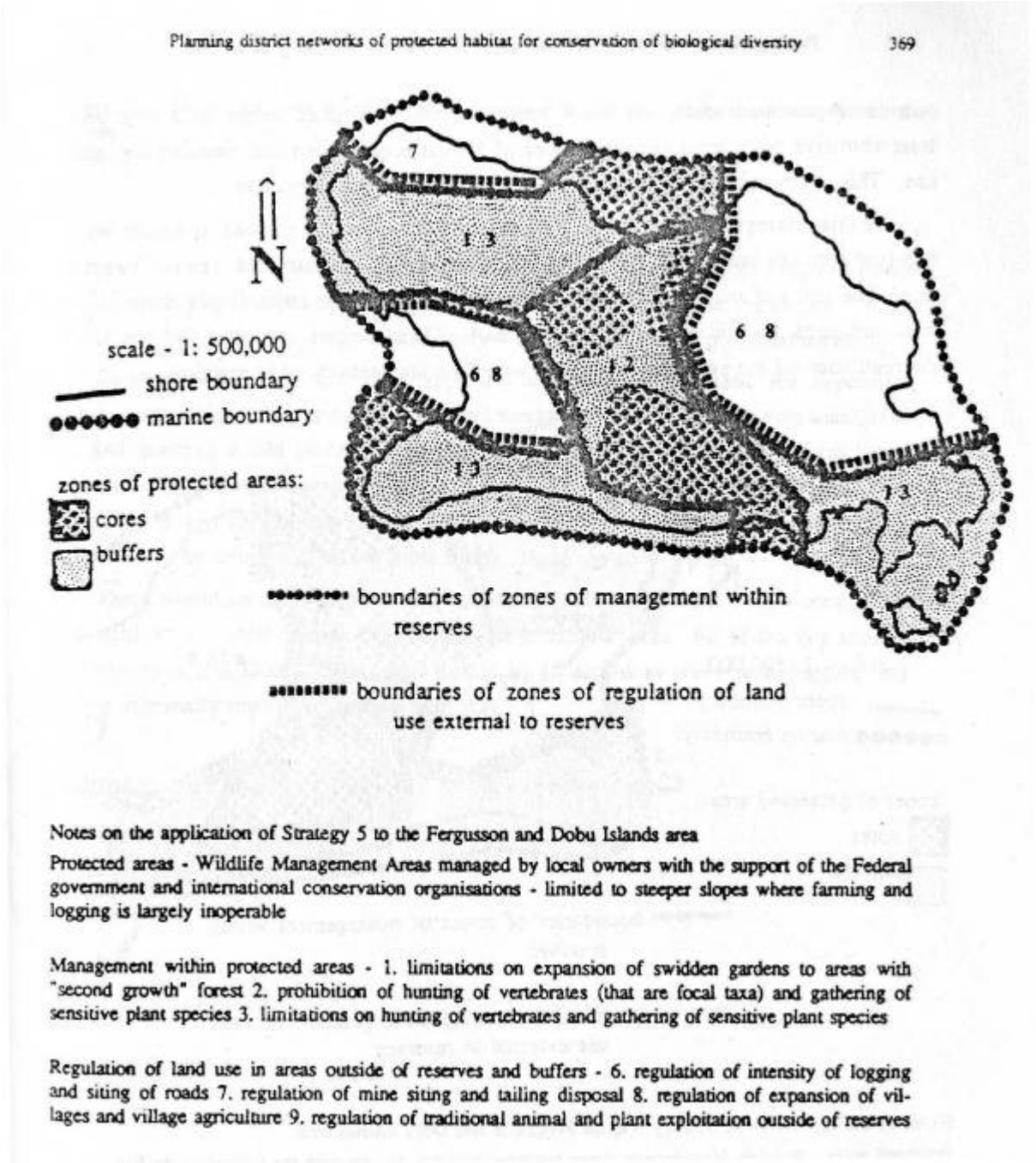
Wildlife Management Areas managed by local owners with the support of the Federal government and international conservation organisations - limited to steeper slopes where farming and logging is largely inoperable

Management within protected areas:

1. limitations on expansion of swidden gardens to areas with "second growth" forest;
2. prohibition of hunting of vertebrates (that are focal taxa) and gathering of sensitive plant species; and
3. limitations on hunting of vertebrates and gathering of sensitive plant species.

Regulation of land use in areas outside of reserves and buffers:

1. regulation of intensity of logging and siting of roads
2. regulation of mine siting and tailing disposal
3. regulation of expansion of villages and village agriculture
4. regulation of traditional animal and plant exploitation outside of reserves



from Gordon Brent Ingram 1989 Planning district networks of protected habitat conservation of biological diversity, page 369

Strategy 6 maximum spatial regulation of external use zones option: high portion of the Fergusson and Dobu Islands area in protected habitat as required with minimum regulation - poor quality of sites - regulation is largely outside of boundaries of protected areas

Conservation activities would emphasize control of large territories, often with inclusion of redundant or marginal habitat types and regulation of land use activities outside of protected areas. Of the 8 strategies, this one relies on the most fluid and least obtrusive boundaries between zones of habitat preservation and consumptive land use. This is the maximum spatial

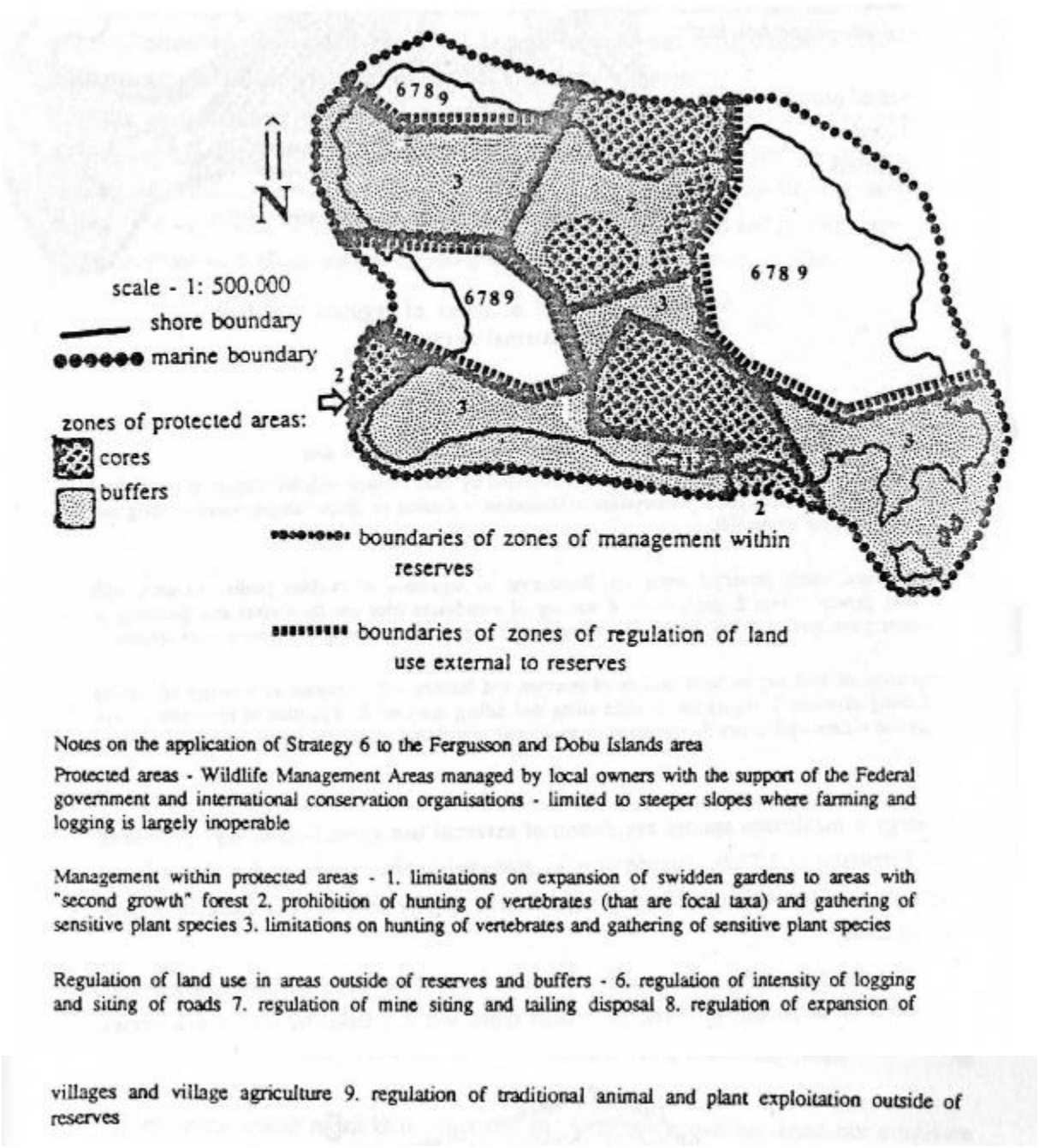
regulation of external use zones option. In this strategy, huge areas of Fergusson Island, would be zoned as buffer with regulation of the impacts of
mining and logging largely implemented through mitigation. The cores of these buffers would only include a few mountain slopes; some strategic lowlands, shores and reefs; and the lake. These buffers would be so large that the regulation of the swidden agriculture would be unnecessary or impractical.

Notes on the application of Strategy 6 to the Fergusson and Dobu Islands area

Protected areas:
Wildlife Management Areas managed by local owners with the support of the Federal government and international conservation organisations - limited to steeper slopes where farming and logging is largely inoperable

Management within protected areas:
1. limitations on expansion of swidden gardens to areas with "second growth" forest;
2. prohibition of hunting of vertebrates (that are focal taxa) and gathering of sensitive plant species; and
3. limitations on hunting of vertebrates and gathering of sensitive plant species.

Regulation of land use in areas outside of reserves and buffers:
1. regulation of intensity of logging and siting of roads;
2. regulation of mine siting and tailing disposal;
3. regulation of expansion of villages and village agriculture; and
4. regulation of traditional animal and plant exploitation outside of reserves.



Notes on the application of Strategy 6 to the Fergusson and Dobu Islands area

Protected areas - Wildlife Management Areas managed by local owners with the support of the Federal government and international conservation organisations - limited to steeper slopes where farming and logging is largely inoperable

Management within protected areas - 1. limitations on expansion of swidden gardens to areas with "second growth" forest 2. prohibition of hunting of vertebrates (that are focal taxa) and gathering of sensitive plant species 3. limitations on hunting of vertebrates and gathering of sensitive plant species

Regulation of land use in areas outside of reserves and buffers - 6. regulation of intensity of logging and siting of roads 7. regulation of mine siting and tailing disposal 8. regulation of expansion of villages and village agriculture 9. regulation of traditional animal and plant exploitation outside of reserves

from Gordon Brent Ingram 1989 Planning district networks of protected habitat conservation of biological diversity, page 370

Strategy 7 more viable island metaphor option: high portion of the Fergusson and Dobu Islands area in protected habitat as required with minimum regulation - high quality of habitat of sites – regulation largely within boundaries of protected areas

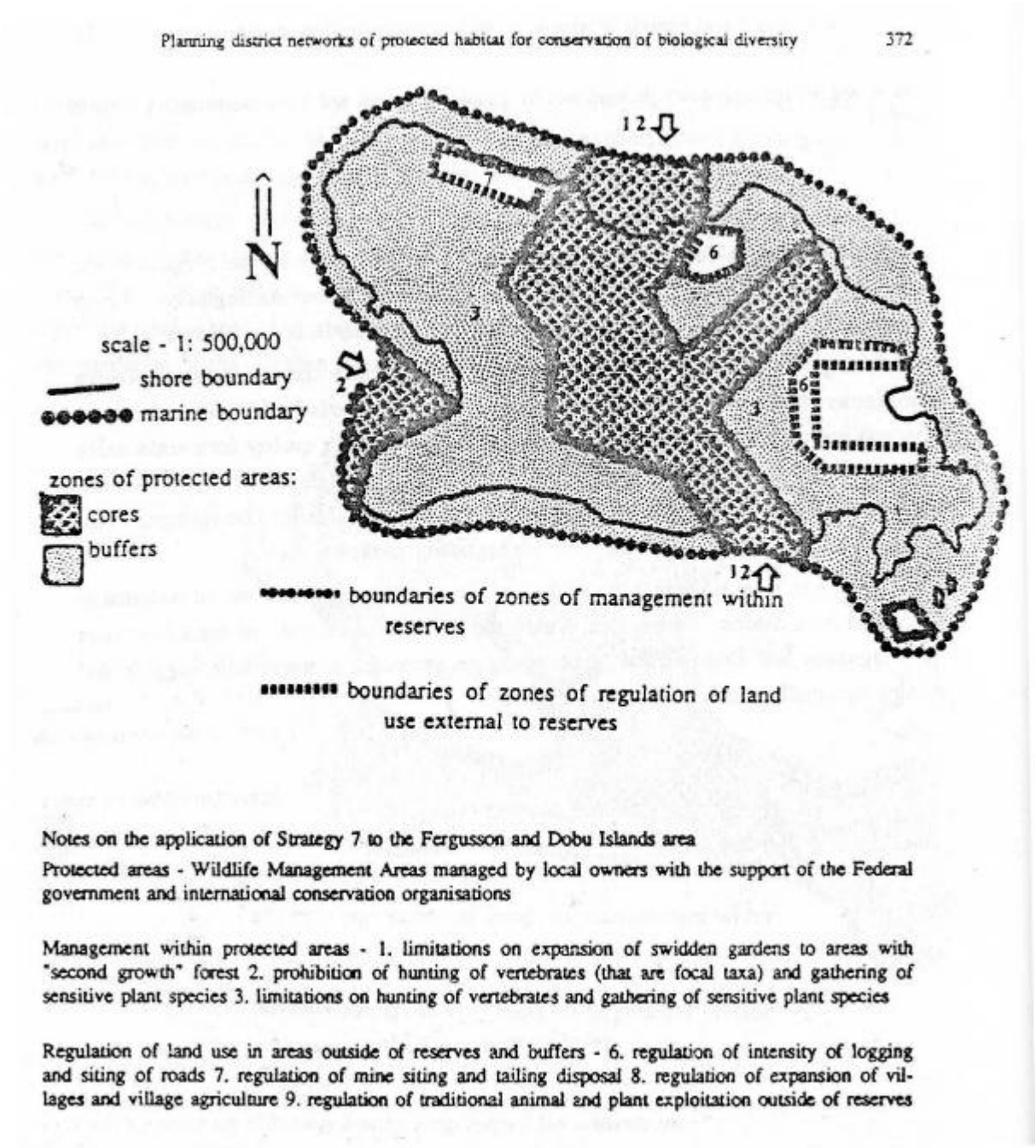
Strategy 7 may be the ideal approach to minimize the need for expensive management while still relying on the island metaphor. Needs for on-going manipulation and policing would be largely be pre-empted by the high quality core areas being surrounded by the extensive buffer areas to accomplish this. Broad territorial monitoring would be crucial to allocation of the scarce resources available for management. This approach can be thought of as the more viable

island metaphor option. There would be no regulation of the swidden gardens and these would continue to be tended, to a modest degree, even within the protected areas. All of the key sites in the Fergusson and Dobu Islands area would be protected as cores with logging and mining minimally regulated, as they are today.

Protected areas:
Wildlife Management Areas managed by local owners with the support of the Federal government and international conservation organisations

Management within protected areas:
1. limitations on expansion of swidden gardens to areas with "second growth" forest;
2. prohibition of hunting of vertebrates (that are focal taxa) and gathering of sensitive plant species; and
3. limitations on hunting of vertebrates and gathering of sensitive plant species.

Regulation of land use in areas outside of reserves and buffers:
1. regulation of intensity of logging and siting of roads
2. regulation of mine siting and tailing disposal
3. regulation of expansion of villages and village agriculture
4. regulation of traditional animal and plant exploitation outside of reserves



from Gordon Brent Ingram 1989 Planning district networks of protected habitat conservation of biological diversity, page 372

Strategy 8 conservation membrane with maximum security: high portion of the Fergusson and Dobu Islands area in protected habitat with high quality sites with minimum regulation - regulation largely outside the boundaries of protected areas

Like strategy 6, the edges between zones of habitat protection and land use expansion could be subtle and often layered in numerous buffer zones. The higher quality of the sites and the relatively large portion of the Fergusson and Dobu Islands area in reserves would mean that pressures for land use expansion need not dominate site selection and that, in turn, it is feasible to place restrictions on land use activities in areas outside of the reserves. This approach would

favour well-sited mining operations over expansion of mining operations. In post-Independence Papua New Guinea, this approach to habitat conservation seems the most efficient and secure in terms of long-term balancing of cost, benefits and risks. Unfortunately, it is also the most utopian for most situations, at the present time.

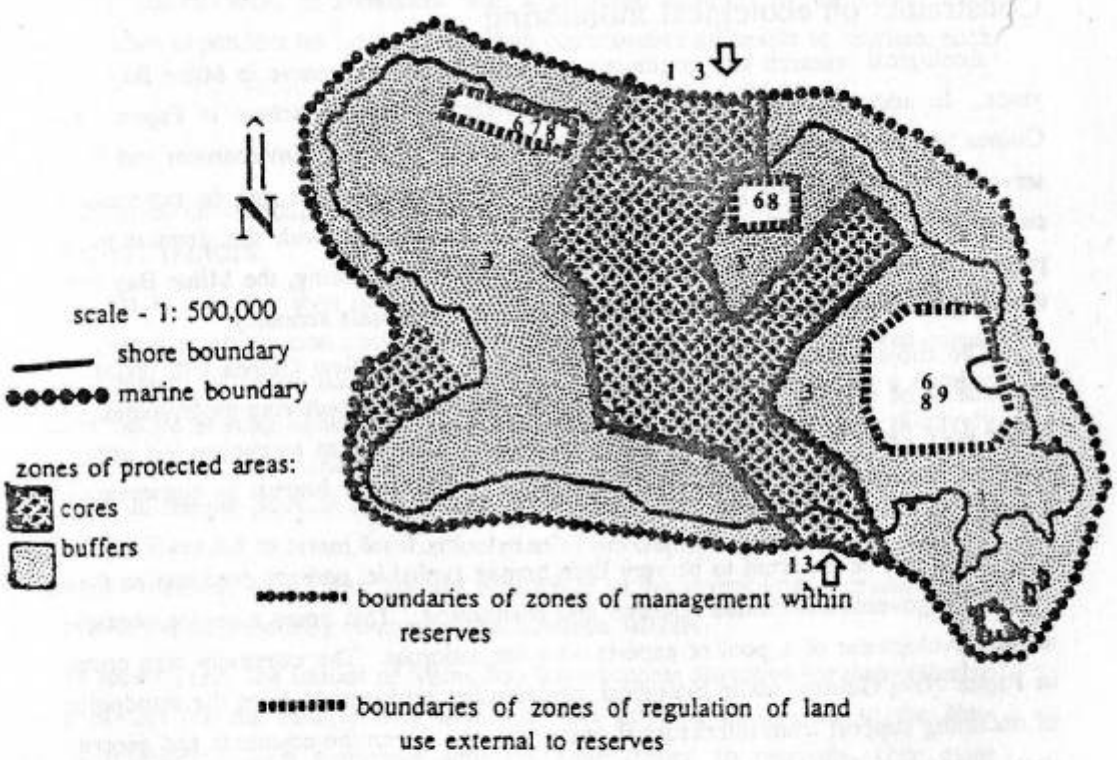
This strategy would also be the most problematic for the provincial government. Funding for the habitat conservation and community development would need to come from the national government and international organisations but the Milne Bay provincial government would see little royalty revenues to, in turn, fund the necessary regulation of extractive activities.

Notes on the application of Strategy 8 to the Fergusson and Dobu Islands area

Protected areas:
Wildlife Management Areas managed by local owners with the support of the Federal government and international conservation organisations.

Management within protected areas:
1. limitations on expansion of swidden gardens to areas with "second growth" forest;
2. prohibition of hunting of vertebrates (that are focal taxa) and gathering of sensitive plant species; and
3. limitations on hunting of vertebrates and gathering of sensitive plant species.

Regulation of land use in areas outside of reserves and buffers:
1. regulation of intensity of logging and siting of roads;
2. regulation of mine siting and tailing disposal;
3. regulation of expansion of villages and village agriculture; and
4. regulation of traditional animal and plant exploitation outside of reserves.



Notes on the application of Strategy 8 to the Fergusson and Dobu Islands area

Protected areas - Wildlife Management Areas managed by local owners with the support of the Federal government and international conservation organisations

Management within protected areas - 1. limitations on expansion of swidden gardens to areas with "second growth" forest 2. prohibition of hunting of vertebrates (that are focal taxa) and gathering of sensitive plant species 3. limitations on hunting of vertebrates and gathering of sensitive plant species

Regulation of land use in areas outside of reserves and buffers - 6. regulation of intensity of logging and siting of roads 7. regulation of mine siting and tailing disposal 8. regulation of expansion of villages and village agriculture 9. regulation of traditional animal and plant exploitation outside of reserves

from Gordon Brent Ingram 1989 Planning district networks of protected habitat conservation of biological diversity, page 373

Lake Lavu Wildlife Conservation Area, Fergusson Island, March 1989, photograph by Gordon Brent Ingram

Conclusions:
The urgent need for a comprehensive plan for both development and *in situ* conservation of biological diversity for Fergusson Island and other islands off of New Guinea

There is an urgent need for a comprehensive plan for both development and *in situ* conservation of biological diversity for Fergusson Island. There are also a shifting set of opportunities for conservation – as well as constraints on the prospects. In envisioning what can be done with limited conservation resources in coming years and decades, the extent of the constraints on conservation warrant re-examination.

Constraints on further biological inventory & ecological monitoring
Ecological research will continue to be sporadic and expensive in Milne Bay Province. In addition, there is a shortage of scientists and researchers in Papua New Guinea and in the south Pacific region. The national Office of Environment and Conservation, as well as the Institute of Papua New Guinea Studies, can be expected to continue to facilitate research but this can be problematic with the devolution of powers to the provinces. Fortunately, for at least the time being, the Milne Bay provincial government can be expected to take research proposals seriously.

The Biology Department of the University of Papua New Guinea will probably continue to be the key link in establishing and maintaining monitoring programmes. It is the only force in the land that has the scientific expertise to appreciate the importance of biological diversity and to perceive an institutional interest in conservation efforts.
There can be expected to be very little money available, perhaps even less so than today, for government-funded research and monitoring. This poses a severe obstacle to the development of a pool of experts who are nationals. The extremely high costs, in Papua New Guinea, make biological conservation problematic from the standpoint of obtaining support from international organisations. Given the economic and geopolitical dynamics of the regions, new funding links with countries other than Australia, including Japan, will be necessary.

There are also constraints on choice of a strategy for the *in situ* conservation of local biological diversity. Choice of a strategy is really a matter for the provincial government and the communities that are the landowners. The contradiction here is that conservation is largely the jurisdiction of the federal government. Given the deteriorating influence of the national government, a surrogate such as a national conservation foundation, with the backing of international organisations, might be able to develop a cooperative relationship with provincial politicians.

Any kind of discussion of conservation options, in the present climate of unhindered extraction, is a potential threat to the interests of logging and mining as well as local politicians. Given the isolation of the area, the internal antagonisms and the low levels of education, opponents of limitations on logging and mining could easily incite various forms of xenophobia. The key will be in supporting the articulation of needs for habitat conservation, as consistent with a particular strategy, by the church parishes, families dependent on local species, and communities amenable to tourism, such as Nade.

There continue to be severe constraints at the provincial and national levels of government on habitat protection plan from economic and institutional factors. A clue to why the style of resource development, emphasizing maximized profit and long-term environmental costs, has been allowed to progress so unhindered comes from the history of Milne Bay Province. Papua was an English colony for a number of years before coming under Australian administration. Colonialism came relatively early in this part of New Guinea with some white settlement with similarities to earlier settlement in remote parts of neighbouring Queensland. The presence of the Allies in World War II tended to retard local articulation of development needs. More recently, corporate expansion in the area has had similarities to the severe grip of multinational concerns in the neighbouring country of the Solomon Islands.

In recent years, the islands of Milne Bay have become attractive for their valuable resources and for the relative ease involved with shipping in contrast to the New Guinea mainland. Such extractive activities have tended to preclude other more community-based economic projects, and the subsequent links to the international import - export economy has tended to raise costs and make life outside of the wage economy more difficult. Subsistence economic patterns are being made less viable and in some areas are being displaced.

What we see in Milne Bay today are two competing approaches to economic and social development. The extractive approach allows for concentration of wealth into the hands of a few individuals with most of the profits leaving the area with the materials going to Japan. In

contrast, the churches have worked towards a community-based development emphasizing better schools and health care facilities. Habitat conservation and wildlife tourism would not generate much money for individuals but could contribute to modest sustainable generation of income within villages. But the political powers in Alotau would receive much less income from conservation.

Analysis of each strategy, in terms of the possibilities of finding compatibility with needs for both development and broader habitat conservation, can be undertaken by a range of stakeholders, of different education levels and relationships to western knowledge systems, over the coming months, years and decades. At this writing, in April of 1989, it is still a bit premature to recommend the strategy that will be most compatible with the direction of local social and economic development. Given the level of endemism and extent of sensitive, island biota, core preserves which are highly secure are necessary. At this time, my choice is for Strategy 7 though if the rapacious selling of timber and mining rights continues, throughout this and next year, Strategy 3 may be the best route available.

Elder, Island of Dobu, D'Entrecasteaux Islands, Papua New Guinea, March 1989, photograph by Gordon Brent Ingram

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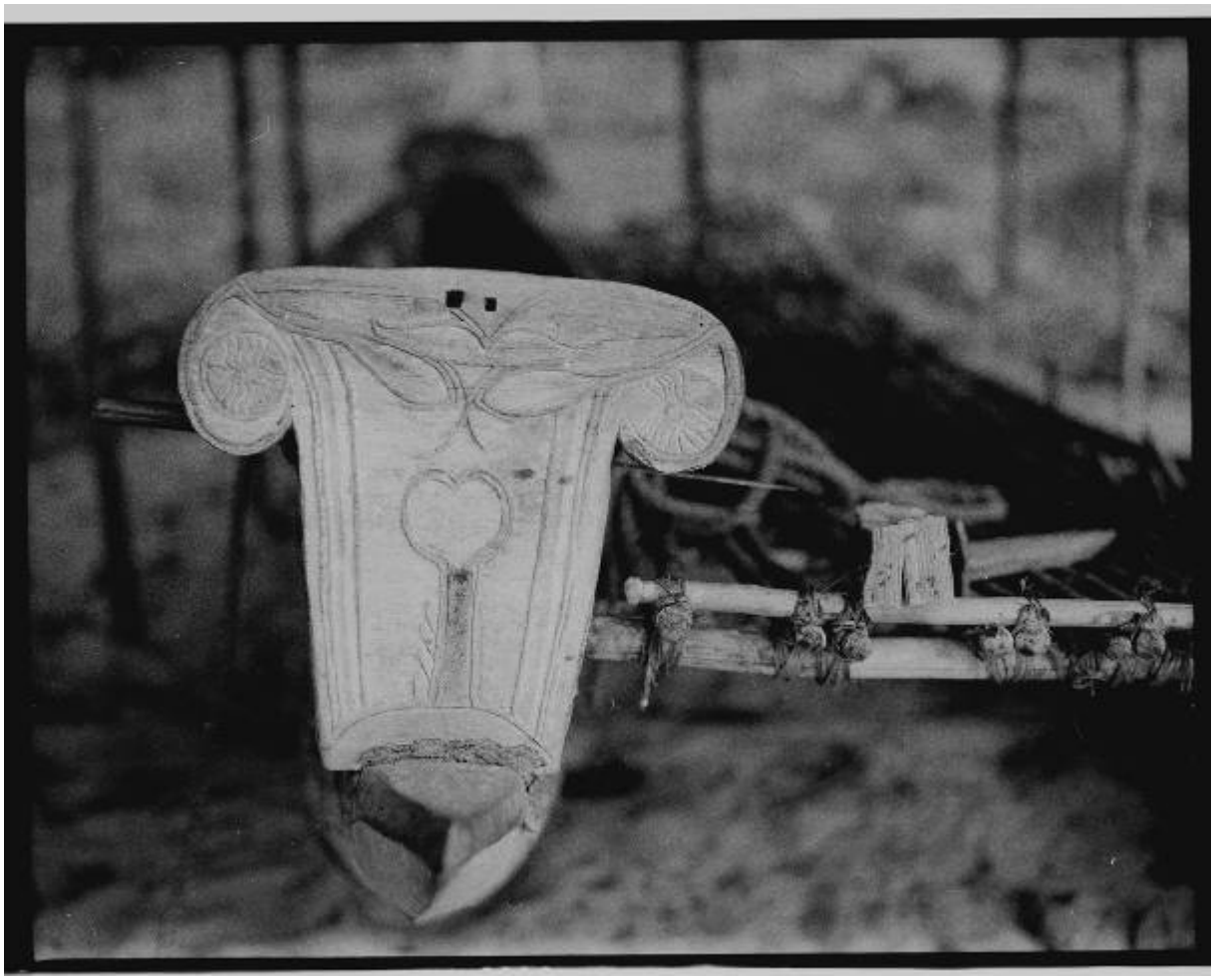

Trobriand-style canoe design, Nade, on the south coast of Fergusson Island, March 1989, photograph by Gordon Brent Ingram

References

Allied Forces Southwest Pacific Area. 1942. Terrain Study N. 23: Area Study of D'Entrecasteaux and Trobriand Islands. on file Papua New Guinea Collection, University of Papua New Guinea.

Ashton, P. S. 1982. Dipterocarpaceae. *Flora Malesiana* Series 1, Volume 9(2): 237 - 552.

van Balgooy, M. M. J. 1976. Phytogeography. In *New Guinea Vegetation*. K. Paijmans (editor). 1 - 22. Canberra, Australia, Australian National University Press.

Beehler, B. 1981. Ecological structuring of forest bird communities in New Guinea. In *Biogeography and Ecology of New Guinea*. Volumes 1 & 2. J. L. Gressit (editor). 837 - 861. London, W. Junk.

Beehler, B. 1985. Conservation of New Guinea rainforest birds. ICBP Technical Publication No. 4.

Beehler, B. M. and B. W. Finch. 1985. *Species - Checklist of the Birds of New Guinea.* Royal Australiasian Ornithologists Union Monograph No. 1. Moonee Ponds, Victoria, Royal Australiasian Ornithologists Union.

Beehler, B. M., Pratt, M. and D. A. Zimmerman. 1986. *Birds of New Guinea*. Princeton, New Jersey, Princeton University Press.

Bell, H. 1984. The importance of foothill forest in the diversity of rainforest birds in New Guinea. *The Emu* 84: 225 - 235.

Benedict, R. 1934. *Patterns of Culture*. Cambridge, Massachusetts, The Riverside Press.

Bleeker, P. 1983. *Soils of Papua New Guinea*. Canberra, Australia, CSIRO and Australian National University Press.

Brass, L. J. 1959. Results of the 5th Archbold Expedition to New Guinea (1956 - 57). *Bulletin of the American Museum of Natural History* 118 (1).

Burgess, P. F. 1971. The effect of logging on hill Dipterocarp forests. *Malayan Nature Journal* 24: 231 - 237.

Carrier, J. 1982. Conservation and conceptions of the environment: A Manus Province case study. In *Traditional Conservation in Papua New Guinea: Implications for today.* L. Morauta, J. Pernetta, W. Heaney (editors). 39 - 43. Boroko, Papua New Guinea, Institute for Applied Social and Economic Research.

Chan, H. T. 1981. Reproductive biology of some Malaysian Dipterocarps III. Breeding systems. *The Malaysian Forest* 44 (1): 28 - 36.

Coates, B. J. 1985. *The Birds of Papua New Guinea Including the Bismark Archipelago and Bougainville.* Volume I Non-Passerines. Alderley, Queensland, Australia, Dove Publications.

Constitutional Planning Committee of Papua New Guinea. 1974. Final Report of the Constitutional Planning Committee. Port Moresby, Government of Papua New Guinea.

Crocombe, R. 1974. An approach to the analysis of land tenure systems. In *Land Tenure in Oceania*. H. P. Lundsgaarde (editor). 1 - 17. Honolulu, Hawai'i, University of Hawaii Press.

Davidson, J. 1983. Forestry in Papua New Guinea: A case study of the Gogol Woodchip Project near Madang. In *Forest and Watershed Development and Conservation in Asia and the Pacific*. L. S. Hamilton (editor). 19 - 138. Boulder, Colorado, Westview Press.

Davies, H. L. and D. J. Ives. 1965. *The Geology of Fergusson and Goodenough Islands, Papua. Geology and Geophysics* Report N. 82. Canberra, Commonwealth of Australia.

De'ath, C. 1982. Forest conservation practices in Papua New Guinea. In *Traditional conservation in Papua New Guinea: Implications for today*. L. Morauta, J. Pernetta, W. Heaney (editors). 203 - 215. Boroko, Papua New Guinea, Institute for Applied Social and Economic Research.

Defense Mapping Center. 1974. Cape Vogel to Cape Nelson with the D'Entrecasteaux Islands. 1:300,000. Washington, D.C., U.S.A., Defense Mapping Center, Department of Defense.

Diamond, J. M. 1971. Comparison of faunal equilibrium turnover rates on a tropical island and a temperate island. *Proceedings of the National Academy of Sciences* (USA): 68 (11): 2742 - 2745.

Diamond, J. M. 1972. Biogeographic kinetics: Estimation of relaxation times for avifaunas of southwest Pacific islands. *Proceedings of the National Academy of Sciences* (USA) 69 (11): 3199 - 3203.

Diamond, J. M. 1986. The design of a nature reserve system for Indonesian New Guinea. In *Conservation Biology: The science of scarcity and diversity*. M. E. Soule (editor). 485 - 503. Sunderland, Massachusetts, Sinauer Associates.

Diamond, J. M. 1987. April 6, 1987 letter to G. B. Ingram with enclosure. on file Department of Physiology, UCLA School of Medicine, University of California - Los Angeles, Los Angeles, California 90024 USA. (and on file with G. B. Ingram).

Eaton, P. 1984. Institutional and legislative frameworks in the field of environment in Papua New Guinea. Presented at the Expert Group Meeting on the Integration of Environment in Development: Institutional and Legislative Aspects: 5 - 11 June, 1984, Tokyo. on file University of Papua New Guinea, Port Moresby.

Eaton, P. 1986. Grassroots Conservation: Wildlife Management Areas in Papua New Guinea. Land Studies Centre Report 86/1. Port Moresby, University of Papua New Guinea, University, Papua New Guinea.

Eaton, P. no date. Tenure and taboo: Customary rights and conservation in South Pacific. on file New Guinea Collection, University of Papua New Guinea, University, Port Moresby.

Forshaw, J. M. 1973. *Parrots of the World*. Melbourne, Australia, Lansdowne.

Fortune, R. F. 1932. *The Sorcerers of Dobu: The social anthropology of the Dobu islanders of the Western Pacific.* London, Routledge.

Frith, C. C. 1979. Othnithological Literature of the Papuan Subregion 1915 to 1976: An Annotated Bibliography. Bulletin of the American Museum of Natural History 164 (3).

Goodwin, D. 1983. *Pigeons and Doves of the World*. Ithaca, New York, Cornell University Press.

Gomez, E. D. and H. T. Yap. 1984. Monitoring reef communities. In *Coral Reef Management Handbook*. R. A. Kenchington and B. Hudson (editors). Jakarta, Indonesia, UNESCO.

Gidu, A. G. 1978. 28 June, 1978 memorandum to the Head Master, Bolubolu Electorate (File 14 - 10 - 3 (A)) from A. G. Gidu, District Wildlife Officer, Departments of Lands and Environment, Wildlife Division, Bolubolu, Goodenough Island, Milne Bay Province.

Healey, C. J. 1977. Effects of human activity on *Paradiseae minor* in the Time Valley - New Guinea. *The Emu* 78: 149 - 155.

Hill, J. E. and J. D. Smith. 1984. *Bats: A natural history*. London, British Museum (Natural History).

Honack, J. H., K. E. Kinman and J. W. Koeppl (editors). 1982. *Mammal Species of the World: A taxonomic and geographic reference*. Lawrence, Kansas, Association of Systematics Collections.

IUCN (The World Conservation Union) & UNEP (United Nations Environmental Programme). 1986. *Review of the Protected Areas System in Oceania*. Gland, Switzerland, IUCN.

House, A. P. N. 1983. The use of palms by man on Siberut Islands, Indonesia. *Principes* 27(1): 12 - 17.

Jenness, D. and A. Ballantyne. 1920. *The Northern D'Entrecasteaux*. Oxford, England, Clarendon Press.

Jones, D. T. 1988. May 6 letter to Gordon Brent Ingram including portions of IBPGR Citrus Data Base on file Jabatan Botani, Fakulti Sains, Universiti Malaya, Kuala Lumpur, Malaysia.

Koopman, K. F. 1982. Results of the Archbold Expeditions No. 109. Bats from Eastern Papua and the East Papuan Islands. *American Museum Novitates*: 2747.

Lamb, D. 1977. Conservation and management of tropical rain - forest: A dilemma of development in Papau New Guinea. *Biological Conservation* 4 (2): 121 - 129.

Laurie, E. M. O. 1952. Mammals collected by Mr. Shaw Mayer in New Guinea 1932 - 1949. *Bulletin of the British Museum of Natural History Zoology* 1 (10).

Laurie, E. M. O. and J. E. Hill. 1954. *List of Land mammals of New Guinea, Celebes and Adjacent Islands. 1758 - 1952*. London, British Museum (Natural History).

Lecroy, M. 1981. The genus Paradisaea display and evolution. *American Museum Novitates*: 2714: 1 - 52.

Lecroy, M., A. Kulupi and W. S. Peckover. 1980. Goldie's Bird of Paradise: Display, natural history and traditional relationships of people to the bird. *Wilson Bulletin* 92 (3): 289 - 301.

Lecroy, M., W. S. Peckover, A. Kulupi and J. Manseima. 1983. Bird Observations on Normanby and Fergusson, D'Entrecasteaux Islands, Papua New Guinea. *Wildlife in Papua New Guinea* No. 83/1. Boroko, Papua New Guinea, Office of Environment and Converation.

Lithgow, D. and P. Staalsen. 1965. Languages of the D'Entrecasteaux Islands. Port Moresby, Department of Information and Extension Services, Territory of Papua and New Guinea.

Loffler, E. 1977. *Geomorphology of Papua New Guinea*. Canberra, Australia, CSIRO.

McAlpine, J. R. and G. Keig. 1983. *Climate of Papua New Guinea*. Canberra, Australia, CSIRO.

MacDonald, D. (editor). 1984. *The Encyclopedia of Mammals*: 2. London, George Allen and Unwin.

Mackay, R. D. 1976. *New Guinea*. Amsterdam, Time-Life Books.

Malinowski, B. 1922. *Argonauts of the Western Pacific*. London, Routledge and Kegan.

Marsh, H., G. E. Heinsohn and L. M. Marsh. 1984. Breeding cycle, life history and population dynamics of the Dugong, *Dugong dugon* (Sirenia: Dugongidae). *Australian Journal of Zoology* 32: 767 - 788.

Mayr, E. 1941. *List of New Guinea Birds*. New York, American Museum of Natural History.

Menzies, J. I. *Handbook of New Guinea Frogs*. Wau, Papua New Guinea, Wau Ecology Institute.

Menzies, J. and E. Dennis. 1979. *Handbook of New Guinea Rodents*. Wau, Papua New Guinea, Wau Ecology Institute.

Moresby, J. 1876. *New Guinea and Polynesia: Discoveries and surveys in New Guinea and the D'Entrecasteaux Islands*. London, Murray Publishers.

Mukherjee, S. K. 1985. *Systematic and Ecogeographic Studies of Crop Genepools: 1. Mangifera L.* Rome, IBPGR.

Munro, I. S. R. 1967. *The Fishes of New Guinea*. Port Moresby, Austrialian Department of Agriculture, Stock and Fisheries.

Paijmans, K. 1975. *Vegetation Map of Papua New Guinea* (and explanatory notes). Melbourne, Australia, CSIRO.

Ollier, C. D. and C. F. Pain. 1980. Actively rising surficial gneiss domes in Papua New Guinea. *Journal of the Geological Society of Australia* 27: 33 - 44.

Ollier, C. D. and C. F. Pain. 1981. Active gneiss domes in Papua New Guinea: New tectonic landforms. *Zeitschrift fur Geomorphologie* 25(2): 133 - 145.

Ollier, C. D. and C. F. Pain. 1988. Morphotectonics of Papua New Guinea. *Zeitschrift fur Geomorphologie* Supplement 69: 1 - 16.

Pain, C. F., Kensington, and C. D. Ollier. 1981. Geomorphology of a Pliocene granite in Papua New Guinea. *Zeitschrift fur Geomorphologie* 25(3): 249 - 258.

Papua New Guinea Bureau of Statistics. 1981. National Census 1980: Milne Bay Province Preliminary Field Counts. Port Moresby, Papua New Guinea Bureau of Statistics.

Papua New Guinea Department of the Milne Bay Province. 1978. Constitution of the Milne Bay Provincial Government. on file Milne Bay Provincial Government, Alotau, Papua New Guinea.

Pernetta, J. and Hill, L. 1982. International pressures on resource management in Papua New Guinea. In *Traditional Conservation in Papua New Guinea: Implications for Today*. L. Morauta, J. Pernetta, W. Heaney (editors). 319 - 332. Boroko, Papua New Guinea, Institute for Applied Social and Economic Research.

Pigram, C. J. 1988. letter to Gordon Brent Ingram on file Bureau of Mineral Resources, Geology and Geophysics, Division of Marine Geosciences and Petroleum Geology, Canberra, Australia.

Pilgram, C. J. and H. L. Davies. Terranes and the accretion history of the New Guinea orogen. *Journal of Australian Geology and Geophysics* 10: 193 - 211.

Powell, J. M. 1976. Ethnobotany. In *New Guinea Vegetation*. K. Paijmans (editor). 106 - 183. Canberra, Australian National University Press.

Pratt, T. K. 1981. Biogeography of birds of New Guinea. In *Biogeography and Ecology of New Guinea*. Volumes 1 & 2. J. L. Gressit (editor). 815 - 836. London, W. Junk.

Rand, A. L. and E. T. Gilliard. 1967. *Handbook of New Guinea Birds*. London, Weidenfeld and Nicolson.

Reti, I. 1986. Resolving conflicts between traditional practices and park management. *Parks* 11 (1): 17 - 19.

Reuther, W., H. J. Webber and L. D. Batchelor. 1967. *The Citrus Industry*. Volume 1. History, World Distribution, Botany and Varieties. Berkeley, California, University of California.

Rosewater, J. 1965. The family Tridacnidae in the Indo - Pacific. *Indo-Pacific Mollusca* 1 (6): 347 - 360.

Rothschild, W. and E. Hartert. 1896. Contributions to the ornithology of the Papuan Islands. IV. List of a collection made by Albert S. Meek on Fergusson, Trobriand, Egum, and Woodlark Islands. *Novitates Zoologicae* III(3): 233 - 251.

Rothschild, W. and E. Hartert. 1914. On collection of birds from Goodenough Island. *Novitates Zoologicae* XXI(1): 1 - 12.

Routley, R. and V. Routley. 1977. Destructive forestry in Australia and Melanesia.In *The Melanesian Environment.* J. H. Winslow (editor). 374 - 397. Canberra, Australia National University Press.

Saulei, S. M. 1984. Natural regeneration following clear - fell logging operations in the Gogol Valley, Papua New Guinea. *Ambio* 13 (5 - 6): 351 - 354.

Seddon, G. 1984. Logging in the Gogol Valley, Papua New Guinea. *Ambio* 13 (5 - 6): 345-50.

Simberloff, D. S. and L. G. Abele. 1976. Island biogeography theory and conservation practice. *Science* 191: 285 - 286.

South Pacific Regional Environment Programme/Government of Papua New Guinea. 1986. Papua New Guinea. In Report of the Third South Pacific National Parks and Reserves Conference held in Appia, Western Samoa, 1985. Volume 3 Country Reviews. Noumea, New Caledonia, South Pacific Commission.

Spring, C. S. 1981. Status of marine turtle populations in Papua New Guinea. Subsistence hunting of marine turtles of Papua New Guinea. In.*Biology and Conservation of Sea Turtles*. K. A. Bjorndal (editor). 281 - 295. Washington, D.C., Smithsonian Institution.

Tylor, J. M (editor). 1979. *The Status of Endangered Australasian Wildllife*. Adelaide, Australian, Royal Zoological Society of South Australia.

Taylor, J. M., J. H. Calaby, H. M. Van Deusen. 1982. A revision of the genus Rattus (Rodentia, Muridae) in the New Guinean Region. *Bulletin of the American Museum of Natural History* 173 (3).

Taylor, J. M., J. H. Calaby and S. C. Smith. 1983. Native Rattus, land bridges and the Australian region. *Journal of Mammalogy* 64 (3): 463 - 465.

Thomas, O. 1895. On some mammals collected by Mr. Albert Meek on Fergusson Island, D'Entrecasteaux Group. *Novitates Zoologica* 2: 163 - 166.

Thornback, J. and M. Jenkins. 1981. *The IUCN Mammal Red Data Book*. Part 1. Gland, Switzerland, IUCN.

Van Deusen, W. M. 1957. Results of the Archbold Expeditions. No. 76. A new species of Wallaby (Genus Dorcopsis) from Goodenough Island, Papua. *American Museum Novitates* 1826: 1 - 25.

Vernon, J. E. N. 1986. *Corals of Australia and the Indo-Pacific*. North Ryde, New South Wales, Australia, Angus and Robertson.

Waiko, J. D. 1977. The people of Papua New Guinea, their forests and their aspirations. In *The Melanesian Environment*. J. H. Winslow (editor). 407 - 429. Canberra, Australia National University Press.

Waiko, J. and K. Jiregari. 1982. Conservation in Papua New Guinea: Custom and tradition. in *Traditional Conservation in Papua New Guinea: Implications for today*. L. Morauta, J. Pernetta, W. Heaney (editors). 21 - 38. Boroko, Papua New Guinea, Institute for Applied Social and Economic Research.

Wallace, A. F. 1869. *The Malay Archipelago The Land of the Orang-Utan and the Bird of Paradise: A narrative of travel with studies of man and nature*. London, Macmillan.

Whitaker, R., Z. Whitaker and D. Mills. 1982. *Reptiles of Papua New Guinea*. Konedobu, Papua New Guinea, Department of Lands and Environment.

White, K. J. 1977. Constraints on developing forest industries in Papua New Guinea. In *The Melanesian Environment*. J. H. Winslow (editor). 398 - 406. Canberra, Australia National University Press.

Wood, A. W. 1981. The soils of New Guinea. In *Biogeography and Ecology of New Guinea*. Volumes 1 and 2.J. L. Gressit (editor). 73 - 83. London, W. Junk.

Wright, A. 1985. Marine resource use in Papua New Guinea: Can traditional concepts and contemporary development be integrated? In *The Traditional Knowledge and Management of Coastal Systems in Asia and the Pacific*. K. Ruddle and R. E. Johannes (editors). 79 - 99. Jakarta, Indonesia, UNESCO.

Yamaguchi, M. 1977. Conservation and cultivation of giant clams of the tropical Pacific. *Biological Conservation* 11: 13 - 20.

Young, M. W. 1971. *Fighting With Food: Leadership, values and social control in a Massim society*. London, Cambridge University Press.

Zweifel, R. 1987. Partial list of the frogs and reptiles of the D'Entrecasteaux Islands on file in data base at American Museum of Natural History, New York (list as of 13 April 1987).

recently cleared swidden garden planted with yams, near the village of Salamo, on the south coast of Fergusson Island, March 1989, photograph by Gordon Brent Ingram

Notes

[1] This PDF version of the 1989 report is based on a reconstruction in January of 2009. The original UNIX code was converted to Word part automatically and part manually. Because this is now more of a historical document than a current assessment of the situation on Fergusson Island, further editing and updating has been minimal. The original paper copies of the scenarios have been lost and those provided here are copied from Ingram's dissertation, Gordon Brent Ingram. 1989. Planning district networks of protected habitat conservation of biological diversity: A manual with applications for marine islands with primary rainforest. A dissertation for a Doctor of Philosophy degree in Environmental Planning, the University of California, Berkeley. Ann Arbor, Michigan, University Microfilms International. Order Number 9006370. The photographs in this version were taken as part of the field work for the dissertation and research for this report but were only added in the 2009 PDF.

[2] This was from a letter to Dr. M. K. Tolba, Secretary-General, UNEP, Nairobi from Paul Cotton, Permanent Representative, New Zealand Embassy, Athens, Greece dated 18 January 1984. It was in response to a July 1983 query from UNEP to its member states in regards to national programmes of *in situ* conservation of endangered, plant and animal genetic resources. The ecological region and district approach was developed by the New Zealand Forest Service as an outgrowth of controversies over competing proposals for logging and conservation for the last, large tract of temperate rainforest on the southern island.

[3] Letter to G. Brent Ingram from Cliff Ollier, 6 June 1988, on file The University of New England, Armidale, New South Wales, Australia

[4] These smaller islands include Neumara and Waiope in the southeast, Naua Island in the southwest and the Barrier Islands in the northwest.

[5] Words in local languages for species are in the Dobuan language unless another language is indicated with curved brackets ().

[6] The "Appia Convention" is on file at the South Pacific Regional Environmental Programme, South Pacific Convention, Noumea, New Caledonia.

Eucalypt and palm savannah, south-western Fergusson Island, March 1989, photograph by Gordon Brent Ingram