ISLAND LIFE IN THE 21ST CENTURY: CURRENT STATUS AND CHALLENGES FOR MAINSTREAMING THE CONSERVATION AND SUSTAINABLE USE OF BIODIVERSITY IN THE PACIFIC ISLANDS[1]

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1 INTRODUCTION

This paper attempts to present a "quick snapshot" of the current status of biodiversity in the Pacific Islands and the prospects and challenges for the mainstreaming of its conservation and sustainable use by Pacific Island peoples during the 21st century. It is hoped that it will form the basis for useful discussion during the conference. Particular emphasis is placed on providing an understanding of the status of biodiversity, not only from a scientific perspective, but also from the view of the Pacific Island peoples who have owned and used it for millennia! It is stressed that most Pacific Island societies have rich terrestrial, marine and freshwater biodiversity inheritances and in-depth, time-tested (and hard-won) knowledge related to their use and management.

Sadly, and perhaps inexcusably, this inheritance, which has been the foundation for sustainable island life for countless generations, is now seriously threatened, mainly by the current generation of Pacific Islanders and their overseas collaborators, i.e., by modern "development". There are already far too many examples of overexploitation, habitat destruction, endangerment and extinction of Pacific Island plants and animals, and the loss and devaluation of the priceless ethnobiological knowledge that Pacific Islanders have accumulated over thousands of years of close contact with their island environment. This has been, in no small way, due to the fact that biodiversity conservation has not been seen as integral to the "mainstream" of the development process over the past century or more, and particularly in the past five "development decades".

It is also stressed that we should not fall into the 'trap' of 'idealizing' traditional management/sustainable use. The current traditional knowledge base has been 'won' or accumulated over the millennia by trial and error – the error resulting in a number of local extirpations and extinctions of birds, shellfish and other organisms. In addition, the use of some aspects of that knowledge/practices (e.g., the harvest of turtles or sea birds and their eggs) can still result in overexploitation when it is divorced from the broader cultural and environmental context, or is miss-used, e.g. for artisanal or commercial purposes. It must also be stressed that Pacific Island societies are not 'frozen' societies, but dynamic, and that we can't isolate the 'ideal' from the changing lifestyles, values and users.

This paper argues that the mainstreaming of the conservation of the unique terrestrial, freshwater and marine biodiversity of the Pacific Islands, including the traditional knowledge and uses that Pacific Island peoples have for this biodiversity, is by far the most important precondition for ecologically, economically and culturally sustainable development in the small-island states and territories of the Pacific Ocean. If action is not

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taken now, internationally, nationally, and, most importantly, at the community or resource owner and user levels, to address this situation, AND to mainstream the conservation of the richness of Pacific Island biodiversity and cultures and the current state of "subsistence affluence" (Fisk 1971) and peacefulness, so often idealized and romanticized overseas, will be replaced by widespread biological, cultural and economic poverty, deprivation and conflict in the Pacific ("Peaceful") Islands of the 21st Century! If we fail to do so our descendents will be condemned to the real poverty and hardship that we see in other parts of the world where biodiversity has been destroyed and traditional links with the land and sea broken.

We must insure, through our actions today, that we are not the ones responsible for depleting or "embezzling" this renewable "living bank account", causing "biobankruptcy" and stealing the development dreams of our children's children in the name of short-term economic and political wellbeing of our generation!

The balance of the paper includes: 1) definitions of the "Pacific Islands" and "biodiversity" as used in the context of the paper; 2) a discussion of the unique nature of Pacific Island biodiversity and ethnobiodiversity and its cultural and ecological importance to Pacific Island peoples; 3) a brief discussion of those ecosystems and types of plants and animals that are endangered or in now short supply; 4) a discussion of major threats to Pacific Island biodiversity that are responsible for the loss of biodiversity and some of the options that could be used to address these threats; 5) a discussion of the critical importance of biodiversity conservation in the Pacific Islands; and, 6) an attempt to suggest how we can use this information as a basis for mainstreaming biodiversity conservation in the Pacific Islands by our generation as a basis for sustainable development for future generations of Pacific Islanders (humans AND their plants, animals and other organisms) in the 21st Century and beyond!

The data presented are based on surveys of available literature, studies conducted under a MacArthur Foundation-funded University of the South Pacific (USP) Community-based Biodiversity Conservation (CBBC) programme in Vanuatu and Fiji and under the South Pacific Regional Environment Programme (SPREP)-based South Pacific Biodiversity Conservation Programme (SPBCP)(Reti 1993) in Tonga and Kiribati, discussions at a number of Pacific Island Roundtable on Nature Conservation Meetings, and other studies and personal observations by the authors over the past 35 years.

2 THE PACIFIC ISLANDS – THE GEOGRAPHICAL FOCUS

The geographical focus of the paper includes all of the island nations or territories of the tropical Pacific Ocean that are considered part of the "cultural areas" of Melanesia, Polynesia and Micronesia. Their locations are shown on the following map of "The Pacific Islands". Within this area there is an almost baffling diversity of island types, including: 1) geologically-ancient continental islands composed of sedimentary, metamorphic, and igneous rocks of continental origin, such as New Guinea (the large island that constitutes the largest part of both West Papua/Irian Jaya and Papua New Guinea) and New Caledonia; 2) older andesitic volcanic islands, such as most of the islands of Fiji, Vanuatu, Solomon Islands, the eastern islands of Papua New Guinea (e.g., Manus, New Britain, and Bougainville), Guam, and the Northern Marianas; 3) recent high basaltic volcanic "hot spot" islands, such as the Samoas, the Cook Islands, Tahiti in French Polynesia, Pohnpei and Kosrae in the Federated States of Micronesia and the Hawaiian Islands; 4) raised limestone islands, such as Nauru, Niue, most of the Tonga group, some of the islands of Palau, such as

the Rock Islands and Angaur, and Aniwa in Vanuatu; and 5) low-lying coral-limestone islands, such as most of the atolls and islands with no lagoons in the Marshall Islands, Federated States of Micronesia (outer islands in Yap, Chuuk and Pohnpei), Kiribati, Tuvalu, Tokelau, the northern Cook Islands, and the Tuamotus in French Polynesia. Each has its own characteristic biota and ethnobiological traditions (i.e., ethnobiodiversity).

There is, similarly, great geographic and demographic diversity. Some "groups" or countries, like Easter Island, Guam, Nauru and Niue, consist of one single small island; some like Fiji, Tonga, French Polynesia, Federated States of Micronesia and Hawaii, are comprised of hundreds of large and small highly-dispersed islands; and others like, Papua New Guinea and West Papua (Irian Jaya) of parts of very large, high continental islands, plus countless offshore islands. The total land areas vary from 12 to 26 km^2 for groups of low-lying coral-limestone islands like Tokelau and Tuvalu to over 400,000 km^2 for the continental island areas of West Papua and Papua New Guinea. Great differences in climate, geological resources, topographical features, soil types, mineral and water availability, and diversity of flora and fauna are also found in the area. Population densities for entire groups range from just over 1 person per km^2 for Pitcairn Island and 2.5 for West Papua to almost 300 or more for Nauru, Chuuk and Tuvalu. If the "most populous islands" are considered, the figures jump to over 100 per km^2 for four islands, over 200 for 3 islands, and 421 for Koror in Palau, 757 for Funafuti in Tuvalu, 1179 for Majuro in the Marshall Islands, and 2190 for Tarawa in Kiribati. The estimated population for Betio Islet of Tarawa atoll was estimated to be about 40,000 at the turn of the century, which gave it a population density rivaling the population densities of Hong Kong and Singapore. If we consider Ebeye, one of some 90 islets comprising Kwajalein Atoll in the Marshall Islands, to which people have been relocated by the U.S. military to free the atoll's lagoon for intercontinental ballistic missile testing, the population density skyrockets to over 25,000! (Thaman 1988a).

3 BIODIVERSITY – A DEFINITION

In the context of this paper the term “biodiversity” includes 1) island and ecosystem diversity, 2) species and taxonomic diversity, 3) genetic diversity, and, 4) ethnobiodiversity.

Island and Ecosystem Diversity: This includes the almost unbelievable diversity of island types found in the tropical Pacific Ocean and all of the ecosystem types found on these islands. Each island type, whether large or small, whether high or low, or whether volcanic or limestone, contains its own unique biodiversity inheritance. The ecosystems found on these islands include all natural AND cultural terrestrial, freshwater and marine ecosystems (e.g. forests, grasslands, swamps, caves, freshwater bodies, agricultural areas, towns, reefs, lagoons, mangroves, open ocean, etc.);

Species and Taxonomic Diversity: This includes all species and “taxa” (e.g., types, groups, classes, families, genera, etc., in biological classification systems, such as vertebrates, invertebrates, mammals, sharks, finfish, shellfish, bêche-de-mer, fungi, palms, gymnosperms, grasses, ferns and other micro-organisms) of wild and domesticated plants, animals and micro-organisms found in these ecosystems;

3. **Genetic Diversity:** This includes all genetic types, breeds, cultivars or varieties of wild AND domesticated or cultivated plants and animals found in these ecosystems (e.g., cultivars of yams, sweet potatoes, sugarcane, coconuts, breadfruit, mangoes, pandanus, etc. and breeds of pigs, chickens, dogs, etc.), and, **for the purpose of protecting intellectual property rights**, all chemical extracts from these organisms; and, finally,

4. **Ethnobiodiversity:** The knowledge, uses, beliefs, resource-use systems and conservation practices and language that a given society (or ethnic group), including modern scientific knowledge, has for their islands, ecosystems, species, taxa and genetic diversity.

It is stressed that, this final category or "level" of biodiversity, **ethnobiodiversity**, must be seen as central to the definition of biodiversity itself because, in the Pacific Islands, people and their knowledge, traditions and spirituality are seen as inseparable from their terrestrial, freshwater and marine ecosystems. For example, in Western Melanesia this is embodied in the Melanesian pidgin concepts of **kastom**/custom or **ples**/place; in Fiji in the concepts of **vanua**/land and **iqoliqoli**/fisheries; in Polynesia under the all-encompassing pan-Polynesian concept of land/**fonua, fanua, fenua, whenua, henua** or **'enua**, depending on where you are; or in Micronesia, by the concepts of **te aba** in Kiribati, **tabinaw** in Yapese and **beluu** in Palauan. From a Pacific Island perspective land, people and their marine environment were, and in most places are still seen as a single all-encompassing entity that is integral to their cultural and spiritual roots, rather than as separate external entities.

4 THE NATURE OF PACIFIC ISLAND BIODIVERSITY

Although there is a wealth of biodiversity in all Pacific Island countries, there is great diversity **and** disparity in the biological inheritances of different countries at the island, ecosystem and local community levels, which is paralleled by the diversity and disparity in the users and stakeholders of that biodiversity.

4.1 Island and Ecosystem Diversity

As stressed above, there is an almost unbelievable diversity of island types in the Pacific Islands, ranging from the large continental islands of New Guinea and New Caledonia and the isolated high volcanic islands of Hawai'i, which have some of the richest biodiversity inheritances on Earth and considered global "biodiversity hotspots", to the small low-lying atolls, limestone islets and associated offshore islets and sand quays, which have among the poorest, or least diverse, terrestrial and freshwater floras and faunas on Earth. In terms of marine biodiversity the disparity is not so great, although there is still an attenuation or drop off in the number of species from west to east as we move from Melanesia and western Micronesia in the western Pacific to the small, more isolated, islands of the central and eastern Pacific.

High islands, in particular isolated, large, high islands, have very high percentages of endemic plants and animals (species that have evolved into unique species that are found nowhere else in the world), whereas some of the smaller, low islands often have no unique endemic plants and animals at all. Similarly, endemism is far more common in the terrestrial and freshwater island environment than it is in the marine environment, although there are pockets of endemic marine organisms in the Pacific Islands.

However, it must be stressed that, regardless of the island type, size or degree of isolation, ALL our islands have ecosystems, plants, animals and microorganism that are critical to the continuing health and survival of each island's biodiversity itself AND to the human communities that depend on it for their ecological, economic and cultural survival.

In terms of ecosystem diversity, an attempt to provide a simple classification of most of the major natural and "cultural" ecosystems of the Pacific Islands is shown in Table 1. The utility or advantage of such a classification system is that it: 1) includes most of the major resource-use zones, in both the traditional (e.g., primary forest, shifting agricultural land,

mangroves, strand forest, rivers, houseyard gardens, tidal flats, lagoons, etc.) and modern (e.g., island-shelf fishery, plantations, grazing land, plantation forest, fish ponds, etc.) contexts; 2) roughly corresponds to local classification systems that have distinct vernacular terms for each resource-use zone; 3) identifies ecosystems types or resource use zones that have relatively distinct biological communities in terms of habitat, ecological niches, species diversity, and the degree of human modification and endangerment status; and 4) identifies ecosystems that can all be managed by governments, NGOs AND local communities themselves to protect, conserve or enhance their biodiversity inheritances.

In terms of ecosystem diversity, the larger islands of the western Pacific have large areas of most of the major ecosystems. Some of the most extensive areas of freshwater swamps are found on the island of New Guinea, and extensive areas of mangroves and unlogged tropical lowland and montane forest are found in many areas of large-island Melanesia. There are also numerous large rivers in Papua New Guinea and Fiji, with large river plains, that provide large inland populations with significant freshwater protein sources in the form of finfish, prawns and shellfish, and which offer considerable potential of irrigation agriculture and the development of hydroelectric power.

Table 1. Terrestrial, freshwater and marine ecosystems of the Pacific Islands that: 1) constitute the major resource-use zones; and, 2) could serve as the focus for community-based, national and regional biodiversity conservation in the Pacific Islands (* indicates that mangroves are listed as both terrestrial and marine ecosystems).

1 TERRESTRIAL/FRESHWATER ECOSYSTEMS

1.1 Lowland Native Forest

1.2 Upland or Montane Rain Forest

1.3 Mature Fallow Forest

1.4 Plantation Forest

1.5 Grassland/Woodland

1.6 Scrubland/Scrub-Fernlands

1.7 Shifting Agricultural Land

1.8 Permanent/Semi-permanent Agricultural Land

1.9 Plantations

1.10 Pasture

1.11 Houseyard/Urban Gardens

1.12 Intensive Livestock Holdings

1.13 Ruderal Sites

1.14 Wetlands/Swamps

1.15 Rivers/Streams/Lakes/Ponds

1.16 Fishponds/Aquaculture

*1.17 Mangroves

1.18 Coastal Strand Vegetation

1.19 Beaches and Dunes

1.20 Bare Rock

1.21 Caves

1.22 Built/Urban

2 MARINE ECOSYSTEMS

*2.0 Mangroves

2.1 Estuaries

Intertidal Zone/Flat

Seagrass Beds

Lagoons

Bays

2.4 Fishponds/Maricultural Areas

2.5 Coral Reefs

Island Shelf/Reef Platform/Deep Reef/Sea mounts

Deep Ocean Floor/Ocean Trenches

2.7 Open Ocean

Source: Adapted from Thaman 1994a.

Rivers and freshwater resources are much more limited on the smaller high islands of Polynesia and Micronesia, although there are some smaller freshwater streams, with limited fisheries resources on the larger islands of Samoa, on Rarotonga in the Cook Islands, the larger islands of French Polynesia, such as Tahiti, the larger Hawaiian Islands, and Pohnpei and Palau in Micronesia. The larger raised limestone islands and low-lying limestone islands, atolls and small reef islets and sand quays rarely have fresh surface water resources, although there are brackish or freshwater water ponds on Nauru (e.g., Buada Lagoon) and some other limestone islands, and an extensive system of landlocked hypersaline ponds on Kiritimati (Christmas) Atoll in the Line Islands of Kiribati.

In terms of mangroves, again, the larger islands of Melanesia, from New Guinea to Fiji, have the most extensive areas of mangroves. There are also extensive mangrove forests in western Melanesia, in Palau, Yap, Pohnpei and Kosrae, and on Butaritari Atoll in northern Kiribati. The mangroves in Pohnpei and Kosrae, where there are few tropical cyclones (typhoons), are particularly interesting, and perhaps the tallest and most well-preserved mangrove forests in the Pacific Islands. The most easterly naturally-occurring mangroves in the Pacific are found in Tonga, Samoa and Tuvalu in Western Polynesia, and Kiribati and the Marshall Islands in Micronesia. Although there is palynological (based on studies of plant pollen) evidence of the presence of mangroves in pre-human contact times in the Cook Islands, there are no native mangroves today in Eastern Polynesia, although there are deliberately planted mangroves in both Tahiti and Hawai'i.

Extensive areas of tropical lowland rainforest and montane rainforest are found only on the larger islands of Melanesia, and in some small concentrations on the larger islands of Polynesia, such as 'Upolu and Savai'i in Samoa, 'Eua and the recent volcanic islands of Kao,

Tofua and Late in Tonga, and the upland areas of Rarotonga in the Cook Islands and on the larger islands of French Polynesia. There are also significant areas of rainforest remaining on some of the islands of Palau and on Pohnpei and Kosrae in Micronesia.

Although the most extensive systems of coral reefs are again found off the larger Melanesian islands of Papua New Guinea, New Caledonia, Solomon Islands and Fiji, where there are extensive systems of barrier reefs and associated lagoons, there are extensive areas of fringing reefs, patch reefs and some barrier reefs surrounding almost all the Pacific Islands, except for the Marquesas in far northeastern French Polynesia. Particularly extensive reef systems are found in Palau, Yap, Chuuk and Pohnpei in western Micronesia, as well as in some lagoon and offshore areas of the larger groups of atolls and low-lying limestone islands (e.g., Marshall Islands, Kiribati, parts of the Federated States of Micronesia, and the Ha'apai group of Tonga). There are very limited areas of fringing reef around upraised limestone islands, such as Nauru and Niue.

Sea grass beds, extremely important habitats and food sources for dugongs, sea turtles, and a wide range of other marine organisms in Melanesia, Micronesia and Western Polynesia, are not found to the east of Micronesia, Tonga and Samoa (Dahl 1980).

Grasslands, woodlands and degraded scrublands and scrub-fernlands are found on all high islands, and on many raised limestone islands. These range from the extensive grasslands of the Highlands of New Guinea, lowland woodlands of Papua New Guinea, the grasslands of the Guadalcanal Plains of Solomon Islands, the "**niaouli**" *Melaleuca* savannas of New Caledonia, and the extensive "**talasiga**", "sunburnt" degraded grasslands of Fiji to the more limited areas of "**sāfa**" grassland in Tonga, the scrub-fernlands of the Cook Islands and French Polynesia, the grasslands of Guam, and the grasslands on Kiritimati in the Line Islands. Although there were undoubtedly indigenous grasslands and savannas in Papua New Guinea and some other areas, such as Fiji, Yap and Palau, and possibly on Kiritimati Atoll, most of these areas are probably of human (anthropogenic) origin, or at least extended by the use of fire, and, in most cases, are composed of mainly introduced exotic grass species.

In terms of cultural ecosystems, shifting and semi-permanent agricultural areas, tree groves or agroforests, perennial plantations, pasture and other livestock husbandry systems, and houseyard gardens are found on almost all high islands, and on many of the upraised limestone islands. On most atolls, the dominant cultural ecosystems include semi-permanent taro gardens, tree groves, coconut plantations and houseyard or village gardens, the latter, which are dominated by "agroforests" of coconut palms, pandanus, breadfruit and a number of other useful trees.

Maricultural production of milkfish was practiced traditionally in Nauru and Hawai'i and possibly elsewhere. Today there is some mariculture of *Echeuma* seaweed in Fiji, Kiritimati and a number of other areas, *Pennaeid* prawns in New Caledonia and Fiji, black-lipped pearl oysters (for cultured pearl production in the Northern Cook Islands, Marshall Islands and the Tuamotus, and the modern maricultural production of milkfish in Kiribati on both Tarawa and Kiritimati. There is limited freshwater aquaculture of tilapia in Fiji, Tonga, Samoa and Kiribati, although tilapia is seen as a pest and a hindrance to the mariculture of milkfish in both Nauru and Kiribati and an invasive when released in the wild (Eldredge 1994). There is also successful village aquacultural production of crocodiles in Papua New Guinea, which has taken pressure off endangered natural populations.

All islands have extensive areas of ruderal sites, such as roadsides, trailsides, open lots, grass airstrips and other sites that are under a constant state of disturbance.

In summary, although the larger high islands have far greater diversity of ecosystems than the smaller low-lying islands, all islands have a range of terrestrial and marine ecosystems and, in the case of larger islands freshwater ecosystems, that provide for most of the subsistence and cash needs of their resident rural communities.

4.2 Species and Taxonomic Diversity

To truly appreciate what biodiversity really means to Pacific Island societies, it is useful to identify the main classes or categories of taxa that constitute the biodiversity of each ecosystem. An attempt to do this is shown in Table 2. There are undoubtedly other classes, sub-classes or types of biological resources, or more "scientific" ways of classifying them (e.g., gymnosperms and angiosperms). The system presented is only a first attempt at providing a system that could be used at the community, school and policy-making levels to bring to people's attention both the diversity of biological resources found on their islands and in "their" ecosystems, and its ecological and functional utility as a basis for sustainable development at the household, community, national and regional levels.

Table 2. Classes, sub-classes, specific types and the utility of terrestrial, freshwater and marine resources that constitute the pool of ecologically important and functionally useful biological resources found in Pacific Islands ecosystems (Under "Utility", E, S and C = direct major Ecological, Subsistence or Commercial/Export utility to people at the community AND national level in Melanesia, Polynesia or Micronesia, and e, s and c = minor or indirect ecological, subsistence or commercial/export importance, e.g. plankton is of indirect importance to commercial tuna fishing in terms of its importance in marine food chains; it must be stressed that taxa in some categories may also be harmful or have a negative impact on sustainable development, e.g. pathogenic viruses or bacteria, malarial parasites, mosquitoes, etc.)

CLASS	SUB-CLASSES	SPECIFIC TYPES	UTILITY
Lower		Bacteria	E,s,c
Life-forms		Viruses	E,s,c
Plants	Indigenous	Phytoplankton	E,s,c
	Aboriginal Introductions	Algae/Seaweeds	E,S,C
	Recent Introductions	Fungi	E,s,c
	Wild Plants	Mosses	E,s
	Domesticated Plants	Other Lower Plants	E,s,c
	Food Plants	Ferns	E,S,C
	Non-Food Plants	Herbs/Forbs	E,S,C
	Terrestrial	Grasses/Sedges	E,S,C
	Freshwater	Vines	E,S,C
	Marine	Shrubs	E,S,C
		Trees	E,C,C

Animals	Indigenous	Protozoa	E,s,c
	Aboriginal Introductions	Zooplankton	E,s,c
	Recent Introductions	Sponges	E,s,c
	Wild Animals	Corals	E,S,C
	Domesticated Animals	Jellyfish	e,s,c
	Food Species	Worms	E,s,c
	Non-Food Species	Molluscs	E,S,C
	Terrestrial	Insects	E,s,c
	Freshwater	Crustaceans	E,S,C
	Marine	Echinoderms	E,S,C
		Other Invertebrates	E,s,c
		Finfish	E,S,C
		Amphibians	E,s
		Reptiles	E,S,C
		Birds	E,S,C
		Non-Human Mammals	E,S,C
		Humans	E,S,C

As can be seen from the classification systems presented in Tables 1 and 2, if one were to list all of the species, subspecies, forms, varieties, cultivars, races, breeds, provenances, etc. of all wild and domesticated terrestrial and aquatic plants and animals from each class, subclass or type of biota in each ecosystem represented in a given community, island or Pacific Island country, the magnitude of biodiversity, even for a small atoll community or a small uninhabited offshore island, becomes all too apparent. From such a perspective, it can be seen that the "biodiversity" of almost all island ecosystems would be considerable, in some cases almost incomprehensible to a “Western-trained” economist or "pure scientist" (but NOT to more traditional Pacific peoples!!). For example, preliminary analyses of the results of University of the South Pacific-MacArthur Foundation surveys of Ucunivanua Village and four villages on Muaivuso Point near Suva in Fiji indicate that for shellfish and finfish, there are over 70 and 200 different edible species, respectively, many of which are also main sources of cash income to the villages. There is also a wide range of edible seaweeds, crustaceans, sea urchins, sea cucumbers, sea anemones and a number of other edible marine invertebrates (Thaman 1999a). In North Ambrym, Vanuatu there are over 250 plant species with local names that are considered useful in some way (Thaman and Devoe 1994), and communities surrounding Mt. Koroyanitu in Fiji had an even larger range of plants and animals that were considered useful from their lowland, montane, freshwater and agricultural ecosystems (Thaman 1996). In the low-lying islands of Tonga’s Ha’apai group, SPBCP study results indicate that over 120 finfish species, over 40 shellfish and 20 crab species are eaten, many of which are also main sources of cash income to villages. The same surveys indicated that there are over 300 named plants that have economic or cultural significance (Thaman *et al*. 1997).

4.3 The Uniqueness of Pacific Island Biodiversity

Despite a number of similarities between the biodiversity in different island groups, the biodiversity of the Pacific Islands is truly unique, which is one of the main arguments for its protection internationally. In terms of uniqueness, there are four generalizations about biodiversity in the Pacific Islands: 1) the western relationships of Pacific Island biodiversity; 2) a diversity gradient or attenuation of diversity from west to east, as one moves away from the Western Indo-Pacific source area of most taxa; 3) a gradual elimination of major groups of plants and animals from west to east; and 4) a range from very high endemism for high isolated islands to virtually no endemism for the smaller, low-lying limestone islands and atolls and sand quays.

In terms of the western affinity of most taxa, studies show that almost all terrestrial, freshwater and marine plant and animal taxa (e.g., ferns, algae, sea grasses, corals, echinoderms, marine and terrestrial molluscs, insects, birds, bats, etc.) are of all Asian or West Indo-Pacific origin. In Hawai'i, although the majority of taxa have a western affinity, a number of plants and other taxa have American affinity and have descended from birds, insects, plants, etc. whose ancestors were of American origin (i.e., from North, Central or South America).

The attenuation or decrease in the total number of species, genera and families with distance from Southeast Asia is also considerable, although smaller and lower islands also have fewer species than larger higher islands. This is due to the differential dispersability of the different organisms, some of which were never able to reach the more distant islands of the eastern Pacific. It is also due to the greater habitat diversity on larger islands, the greater chance of extinction or extirpation (local extinction) among smaller populations on small islands, and the associated lower probability of initial colonization or recolonisation after extirpation or extinction. For example, a large number of finfish families absent from the more distant islands on the Pacific Plate in the central Pacific, have shorter larval stages and are unable to disperse over the great distances of open water between oceanic islands (Myers 1991). Also estuarine and freshwater habitats are limited to high islands, thus such species are rarely found on low islands.

For example, benthic marine algae (including green, brown and red, but not blue-green algae) species drop from 1,185 in North Australia, to 520 for all of Micronesia, 336 for New Caledonia, 302 for Fiji, 268 for the Marshall Islands, 151 for Tahiti, 90 for Samoa and 40 for Nauru (N'Yeurt and South 1997). The number of fern species drops from 230 in Fiji to 215 in Samoa and 150 in the Society Islands; the number of angiosperm genera from 654 in Solomon Islands, to 476 in Fiji, 302 in Samoa, 263 in Tonga and Niue, and 201 in the Society Islands; the number of birds species from 520 in New Guinea, to 127 in Solomon Islands, 54 in Fiji, 33 in Samoa, 17 in the Society Islands and 11 in the Marquesas in far eastern French Polynesia; the number of cowrie species from 70 in the Philippines, to 57 in Fiji and 34 in Hawai'i; and coral genera from 46 in Fiji, to 41 in Samoa, 40 in the Line Islands, 18 in the Tuamotus and 15 in Hawai'i (Kay 1980). Most recent estimates of inshore finfish species range from about 2,500[*] for the Philippines, to 2146 for Papua New Guinea, 1,387 (1593*) for Palau-Yap, 955 (1189*) for the eastern Caroline Islands, 1610 for New Caledonia, 919 (1235*) for Fiji, 915 for Samoa, 935 (943*) for the Marianas, 845 (854*) for the Marshall Islands, 633 for the Society Islands, 566 for the Hawaiian Islands, 352 for the Marquesas, 334 for the Pitcairn group and 126 for Easter Island (* indicates estimates of real totals for areas where comprehensive surveys have not been completed) (Myers 1999). Even among orchids, which are famous for the high dispersibility of their

very small light seeds, this same attenuation is reflected, with the number of indigenous orchid species dropping from about 3000 for Papua New Guinea, which has one of the richest orchard floras in the world, to 164 for Fiji, 100 for Samoa and only 3 for Hawai'i (Sekhran and Miller 1996; Kores 1991; Whistler 1992; Carlquist 1980). There is a similar attenuation in the genera of reef forming (hermatypic) corals from Papua New Guinea in the west to Hawai'i in the far northwest, as shown in Table 3.

Table 3. Maximum number of hermatypic (reef forming) coral species in the Pacific Islands. [Spalding, *et al.* 2001, using data from Veron 2000]

Area	No. of Species
Papua New Guinea	517
Solomon Island	398
Vanuatu	379
New Caledonia,	359
Fiji	398
Kiribati	365
Guam	220
Palau	384
Marshall Islands	340
Samoa	211
Cook Islands	172
French Polynesia	168
Pitcairn Islands	42
Hawaiian Islands	49

The same factors related to differential dispersability of organisms, distance of islands from source areas and island type and size have resulted in the gradual elimination of major groups of plants and animals from west to east, resulting in successively more "disharmonic" biotas as one moves from west to east or from larger islands with diverse habitats to smaller islands with limited habitat diversity. For example, fruit bats are not found to the east of the Caroline Islands in Micronesia and Fiji, Tonga and Samoa in the central Pacific, and amphibians (e.g., frogs) are not found to the east of Fiji. There is similar fall out from west to east of marine animals such as crinoids, giant clams (Tridacnidae) and chambered *Nautilus* (Kay 1980). In terms of plant taxa, most Pacific Islands have no indigenous gymnosperms. Whereas there are 44 native species of gymnosperms in New Caledonia and 9 in Fiji, there is only one in Tonga, and none on the geologically recent islands to the east of Tonga, in Samoa, the Cook Islands, French Polynesia and Hawai'i or in the islands of Micronesia (Dahl, 1980; Yuncker, 1959). Even some biotas of the larger islands of the western Pacific, such as New Caledonia, are also disharmonic and missing some of the major animal taxa, such as terrestrial predatory mammals that characterize the more "harmonic" biotas of

continental areas, such as Southeast Asia and Malesia[5], the source areas for most Pacific Island biota.

Finally one important aspect of biodiversity in the Pacific Islands, in terms of species diversity, is the high endemism on most of the larger higher islands in the Pacific. Due to isolation, the difficulty of oceanic dispersal, the disharmonic nature of most islands biotas, with little competition for available habitats and niches, there has been sometimes spectacular adaptive radiation and rapid speciation leading to baffling diversity of species descending from a limited number of ancestor or "founder" organisms. The greater the isolation of an island, the greater the size and elevation and habitat diversity, the greater the time (e.g., geological age of an island) over which speciation and adaptive radiation can take place, and the greater the environmental stability (e.g., in terms of climatic, geologic, and sea-level stability), the greater the endemism. Conversely, small low-lying limestone islands and atolls, even if isolated, have few if any endemic species (Thaman 1992a).

The classic example is the adaptive radiation that has taken place in Hawai'i among insects, terrestrial molluscs (e.g., land snails), fruit flies, birds and plants. For example 99+% of Hawai'i's 3730 insect species and 1064 terrestrial mollusc species are endemic, and 98.8% of the 71 bird species, 94.4% of 1729 flowering plant species and 64.9% of fern species in Hawai'i are endemic. Due to the rarity of long-distance dispersal events, these species have in most cases evolved out of very few ancestral "founder" species (Carlquist 1980). In the Marquesas of northeastern French Polynesia, 83 species of plants and 25 species of birds (80 per cent) are endemic, and 66 per cent of ferns and 86 per cent of angiosperms are endemic on Rapa in southeastern French Polynesia (Dahl, 1980).

There is likewise very high endemism on some of the larger islands of Melanesia. The continental island of New Caledonia, which broke off from the southern supercontinent of Gondwana with its cargo of ancient plants and animals some 80 to 85 million years ago, has an extremely rich flora of some 3,256 vascular plants, of which 76% are endemic. The floristic richness of New Caledonia can be explained in part by its not having been glaciated and its historically rather equable climate over millions of years. It is particularly noted for the richness of its gymnosperm flora, particularly its Araucariaceae, having 13 endemic species out of a total of 19 species worldwide, making it the centre of diversity of this genus. In terms of the affinity of its flora, about 30% are of Gondwanic affinity, 35% Indo-Malesian affinity, 28% Pacific affinity and 7% affinity with islands south of New Caledonia (e.g., New Zealand, Lord Howe and Norfolk)(Mueller-Dombois and Fosberg 1998).

Endemism is also very high in Papua New Guinea, particularly on the main island of New Guinea, which is considered to be an important global center or "hotspot" of biodiversity. Although having less that one percent of the Earth's land area, it has been estimated that about 700,000 species (5%) of a estimated total number of 14,000,000 multicellular species found on Earth are found in Papua New Guinea. Not including the totally unknown number of algae, mosses, liverworts, nematodes and mites, this is estimated to include about 90,000 fungi, 20,000 plants, 300,000 insects, 5000 other invertebrates and 4,000 vertebrates. Of these, probably from 300,000 to 500,000 are found on the main island of New Guinea (Sekhran and Miller 1996). In terms of endemism, statistics of various groups vary

[5] Malesia is a biogeographical region consisting of the tropical islands of the western Pacific located between the Asian continent and Australia. It includes all of the islands of Indonesia and Malaysia, the island of New Guinea and nearby offshore islands and the Philippines, with Taiwan (southern Taiwan being tropical) being included by some authorities. It is considered to be the major source area for most of the indigenous organisms found in the Pacific Islands.

considerably, from very low for marine groups to quite high for many vertebrates. It has been estimated that possibly 60% of Papua New Guinea's vascular plants are endemic (Johns 1993), with there being well over 3000 species of orchids alone. Despite its small area, Papua New Guinea ranks twelfth among the world's nations in terms of endemism of large butterflies, with 56 of 303 species, many of which have great commercial economic development potential, being endemic (Sisk *et al*. 1994). Of New Guinea's native freshwater fish 149 (70%) of 214 species are endemic (Kailoa 1987-91). There is a great diversity of amphibians, with 197 described species, the majority of which are endemic to New Guinea or Papua New Guinea. The reptilian fauna is likewise rich, with 13 turtle or tortoise species, seven of which are associated with freshwater habitats, with 3 of these being endemic. There are 195 and 98 species of lizards and snakes, respectively, of which about 60% are endemic. Because of former land connections with Australia, many groups of plants, freshwater fish and reptiles have an affinity with Australian biota. Birds, which have been well studied compared to other animals, show a very high degree of endemism, with 405 of 762 species being considered endemic. On a world basis, Papua New Guinea ranks fifth in terms of the number of restricted–range bird species and seventh in the number of endemic bird areas as mapped by the International Council of Bird Preservation (Sekhran and Miller 1996).

Although Papua New Guinea, when compared to Southeast Asia, is impoverished in term of the range of mammal groups, (e.g., Papua New Guinea does not have tigers, apes, elephants, etc.), at least two of the existing four groups, marsupials and rodents, show a high degree of endemism. With 187 indigenous mammals, the New Guinea region has only slightly fewer mammal species than Australia, despite having only about 10% of the area. There are also some 24 marine mammals, including the dugong, in Papua New Guinea waters. Of the approximately 71 species of marsupials, 60% can be considered to be endemics that do not occur in Australia. Two species of monotremes occur in New Guinea, with the long-beaked echidna (*Zaglossus*) being endemic to New Guinea. There has also been extensive radiation of bat species, with about 75 species belonging to six families found in Papua New Guinea, and rodents from the family Muridae have radiated extensively in the New Guinea region (Sekhran and Miller 1996).

Elsewhere in Melanesia, endemism of Fiji's vascular plants has been estimated to be about 23%. For example, of 164 indigenous species of orchids, 51 (31%) are reported to be endemic (Kores 1991). In Solomon Islands, where overall endemism is lower, endemism is very high among figs (*Ficus* spp.), of which Corner (1967) found 23 of 63 species (35%) to be endemic. He considered Melanesia, and particularly Solomon Islands, to be the center of fig evolution (Mueller-Dombois and Fosberg 1998).

As stressed by Kay (1980), endemism is far more common in terrestrial and freshwater environments than in the marine environment, where endemism is usually highest around very isolated island groups, such as Hawai'i and the islands of southeastern Polynesia. Whereas there is over 99% endemism among terrestrial molluscs in Hawai'i, only 20% of marine molluscs are endemic. Among marine molluscs, almost all endemism is confined to Hawai'i and southeastern Polynesia. There is also relatively high endemism among finfishes in the Hawaiian Islands, Easter Island and the Marquesas, with the rates of endemism in these areas being 29%, 27% and 10% respectively (Bleakley 1995). In Micronesia, Myers (1999) estimates that 49 species (3%) of inshore finfish are endemic, with many of these being rare deepwater forms, tiny cryptic forms or burrowing eels that could be discovered elsewhere. For corals, very few species can be considered with great confidence to be endemic, with the level of endemism being less than 5% for most major regions in the Indo-Pacific. For example, of about 350 coral species on the Great Barrier Reef, only about 10

species are endemic. Hawai'i has the highest percentage of coral endemism, possibly because it is a relict coral fauna that rarely receives immigrants from anywhere (Veron 1995).

Related to rapid speciation in disharmonic environments is the widespread lost of competitiveness in species that have evolved in an absence of the predators, parasites and disease organisms that affected, and probably co-evolved with the ancestor species, in their place of origin, of the founder species of today's Pacific Islands biotas. This has resulted in the loss of dispersibility in plants, flightlessness in insects and birds, gigantism and miniaturism, and loss of toxicity and other defense mechanisms, that make these endemic organisms almost defenseless in, and very maladapted to, competition with organisms introduced by humans (Carlquist 1980). In the case of gigantism, New Caledonia has the largest recorded gecko (*Racadactylus* sp.), and "wildlife wonders" of Papua New Guinea reportedly include the world's most extreme examples of the following plants and animals: largest mosses (*Dawsonia* spp.), most massive orchid (*Grammatophyllum* sp.), tallest tropical tree (klinkii pine, *Araucaria hunsteinii*), tallest banana (*Musa* sp.), largest bush grasshopper/katydid (*Siliquofera grandis*), largest butterfly (*Troides alexandra*), moth with the largest wing area (Hercules moth, *Coscinocera hercules*), largest tree frog (*Litoria infrafrenata*), largest crocodile (saltwater crocodile, *Crocodylus porosus*), longest lizard (Salvadori's monitor, *Varanus salvadorii*), smallest parrots (*Micropsitta* spp.), largest pigeons (crowned pigeons, *Goura* spp.), largest monotreme (long-snouted echidna, *Zaglossus bruijni*), and the largest bandicoot (*Peroryctes broadbenti*) (Sekhran and Miller 1994).

5 CULTURAL AND ECOLOGICAL IMPORTANCE AS A MEASURE OF ETHNOBIOLOGICAL DIVERSITY AND A TOOL FOR BIODIVERSITY CONSERVATION

Although endemism and rare life rare forms are of great interest to scientists and are often the main focus of developed-country conservation programs, they are often not among the most culturally useful resources to local communities. Endemic plants and animals are most commonly found on remote mountains and in less accessible, less visited and less used areas, and often do not even have local vernacular names or uses. As a result, it is often the more accessible, non-endemic plants and animals, including genetic varieties of staple food plants, often those found in coastal areas, and near villages or towns, that are of greatest cultural importance. They are also the species that are commonly overexploited or endangered and are in need of conservation or protection in the eyes of local communities. Consequently, the cultural importance of "biodiversity" (i.e., ethnobiological diversity) is, perhaps, one of the most powerful tools for promoting the mainstreaming of biodiversity conservation at the local or community level.

When we attempt to catalogue all the ecological services, uses (the "bio-utility") and economic value of all taxa in all ecosystems to a given community the true value of biodiversity becomes very apparent. The overall long-term economic benefit of the conservation or restoration of this "useful" biodiversity is normally much, much greater than any proposed "income" or "enterprise" generating developments that are commonly linked to conservation initiatives. **Thus, the main "selling point" or incentive for biodiversity conservation, if we really want to mainstream it, should be its conservation as the economic and cultural foundation for sustainable long-term livelihoods, rather than the "scientific" value or the, often short-term, aid-funded, replacement value provided by "enterprise development" or "debt for nature swaps".** This is not to say that nature

conservation for scientific or international "ethical" reasons or sustainable enterprise development initiatives are not useful ingredients in nature conservation initiatives, but, rather, that they should enhance the existing value of biodiversity rather than replacing the sustainable long-term provision of culturally valuable services and products as the main motivating factor.

The four following case studies of; the cultural importance of: 1) Pacific Island trees, 2) Pacific Islands coastal and mangrove plants, 3) of biodiversity as a foundation for nutritional wellbeing, and 4) biodiversity to the people of Tonga's Ha'apai group, serve to illustrate the critical importance of biodiversity as a foundation for sustainable living in the island environment AND why it should be the main reason for biodiversity conservation, if we are really worried about the wellbeing of both plants and animals and the people who depend on them.

5.1 The Ecological and Cultural Importance of Pacific Island Trees

A study of Pacific Island trees and agroforestry by Thaman and Clarke (1993) shows that trees serve at least twelve distinct ecological functions, have over 70 cultural uses (Table 4), and provide between 10 to as high as 75% of the real income and production of rural Pacific peoples. To replace tree products and ecological services with imported substitutes would either be impossible or too expensive. To eliminate these trees would, thus, constitute a major ecological, cultural and economic disaster that would seriously undermine self-reliance and sustainability in the Pacific Islands.

Table 4. Ecological and cultural functions and uses of trees in the Pacific islands.

ECOLOGICAL		
Shade	Soil Improvement	Animal/Plant Habitats
Erosion Control	Frost Protection	Flood/Runoff Control
Wind Protection	Wild Animal Food	Weed/Disease Control
CULTURAL/ECONOMIC		
Timber(commercial)	Broom	Prop or Nurse Plants
Timber(subsistence)	Parcelisation/Wrapping	Staple foods
Fuelwood	Abrasive	Supplementary Foods
Boatbuilding(canoes)	Illumination/Torches	Wild/Snack/Emergency
Sails	Insulation	Foods
Tools	Decoration	Spices/Sauces
Weapons Hunting	Body Ornamentation	Teas/Coffee
Containers	Cordage/Lashing	Non-alcoholic Beverages
Woodcarving Handicrafts	Glues/Adhesives Caulking	Alcoholic Beverages Stimulants
Fishing Equipment	Fibre/Fabric	Narcotics
Floats	Dyes	Masticants/Chewing Gum
Toys	Plaited Ware	Meat Tenderiser
Switch for Children/	Hats	Preservatives

Discipline	Mats	Medicines
Brush/Paint Brush	Baskets	Aphrodisiacs
Musical Instruments	Commercial/Export	Fertility Control
Cages/Roosts	Products	Abortifacients
Tannin	Ritual Exchange	Scents/Perfumes
Rubber	Poisons	Recreation
Oils	Insect Repellents	Magico-religious
Toothbrush	Deodorants	Totems
Toilet Paper	Embalming Corpses	Subjects of Mythology
Fire Making	Lovemaking Sites	Secret Meeting Sites

Source: Adapted from Thaman and Clarke 1993.

5.2 The Ecological and Cultural Importance of Pacific Island Coastal Plants

Similarly, an analysis of the ecological and cultural importance of 140 ubiquitous or locally important Pacific Island coastal and mangrove species found from the continental islands of New Guinea and New Caledonia in the west to the smallest atolls, Easter Island and the Hawaiian Islands in the east showed the "bio-utility" of these plant communities to be high wherever they are found (Thaman 1992b, 1994b).

In terms of the ecological utility of coastal plant resources, the most important functions include the provision of shade and animal and plant habitats, protection from wind, erosion, flood and saltwater incursion, land stabilisation, protection from the desiccating effects of salt spray, soil improvement and mulching, and as animal food or links in important terrestrial and marine food chains.

Of particular importance are mangrove ecosystems, which contribute either directly or indirectly, through primary and secondary productivity, to the nutritional requirements of a high proportion of marine food species (Watling 1985). Research in Fiji has shown that over 60% of commercially important species live in mangroves or depend on mangrove food webs at some stage in their life cycle (Lal et al. 1983), whereas more rigorous research gives figures of 67% and 80% for eastern Australia and Florida (Watling 1985). Destruction and reclamation of mangroves have deleterious effects on fisheries yields, with studies in the Malacca Straits indicating that mangrove reclamation for industrial expansion led to a substantial drop in catches per effort (Khoo 1976), and Baines (1979) argues that mangrove removal can lead to offshore fisheries yield declines of 50 to 80%.

Similarly, *Pisonia grandis* is the most important seabird rookery species throughout the atoll Pacific. It is a species under which phosphate-rich, bird-guano- derived soil and rock are found, and a very important pig feed in many parts of the Pacific. Where *Pisonia* has been removed, seabird populations decline and the location of schools of tuna based on the presence of seabird flocks becomes problematic for fishermen.

One of the most important ecological roles played by coastal plants is the protection of inland agricultural areas, non-coastal vegetation and fauna, settlements, and water supplies from saltwater spray and storm surge. Of particular value because of their remarkable tolerance to high levels of salinity, are plants with particularly high tolerance to salt spray and saline soils. Farmers throughout the Pacific purposely leave strands of mangrove forests

intact seaside of their gardens, as they know that to remove these trees would make farming problematic. In Tonga, where coastal trees were removed to make boxes for shipping bananas to New Zealand, it is now almost impossible to farm coastal allotments due to salt spray.

In terms of cultural utility, the analysis showed that there are some 75 different purpose/use categories for Pacific Island coastal plants, with the total frequency of usage for 140 plants being 1024, an average of 7.3 purpose/use categories per plant, ranging from no reported uses for only two species to as many as 125 for the coconut, if distinct uses within categories (e.g., tools with distinct functions) are counted. Another 17 species have 20 or more reported uses, and 29 species have at least 7 uses each. Moreover, the list does not include the more strictly ecological functions of coastal plants, such as shade, protection from wind, sand and salt spray, erosion and flood control, coastal reclamation, animal and plant habitats, and soil improvement, all of importance to Pacific societies.

In terms of specific uses, the most widely reported uses are for medicine, general construction, body ornamentation, fuelwood, ceremony and ritual, cultivated or ornamental plants, toolmaking, food, boat or canoe making, dyes or pigments, magic and sorcery, fishing equipment, cordage and fibre, games or toys, perfumes and scenting coconut oil, fertilizer and mulching, woodcarving, weapons or traps, food parcelisation or wrapping, subjects of legends, mythology, songs, riddles, and proverbs, domesticated and wild animal feed, handicrafts, cooking equipment, clothing, fish poisons, items for export of local sale, adhesives or caulking, and musical instruments, all of which were reported for at least eleven species. The analysis, however, is based on traditional uses, many of which have lapsed or are only employed in emergency, because modern technology has pre-empted them.

Examples of the medicinal, ceremonial or spiritual and body ornamentation or perfumery use of coastal plants are provided below. To provide greater detail on those plants of particular importance for specific purposes is beyond the scope of this paper, but can be found in the paper "Batiri kei Baravi: the Ethnobotany of Pacific Island Coastal Plants" (Thaman 1992b).

Medicinal use was the most widespread with 113 species (81%) reportedly used medicinally, in at least one area of the Pacific. Of these 113 species, almost a quarter (27) are used medicinally for a variety of purposes, often the same purposes, wherever they are found throughout the Pacific, as well as in southeast Asia the ancestral homeland of Pacific peoples (Perry and Metzger 1980). Importantly, the effectiveness of these medicines has been recorded scientifically in writing by Chinese “doctors” and Indian Aryuvedic medicinal practitioners for over 800 years (!). Most of these medicines have been tested and documented much more thoroughly than most of the “modern” medicines that we buy in chemists or drug stores, many of which have known side effects and have only been tested extensively on laboratory animals. Moreover, for most rural Pacific Island communities, apart from the 3 P’s (penicillin, pain relievers and Pepto Bismol/Enos), there is little or no access to modern medicines and an almost exclusive dependence on traditional medicines to treat all diseases, sicknesses, injuries and other complaints. To replace these with modern medicines is almost impossible.

The ceremonial and spiritual importance of plants, cannot be overstated, with 40 species having ceremony or ritual importance, 29 used in magic and sorcery, and 18 featuring legends, mythology, songs, riddles, or proverbs. Those of more ceremonial importance, include species used in ceremonies or rituals associated with death, war and peace, human sacrifice and cannibalism, circumcision or coming of age, house or temple building, canoe making and launching, fishing, planting cycles, lovemaking, wavemaking or control of sea

state, prayer sessions, as well as species serving as symbols or totems and mediums for communicating with spirits or gods or those planted in sacred groves or burial grounds. Others are associated with times of revelry or are used in the production of baskets, mats, and other articles reserved for ceremonial exchange or dress. As stressed by Setchell (1924), in his *Ethnobotany of Samoa*, plant names were given to gods or vice versa and songs and legends have developed around them and the "heroes, families, or villages, etc. they represent." One particular Samoan text of the battle of trees and stones enumerates between 70 and 80 tree names.

The importance of body ornamentation and perfumery is attested to by the considerable time and expense devoted by most societies (very extravagant expenditures in the case of more affluent societies) to clothing, jewelry, perfumes, and other items of personal adornment. Pacific island societies, similarly, placed great importance on the importance of plant products for body ornamentation and perfumery, with 44% (62 of 140) of all coastal species being used in body ornamentation and 21 species used to scent coconut oil or for perfumery.

Many places, such a Hawaii or Tahiti, are commonly associated with flower leis or sweet smelling flowers, such as the **tiare Tahiti**. The **salusalu**, **kahoa** and **sisi**, **ula**, and **te bau** and **te mae**, the Fijian, Tongan, Samoan, and Kiribati equivalents of the Hawaiian lei, are all of great social, ceremonial, magical or spiritual importance, with other Pacific societies having equivalent terms for such body ornamentation. Powell (1976), Bonnemaison (1985), Neal (1965); Brown (1931) and McDonald (1978) all stress the ceremonial or magical importance of body ornamentation in Papua New Guinea, Vanuatu, Tuvalu and Hawaii, with Koch (1983) noting that ornaments used for special occasions in Tuvalu are now almost exclusively made of plants because "the longer-lasting ornaments succumbed to the puritanical zeal of the Samoan missionaries."

5.3 Importance of Biodiversity as a Foundation for Nutritional Wellbeing

Local biodiversity is the original source of almost all food for most Pacific Islanders. Traditionally, Pacific Island peoples were among the most well nourished and healthy people on Earth. Their extremely “biodiverse” traditional diet included: 1) fresh root crop and tree staples, such as taro, yams, sweet potatoes, breadfruit, bananas and plantains, coconut, sago palm and pandanus, all of which were represented by many different named cultivars; 2) a range of fruits, vegetables and supplementary food crops, such as Polynesian vi-apple (*Spondias dulls*), Malay apple (*Syzygium malaccense*), Tahitian chestnut (*Inocarpus fagifer*), sugarcane, sugarcane inflorescence (*Saccharum edule*), hibiscus spinach (*Abelmoschus manihot*) and amaranth spinach (*Amaranthus* spp.); 3) domesticated animals, including pigs, chickens and dog; 4) a wide range of terrestrial wild foods, including birds, fruit bats, snakes, insects, ferns, wild yams, wild vegetables and wild fruits, such as figs (*Ficus* spp.); 5) freshwater, finfish, eels, prawns, and shellfish, 6) an extremely wide range of marine foodstuffs, including finfish, shellfish, crustaceans, sea urchins, sea cucumbers or bêche–de-mer, octopus and squid, jellyfish, sea anemones, turtles, dugongs and seaweeds; 7) the important social beverage, kava (*Piper methysticum*), and the masticant, betelnut (*Piper betle*); 7) for water (perhaps the most important of all nutrients!!) or drinks, fresh water, coconut juice, coconut toddy (both fresh and fermented) and the high percentage of water contained in sugarcane, fruits and most traditional crops; and, 8) for infants, breastmilk provided during prolonged breastfeeding, and fresh weaning foods premasticated by the mother and/or father. Serious malnutrition, diabetes and cardiovascular disease were rare, and people had good teeth (Barrau 1958, 1961; Durnin, 1970; Parkinson 1982; Powell 1976; Thaman 1982; Yen 1980)

Today, however, a large percentage of Pacific Islanders, mainly in urban areas, are among the most poorly nourished people in the world. They have extremely high rates of iron-deficiency anemia, vitamin-A deficiency, obesity, dental disease and nutrition-related non-communicable diseases, such as diabetes, hyperuricemia and gout, hypertension, cardiovascular disease and some forms of cancer, such as stomach and bowel cancer. The main causal factor associated with this drastic health transformation is the abandonment of the traditional biodiverse diet, which was rich in vitamins and minerals, fiber, and complex carbohydrates, and low in salt, fat, sugar and highly refined carbohydrates, and its replacement by an urban diet based on highly refined or canned imported foods and drinks, such white flour, noodles, cabin biscuits, white rice, sugar, tinned corn beef, "Spam", cheap fatty cuts of meat, beef dripping, ice cream, candy, soft drinks and cordials, heavily-sugared tea, coffee and hot chocolate and alcohol. This change in diet, away from the biodiverse traditional diet, coupled with a more sedentary lifestyle and widespread consumption of tobacco, has been widely considered a nutritional, health and social disaster, with many of the most highly trained and skilled people dying prematurely (Baker 1979; Bindon 1982; Haywood and Nakikus 1982; Jeffries 1979; Parkinson 1973; Speake *et al*. 1979; Thaman 1984, 1988b; Zimmet *et al*. 1977, 1978, 198ab).

5.4 Cultural Importance of Biodiversity in Ha'apai, Tonga

Finally, from a broader perspective, an in-depth study of the importance of biodiversity to six communities in the low-lying islands of the Ha'apai Group of Tonga, conducted under the South Pacific Biodiversity Conservation Programme (SPBCP)(Reti 1993), further underlines the critical cultural and economic importance of biodiversity to local communities. To stress the economic, in particular monetary, importance of biodiversity, the target communities were asked to list those terrestrial and marine plants and animals they sold to earn money. They were also asked to list plants of particular economic and cultural importance that were used for food, medicine, fuel, body ornamentation and a number of other purposes, as well as those species that were rare, endangered or in short supply, and the reasons for this.

The analysis of the survey results indicated that there are over 300 plants that have economic or cultural significance. For example, there are at least 74 food plants, 66 plants used medicinally, 42 as fuelwood, 35 classified as sacred or fragrant plants (**kakala**) used for garlands and scenting coconut oil, 28 for timber, 27 for animal feed, 21 for woodcarving, 19 for living fencing and hedging and 15 each for weaving and plaited ware and as dyes. The results also indicate that a range of seaweeds, over 120 finfish species, over 40 shellfish, about 20 crab species, and a number of other marine invertebrates are eaten and many of them sold. In terms of commercial importance, the survey showed that, even on low-lying islands at a distance from the main urban island, almost 100 different plant products (68 cultivated and 25 wild species) were sold to obtain cash income.

Of the 68 cultivated species, the most frequently mentioned as being sold is a range of fruit trees found through the Pacific Islands. The most important are mangoes, papayas, oceanic litchi (*Pometia pinnata*), coconut, plantains and bananas, a range of citrus trees and Malay apple (*Syzygium malaccense*) which were all mentioned as being sold by at least half of the respondents. Also reportedly sold were: 1) staple root crops including taro, yam, cassava, giant taro, sweet potato, sweet yam and potato; 2) non-tree fruits including sugarcane, passionfruit, pineapple, watermelon and granadilla; 3) export crops such as squash or butter pumpkin (which was exported to Japan) and vanilla; 4) supplementary food plants including, English and Chinese cabbage, hibiscus spinach (*Abelmoschus manihot*), peanuts, tomatoes,

carrots, corn, beans, sweet capsicum and chilies; 5) handicraft plants such as pandanus (used to make mats, baskets, hats and other plaited ware), paper mulberry (*Broussonetia papyrifera*) (used to make tapa cloth), and Polynesian arrowroot (*Tacca leontopetaloides*) (used as an adhesive for tapa cloth); 6) a range of culturally important plant products used for scenting coconut oil, leis or garlands; 7) the important social and ceremonial beverage, **kava** (*Piper methysticum*), and coffee; and, 8) a number of timber species including raintree, kauri (*Agathis* spp.), Caribbean pine, eucalyptus and West Indian cedar.

Wild plant products reportedly sold include: 1) guava and pummelo (*Citrus grandis*), the fruit and firewood of both being sold; 2) sandalwood, which is sold to Asian traders; 3) **milo** (*Thespesia populnea*), **feta'u** (*Calophyllum inophyllum*), and **puataukanave** (*Cordia subcordata*) which are used in woodcarving; 4) the inner bark or bast fibre of **fau** (*Hibiscus tiliaceus*) which is used for making dancing skirts and in other handicrafts; 5) **piini Tonga** (*Lablab niger*) which is used both as human and animal food; 6) a range of trees that are sold for carving, construction or firewood purposes; 7) **lopa** (*Adenanthera pavonina*) and **moho** *Abrus precatorius*), the bright red seeds of which are used to make necklaces and other handicrafts; 8) and a number of other culturally valuable plants.

Six domesticated animals are sold to obtain money in Ha'apai, the most important of which are pigs, horses and cattle. Pigs are central to social and ceremonial life in Tonga and most other areas throughout the Pacific, with no important feast or important meal being complete without a roasted or baked (in the earthen oven) pig. Pigs are also very important presentations, and part of most ceremonial exchanges. Horses are a very important means of transportation in Ha'apai, and are occasionally eaten as a delicacy, whereas beef cattle are also important for feasts and an important part of the Tongan diet. Goats are occasionally sold, as are chickens, which are very common, but mostly raised for subsistence consumption.

Finfish reportedly sold by over a third of the 23 groups of respondents included: 1) rabbitfish (*Siganus* spp.); 2) parrotfish (*Scarus* and *Leptoscarus* spp.); 3) jobfish and deepwater snappers (*Aphareaus, Pristipomoides* and *Etelis* spp.); 4) goatfish (*Mulliodichthys, Parupeneus* and *Upeneus* spp.); 5) groupers or coral trout (*Cephalopholis, Plectropomus* and *Epinephelus* spp.); 6) surgeonfish **(***Acanthurus* spp.and *Ctenochaetus striatus*); 7) seaperch or snappers (*Lutjanus* spp.); 8) big-eye scad (*Selar crumenophthalmus*); 9) unicornfishes (*Naso* spp.); tunas (*Gymnosarda, Katsuwonus* and *Thunnus* spp.); and 10) emperors (*Lethrinus* spp.). Other highly sought after fish that are sold include mullets (*Crenimugil* and *Liza* spp.); the sabre squirrelfish (*Sargocentron spiniferum*); trevallys (*Carangoides, Caranx* and*Gnathanodon* spp.); Japanese sea bream (*Gymnocranius euanus*); barracudas (*Sphyraena* spp.); and wrasses (*Cheilinus* spp.). Together, these finfish, most of which are found throughout the Pacific Islands, constitute an extremely important and potentially sustainable resource, if managed wisely.

Although there are possibly as many as eight species of marine mammals (whales and dolphins) and at least six species of marine reptiles (turtles and sea snakes) found in Ha'apai's waters, only turtles are still exploited commercially on a seasonal basis. Their eggs and meat (mainly of the green turtle, *Chelonia mydas*) are still occasionally consumed, and the shell of the hawksbill turtle (*Eretmochelys imbricata*) is sold whole or carved into jewelry for sale to tourists. Although whaling, which was formerly practiced by some families in Ha'apai, has ceased due to Tonga becoming signatory to the International Whaling Commission, some skilled Tongan craftsmen carve whalebone into scrimshaw for sale locally to tourists and for export. Although the sale of both marine turtle-shell and

whale-bone or whale-tooth products is discouraged internationally, Tonga is not yet party to the Convention on International Trade in Endangered Species of Fauna and Flora (CITES), and is not bound by its provisions.

There are over 20 shellfish species or groups of species sold and of commercial value in Ha'apai. This does not include a wide range of species, such as small cowries, cone shells, miters, auger shells, tritons, conches and other shells used in handicrafts or sold to tourists as specimen shells or souvenirs. The most important species, which were reportedly marketed (often shipped to Nuku'alofa) by over half of the respondents, included ark clams (A*nadara* spp.), turban shells **(***Turbo* spp.) and giant clams (*Tridacna* spp.). Other species commonly marketed include venus clams (*Gafrarium* spp.), palate tellin (*Tellina palatam*) and youthful venus clam (*Periglypta puerpera*). All of these species are considered delicacies and fetch good prices on the market. Also of considerable commercial importance are black-lipped pearl oysters, the shells of which are exported overseas as mother-of-pearl used in jewelry and button manufacture.

Nine species of bêche-de-mer or holothurians are sold commercially in Ha'apai. Most of these, with the exception of the **te'epupulu** (*Holothuria leucospilota*), which is sold locally as a delicacy, have been heavily exploited throughout the Pacific Islands, for export to the lucrative Asian market where they are considered a delicacy and an aphrodisiac.

Other marine invertebrates (excluding shellfish and beche-de-mer) reportedly sold and of commercial value in Ha'apai include octopus, chitons, sea urchins and lobsters, all of which bring good returns to the producers. Other animals reportedly sold at one time or another include jellyfish, sea anemones, sea hares, crabs, fan coral, black coral and cuttlefish. All of these also constitute either important seasonal delicacies or subsistence foods that are eaten when available.

Eleven seaweeds are reportedly sold and of commercial value in Ha'apai. The most important are sea grapes (*Caulerpa racemosa*), **limu tanga'u** (*Cladosiphon* sp.) and **limu te'epuaka** (?), with **limu tanga'u** having been exported in large quantities to Japan from Tongatapu and Ha'apai in 1996-97. The other species constitute an important supplementary nutritional resource, although some are not edible.

The results of the survey clearly show: 1) the economic importance of biodiversity in terms of its cash-earning role; and 2) that, for isolated rural communities, for which there is generally no single terrestrial or marine product that can make them rich or provide them with sustainable incomes throughout the year, that the protection of the widest range of biodiversity is the best way of ensuring that rural families' cash and subsistence incomes can be sustained. Although the low-lying islands of Tonga's Ha'apai have a poorer biodiversity inheritance than the larger islands of the Pacific, most of the species of importance there are of importance and used in a similar manner throughout the high-island and low-island Pacific.

These few examples from the analysis of the cultural value of trees, coastal plants, the traditional Pacific Island food systems, and the biodiversity of Tonga's Ha'apai group, show the cultural sophistication and storehouse of empirical knowledge possessed by Pacific island societies in relation to their biodiversity inheritances. If analyses are performed for other ecosystems, both terrestrial and marine (Table 1), and for all taxa, both wild and domesticated and plant and animal (Table 2), the "bio-utility" of the biodiversity to Pacific Island peoples becomes almost incomprehensible to the ordinary urban planner or scientist who has lost touch with the natural world and subsistence living systems. In short, the term

"biodiversity" for people who depend on it and know it, particularly rural Pacific peoples with only limited opportunities for generation of cash income, takes on immense meaning. **However, the economic, cultural and ecological value of biodiversity is rarely acknowledged in detail in development plans, project documents, or aid proposals, despite the fact that the products and benefits provided by it (even in the case of coastal vegetation alone) would be extremely expensive or impossible to replace with imported substitutes.**

6 THE CURRENT STATUS: PACIFIC ISLAND ECOSYSTEMS, PLANTS AND ANIMALS THAT ARE RARE, ENDANGERED OR IN NEED OF PROTECTION OR RE-ESTABLISHMENT

As stressed before, although all Pacific Island societies have a wealth of terrestrial and marine biodiversity, as we begin the 21st Century, as a result of the threats discussed in section 6 (Table 5), there are frightening signs of the loss or endangerment of this living inheritance that has supported Pacific Island societies for millennia. These include a wide range of terrestrial, freshwater and marine ecosystems and species that are now rare or endangered and under threat. As stressed by Kirsch (1982), Flenley and King (1984), Steadman (1995) and Lewis *et al*. (1988), this is not a new phenomenon, but rather a phenomenon that began long before European contact with the islands, when the early Pacific Islanders severely deforested some of the Hawaiian Islands and Easter Island (Rapa Nui), brought many bird species to extinction or extirpation (local extinction) throughout much of Polynesia, and brought to extirpation some species of giant clams in Fiji, Tonga and Samoa. The process has, however intensified, and the identification of the ecosystems, species and genetic resources that are rare, endangered or in need of protection or re-establishment is critical to the success of biodiversity conservation efforts and for the maintenance of cash and non-cash incomes in the Pacific Islands, at ALL levels (regional, national and local). This would also include the identification of ecosystems, plants and animals that are of particular economic or cultural importance as a basis for the promotion of ecologically, culturally and economically sustainable development. An attempt to do this for the entire Pacific is shown in Table 6 below.

As can be seen from Table 5, there is a wide range of ecosystems and organisms that are in need of protection. Although the need for the protection of these organisms is slightly less in the larger islands of Melanesia, where there is greater ecosystem and biotic diversity, larger areas of strategic ecosystems, larger populations of individual organisms, and lower human population densities, there is, nevertheless, a serious need to protect designated ecosystems and specific endangered organisms throughout the Pacific. Even in the larger island countries, there exist many small-island communities with limited resources and high population densities that experience the same trends of degradation and loss of biodiversity as the communities in the smaller islands of the eastern Pacific.

Table 5. Ecosystems and groups or taxa of terrestrial, freshwater and marine plants and animals that are rare, endangered or in short supply, and in need of some form of protection in the Pacific Islands (+++ = of serious widespread concern and in need of immediate protection; ++ = of some widespread concern or of serious concern in specific areas; + = of limited or localized concern; - = of no concern; NP = not present)(* Note: Palau does have apparently have one species of endemic frog, Crombie and Pregill, 1999).

Category	Melanesia	Polynesia	Micronesia
Ecosystems			

uninhabited islands	++	+++	+++
coastal littoral and mangrove forests	++	+++	+++
lowland forests	++	+++	+++
montane/cloud forests	++	++	++
rivers and lakes	+++	+++	+++
wetlands/swamps	++	+++	+++
shifting agroforestry lands and agroforests	++	+++	+++
semi-permanent/intensive agricultural areas	++	++	+++
houseyard and village gardens	++	++	+++
selected productive reefs	+++	+++	+++
intertidal zone and seagrass beds	++	+++	+++
reef passages	++	+++	+++
coral reefs	+++	+++	+++

Terrestrial Organisms

native coastal and mangrove plants	++	+++	+++
native inland trees and plants	++	+++	+++
cultivated trees and plants	++	+++	+++
plant cultivars/varieties	++	+++	+++
native insects/arthropods	++	+++	+++
land crabs	++	+++	+++
native molluscs	++	+++	+++
other native invertebrates	++	+++	+++
native amphibians	+++	NP	+*
native reptiles	+++	++	++
native birds	+++	+++	+++
native mammals	+++	+++	+++
humans (ethnobiological knowledge)	+++	+++	+++

Freshwater Organisms

freshwater plants	++	+++	+++
crustaceans	++	+++	+++
shellfish	++	++	++

	insects		+++		+++		+++	
finfish/eels		++		+++		+++		
	amphibians		++		NP		NP	
	reptiles		+++		+		+	
Marine Organisms								
	Seaweeds (marine macro-algae)		++		++		++	
sea grasses		+++		+++		+++		
	stony reef-forming corals		+++		+++		+++	
	shellfish (giant clams, trochus, turban snail, pearl oyster, triton)		+++		+++		+++	
bêche-de-mer/holothurians		+++		+++		+++		
	crabs, lobsters, mantis shrimp		++		+++		+++	
	reef and lagoon fish		++		++		++	
	eels (conger, moray)		++		++		++	
	large demersal finfish (rockcods, wrasses, parrotfish)		+++		+++		+++	
sharks and rays		++		+++		+++		
	billfish		+++		+++		+++	
	turtles		+++		+++		+++	
	crocodiles		+++		-		+	
sea birds		+++		+++		+++		
	mammals (whales, dolphins, dugongs)		+++		+++		+++	

7 THREATS TO PACIFIC ISLAND BIODIVERSITY AND BIODIVERSITY CONSERVATION IN THE PACIFIC ISLANDS

As outlined in the previous section, the rich biodiversity inheritance of the Pacific Islands is seriously threatened. Many ecosystems are being degraded and reduced in size and many terrestrial, freshwater and marine plants and animals are rare, endangered or in short supply. Table 6 is an attempt to identify and classify the most significant threats to biodiversity and biodiversity conservation that need to be addressed in the mainstreaming of biodiversity in the Pacific Islands. The classification is designed for use at the regional, national and local or community levels to prioritise, address, monitor and reassess the severity of these threats. An attempt has been made to group the threats into the following categories: 1) natural or ecological threats, including both natural and cultural threats, that seriously degrade and upset the stability of natural and cultural ecosystems and their biodiversity, and 2) social, institutional or infrastructural activities or phenomena that indirectly threaten, or undermine the capacity to conserve or sustainably use biodiversity.

Most of these threats are of global or international and national or local concern, and can be addressed, in some way, at all levels through "mainstreaming". Some, however, like the depletion of stratospheric ozone and international trade of endangered, or potentially invasive, plants and animals, are best dealt with regionally or internationally, whereas, the protection of endangered or threatened species and ecosystems are, perhaps, best dealt with at the national or community levels. Similarly, many of these threats overlap or feed into each other, and if not addressed in some way, could lead to a dangerous negative synergistic effect and the collapse of entire ecosystems or biological communities and the countries and cultures that depend on them. Conversely, if a number of threats are addressed simultaneously, the result could be very positively synergistic and lead to significant gains in the mainstreaming of conservation and sustainable use of biodiversity in the Pacific Islands.

Table 6. Significant reasons for the loss of biodiversity or threats to biodiversity and biodiversity conservation in the Pacific Islands that can be addressed in the mainstreaming of biodiversity conservation at the regional, national and local community levels.

I. DIRECT THREATS TO BIODIVERSITY

High Frequency of Extreme Events/Natural Disasters

Global Warming/Eustatic Sea-Level Rise

Stratospheric Ozone Depletion and Increasing UV-B Radiation

Breakdown and simplification of the species composition and trophic structure of terrestrial, freshwater and marine ecosystems and ecosystem functions

Degradation of uninhabited Islands

Upland and Inland Deforestation and Forest Degradation

Coastal and Mangrove Deforestation and Degradation

Degradation of Freshwater Resources and ecosystems

Agricultural Simplification and Degradation, Agrodeforestation and the Loss of Biodiversity in Agricultural Systems

Overgrazing and degradation of biodiversity by domestic livestock

Destruction due to feral animals

Alien Invasive Plants and Animals

Pest and Disease Infestations and Epidemics

Soil Degradation and Accelerated Soil Erosion

Fire

Destruction and Degradation of Productive Marine Ecosystems and Disruption or Change in the Dynamics of Marine Ecosystems

Overuse/Overexploitation/Unsustainable Use of Terrestrial Plant and Animals Resources

Overfishing/Overexploitation/Unsustainable Use of Marine Resources

Use of Destructive Fishing Technologies

Illegal Fishing

Pollution of Freshwater Resources

Air Pollution

Marine Pollution

Indiscriminate and Increasing Use of Pesticides

Hazardous/Toxic Waste Disposal

Nuclear/Radioactive Pollution and Contamination

II. SOCIAL, INSTITUTIONAL AND INFRASTRUCTURAL THREATS

Uncontrolled Population Growth

Loss of Traditional and Contemporary Ethnobiological Knowledge

Breakdown in Traditional Diversified Subsistence Economy

Inadequate Modern Scientific Baseline Knowledge of the Nature and Status of Biodiversity

Inadequate Systems of Marine and Terrestrial Conservation Areas

Inadequate Capacity to Deal with Terrestrial, Freshwater and Marine Invasive Species

Inadequate Legislation/Legal Instruments

Inadequate Infrastructure/Capacity for Biodiversity Conservation

Inappropriate Modern Education and Curricula

Rapid and Uncontrolled Urbanization

Unforeseen large-scale Developments

Free Trade/Globalization and Increasing International Free Trade in Biodiversity

Poverty and Economic Deterioration

Gender Inequity in the Control, Use and Management of Biodiversity

Political Instability and Political Ignorance or lack of Political Will to Commit to Conservation

Although it is beyond the scope of this paper to discuss each of these threats in detail, Although many of these threats have been discussed briefly in the previous sections, the following sections attempt to discuss most of the more serious direct threats and some of the indirect threats in somewhat greater detail, as well as including some with brief suggestions for mainstreaming actions to address them. Suffice it to say that all of these threats, many of which are interrelated, are of serious concern to varying degrees throughout the Pacific. If our efforts to mainstream biodiversity conservation are to be successful, these threats need to be systematically addressed, at a range of different levels (government, school systems, local communities), by different agencies (e.g., NGOs, private enterprises, funding/aid agencies) and in a range of different forums (e.g., at this conference and the Earth Summit in two months time in Johannesburg, etc.). To better understand the threats that confront the ecological integrity of Pacific Island biodiversity, it frequently helps to break down “threats” into the “stress” affecting the system or species, and the “source of the stress”. A source of stress is an extraneous factor, either human or biological, that infringes on a system or species in a way that results in the stress, e.g., habitat fragmentation or sedimentation would

be stresses, and incompatible forestry practices might be one of the causes of those stresses. Such distinctions help focus the development of effective strategies.

7.1 High Frequency of Extreme Events/Natural Disasters

Tropical cyclones, high winds, tornadoes, droughts, floods, tidal waves, king tides, volcanic eruptions, earthquakes, tsunamis/seismic sea waves, prolonged droughts, coral bleaching and El Niño and La Niña (ENSO) events all have a dramatic impact of the biodiversity of islands, particularly small islands that have small populations of different species of terrestrial, freshwater and marine plants and animals and limited areas of important ecosystems and limited potential for replacement by over-ocean dispersal. Recent increases in the frequency of such events have caused widespread habitat/ecosystem destruction and degradation and the reduction in numbers and extirpation or extinction of rare or endangered species, particularly those that are in small populations. Temporary increases or falls in sea level and sea-surface temperatures have shown to have extremely serious impacts on coral reefs, in the form of widespread coral reef bleaching, the death of corals and breakdown in coral reef and marine ecosystems. These in turn cause economic deterioration and increased poverty at the national and local levels which in turn leads to an increase in the commercial and subsistence exploitation of biodiversity and negatively affects the willingness of countries and communities to promote environmentally sustainable development and biodiversity conservation

To address this threat there is a need to improve systems for preparedness, response to and recovery from extreme events. Of critical importance is the preservation of both natural and cultural biodiversity (e.g., crop and cultivator diversity and the knowledge of emergency food use) as in-built insurance against extreme events. Of particular importance for small island states and coastal communities is the protection and planting of coastal forests and vegetation. In addition, the replication of, and connectivity between areas of protection, will greatly facilitate the prospects of survival, or recovery of areas after extreme events (e.g., networks of marine protected areas that contain areas of corals resistant or resilient to coral bleaching, will greatly facilitate recovery of reef systems after a bleaching event).

7.2 Global Warming/Eustatic Sea-Level Rise

There is serious concern in the Pacific Islands over global warming and rising sea levels, associated with the accumulation of greenhouse gases (e.g., carbon dioxide, methane, etc.), thermal expansion of the oceans, melting of snow pack and ice caps, glacial rebound, etc. This will, and probably already has, led to an increase in the frequency and severity of impacts of extreme events on low-lying islands, coastal areas, coral reefs and associated ecosystems. It is feared that it will alter ocean circulation and upwelling patterns, precipitation distribution and storm tracks. This can, and has, caused habitat destruction, ecosystem degradation and the extinction, extirpation or changes in distribution of some species and ecosystems. Because temperature is the main controlling factor on the health and distribution of corals and other marine organisms, global warming, particularly when El Niño events are superimposed on it, could have serious effects on the distribution and health of coral reefs and other marine ecosystems and their component biodiversity. Of particular concern are increasing coastal erosion and salt water incursion into freshwater lenses due to rising sea levels and increased severity and frequency of major storm events.

To address this threat there is a need to implement strategies to prepare for and address the negative impacts of global warming and sea level rise and become party to, and vigorously support regional and international initiatives (e.g., the Kyoto Protocol) to limit the emission

of greenhouse gases, reduce the future magnitude of global warming and to develop actions that can minimize the negative impacts on small islands and coastal areas in the Pacific Islands. Foremost among these actions should be universal programs to promote the protection and/or restoration of coastal forests/vegetation and coral reefs at the national and community levels throughout the Pacific Islands. Pacific Island countries can also limit their own emissions to show their commitment to global efforts to reduce global warming

7.3 Stratospheric Ozone Depletion and Increasing UV-B Radiation

Although often confused with global warming, the breakdown in the Earth's stratospheric ozone layer, the Earth's primary shield against biologically damaging ultraviolet radiation from the sun is possibly the most serious long-term threat to the Earth's biodiversity. This is caused by the manufacture and release of certain compounds (e.g., chloroflourocarbons/CFCs and brominated compounds, including refrigerants, foam products, aerosol propellants and solvents) that gradually migrate upwards into the stratosphere and destroy ozone. Even if stopped now this process will continue to increase on a global scale because of continued emissions worldwide that will take years to reach the stratosphere. UV-B radiation is ionizing radiation that can change the proteins and nucleic acids in living things. In addition to causing increases in human cancer, it also has similar, possibly more serious effects, on other organisms, such as frogs. UV-B can also penetrate to ecologically significant depths in the marine environment (typically tens of meters) and has shown to cause population reductions in marine phytoplankton, zooplankton and juvenile stages of some fish. It, thus, has the potential to upset the entire marine food chain and to lead to serious extinctions in the marine and terrestrial environments.

Pacific Island countries must become party to, and very strongly support, international and regional protocols (e.g., the Montreal Protocol) to limit the emission of ozone depleting substances and/or to slow down the ongoing breakdown in the Earth's ozone layer

7.4 Breakdown and Simplification of the Species Composition and Trophic Structure of Terrestrial, Freshwater and Marine Ecosystems and Ecosystem Functions

There is increasing evidence of the loss or endangerment of important "keystone" species in many Pacific Island ecosystems. Such species include insects, spiders, birds, fruit bats, crabs, sharks, parrotfish, foraminiferans, etc. that serve as pollinators, dispersal agents, decomposers, top predators or sand producers, which play critical roles in maintaining the balance within, and the healthy functioning of, ecosystems. Many of these species are endemic species that have co-evolved with other species over hundreds of thousands or millions of years in the island ecosystem and are highly specialized and highly dependent for their survival on the species that they have co-evolved with. The loss of these species, upon which many other species and the functioning of ecosystems depend, can lead to the breakdown in fragile interspecies relationships, entire food chains and reproductive cycles and to the collapse of entire ecosystems and the breakdown in local subsistence economies that depend on terrestrial and marine biodiversity. For example, the loss of pollinators can lead to the eventual extinction of the plants that depend on the pollinator, which in turn can lead to the extinction or reduction in the populations of those animals that depend on plants or feed on the animals that feed on plants. Similarly, the decrease in parrotfish and foraminiferans (one-celled marine organisms with calcareous shells), both of which are responsible for the production of a high proportion of sand and marine sediments, can lead to the loss of beaches and accelerated coastal erosion and the breakdown in coastal and lagoon ecosystems, especially when coupled with loss of corals due to bleaching events.

There is a need for improved institutional and public awareness of the complexity of interspecies relationships in island ecosystems. There is also a need to continually focus on the preservation of entire ecosystems as the most effective way of ensuring that all species are protected and that ecosystem functions are not compromised by the elimination of critical keystone species, such as pollinator insects, which have only recently been targeted in programs focused on the protection of individual species.

Degradation of Uninhabited Islands

The degradation of uninhabited remote or offshore islands is a serious threat to biodiversity in the Pacific Islands. Because there are no human resident populations and associated domesticated or feral animals (e.g., pigs, goats, cats, chickens, etc.) some uninhabited islands, particularly the inland vegetation and associated habitats, are often less disturbed and constitute refuges for endangered or overexploited terrestrial and marine plants and animals, as well as marine organisms. Uninhabited islands are also often free of many introduced invasive plants, animals and micro-organisms (e.g., rats, mongooses, mynah birds, ants, malaria, snails, snakes, etc.) that are threats to indigenous biodiversity. Because they are uninhabited, uninhabited islands are often treated as “unowned” or "unoccupied" common property that can be plundered for their terrestrial and marine resources, or selected as prospective sites for waste disposal or weapons testing because there are no people physically present to restrict such exploitation. Although they are owned, or considered the property of traditional owners or the government, their trees, other plants and near-shore fisheries resources are commonly used, without permission, often illegally and secretly, by outsiders. For example, uninhabited islands are commonly used as temporary bases by both local and foreign or "outside" fishermen, most recently by bêche-de-mer and live reef food fish operators. While they are there they often freely exploit firewood and a range of other resources. Uninhabited islands are also popular yacht anchorages, and the unauthorized use of uninhabited islands and their marine resources, and possible destruction to surrounding reefs by people from yachts is also a concern of the communities that own or fish around uninhabited islands. A number of islands are also known to have excellent waves for board surfing, which, if unregulated could lead to further conflicts over resources.

Of particular concern is the indiscriminate exploitation, on uninhabited islands, throughout the Pacific Islands, of: 1) seabirds and seabird eggs, a traditional delicacy; 2) turtles and turtle eggs on islands known to be turtle nesting sites; 3) coconut crabs, hermit crabs and other onshore invertebrate resources; 4) finfish, shellfish and other marine resources, such as bêche-de-mer and giants clams, for commercial purposes; and, 5) trees, such as sandalwood for export to Asia, trees for woodcarving, and trees for firewood for cooking meals and to dry and cure bêche-de-mer and other marine products.

Uninhabited islands should receive some form of protected status so that their resources are not destroyed or used unsustainably. Almost all uninhabited islands, both large and small, constitute important “resource islands” to the local communities and biological reserves of scientific and global importance, and should be given either “protected status” or rules should be put in place immediately to use their resources more sustainably.

7.6 Upland and Inland Deforestation and Forest Degradation

Many forest ecosystems and many indigenous and introduced trees, particularly on small islands, are either degraded, endangered, scarce or in need of protection. Primary or relatively undisturbed inland indigenous lowland, slope, montane or cloud forest, is rare, endangered or absent on most populated small islands. Deforestation of watersheds throughout the Pacific is also the main cause of increasing flooding and sedimentation of rivers and streams and increasing sediment loads that are destroying or degrading many nearshore coral reefs and other coastal ecosystems and their biodiversity. Forests are the main habitat for the great majority of terrestrial plants and animals. These plants and animals, particularly major timber trees, vines, orchids, a wide range of medicinal plants, birds, bats, reptiles, frogs, indigenous mammals, land snails, butterflies and a wide range of other ecologically important insects depend on forests for both food and a place to live and

reproduce. Moreover, a vast majority of unique endemic species live almost exclusively in indigenous inland and upland forests. Where forests have been destroyed, degraded or reduced, the plants and animals, including the human cultures that depend on have disappeared along with them. This is particularly true in the cases of birds, fruit bats and other mammals and other larger vertebrates that are near the top of terrestrial food chains.

Most inland forest areas should be given some form of protected status, particularly on smaller islands where there is very limited inland forest cover. In some areas indigenous reforestation and forest restoration efforts may be required. Where logging must take place, this should be restricted to systems of sustainable rotational logging. Such programs should be promoted at both the national and community levels, and should be complemented by awareness programs that stress the critical ecological importance of forest ecosystems as reservoirs of biodiversity of critical ecological, economic and cultural importance to Pacific Island nations and societies. Most local communities clearly understand the ecological importance of forests and, given the appropriate support, are willing to give some form of protection to remaining areas of forest and small tree groves on all islands.

7.7 Coastal and Mangrove Deforestation and Degradation

Coastal deforestation and the degradation of coastal and mangrove forests and the loss of coastal and mangrove biodiversity is a serious problem throughout the Pacific. This commonly takes the form of the conversion or reclamation of coastal vegetation and mangroves for other, often agricultural, urban or industrial uses. On many smaller islands, and in some coastal areas on larger islands, thousands of years of habitation of coastal areas and the selective use of coastal and mangrove species for firewood, construction and boatbuilding materials, for woodcarving, medicines and other purposes, including widespread destruction during World War II, have led to either the total removal of coastal vegetation or the selective removal of many of the more culturally valuable species. The protection of coastal littoral and mangrove forests is considered a priority area for most governments and local communities. Their protection is particularly important because these forests protect inland garden areas and coastal settlements from cyclone damage, storm surge, saltwater/tidal incursion, coastal erosion and salt spray and the threat posed by global warming and associated sea-level rise. These ecosystems are also important habitats for a wide range of culturally and economically important plants and animals and, in the case of mangroves, of a very wide range of marine organisms. When coastal forests and vegetation are removed or degraded coastal erosion is accelerated, salt water incursion and salt spray damage to crops and property increases, and coastal and mangrove plant communities are threatened

Coastal and mangrove forests should receive some form of protection at both the national and community levels, particularly in small islands where they are limited. Coastal forest and mangrove species that are rare or endangered should be declared threatened species and given protection status on an individual basis and programs implemented for their propagation and planting. Associated with these programs should be programs, at the policy maker, community and resource-owner levels, to heighten public awareness of the ecological, cultural and economic importance of coastal forests and mangroves and the reasons that they should be protected and used sustainably.

7.8 Degradation of Freshwater Resources and ecosystems

The pollution, overuse and diversion or drainage of rivers, swamps, other surface water resources and groundwater sources is a serious problem in many areas. Major pollutants

include domestic waste and sewage, animal waste, agricultural waste, including fertilizer and pesticide runoff and leachate, industrial waste including waste from timber milling and mining. There are also the problems of siltation of rivers, reservoirs and drainage ditches, and the incursion of saltwater into freshwater lenses on atolls, other small islands and coastal areas throughout the Pacific Islands.

Overuse or overdraught of limited freshwater resources is also a problem, especially on atolls and small islands that are susceptible of prolonged droughts and particularly in areas where there is increasing use of electric pumps that can rapidly deplete the freshwater lens. As stressed before, there are also serious cases of the pollution and degradation of freshwater ecosystems due to the introduction and spread of introduce aquatic plants and fish, such as water hyacinth and tilapia.

Freshwater is, perhaps, the most basic and important resource for insuring the continuing health of both human communities and the non-human terrestrial and freshwater biological communities. The pollution, overuse and degradation of freshwater resources, thus, constitutes perhaps one of the greatest threats to the conservation of biodiversity in the region. Freshwater ecosystems and freshwater resources, in general, must be among the most highly threatened ecosystems in the Pacific, particularly on small islands, given their highly restricted distribution, sensitivity to disruption, attractiveness to human development, and the high dependence of human communities on water. The problem is exacerbated in times of prolonged drought when drought-sensitive plants and animals decline in numbers or become locally extinct.

There is, thus, an urgent need for legislation, public awareness and water conservation and protection actions to protect freshwater resources from further degradation. On some small drier islands where local demand for water is great there is a priority need for the development of improved rainwater catchment systems and, possibly, the use of appropriate desalination technologies.

7.9 Agricultural Simplification and Degradation, Agrodeforestation and the Loss of Biodiversity in Agricultural Systems

In many areas of the Pacific, agricultural lands are rapidly being degraded, and the biodiversity from these systems lost. There is an urgent need for the protection and restoration of agricultural biodiversity. Of particular concern is the breakdown of traditional shifting agroforestry systems in which a wide range of fruit trees and other culturally and ecologically valuable trees, plants and wild and domesticated animal life were deliberately protected within a matrix of ground and tree crops and various stages of fallow vegetation. The loss of trees within agricultural areas and the degradation of agricultural areas are considered by many communities as the main reasons for the endangerment or loss of a considerable number of useful trees and other plants, birds and other animals of economic or cultural importance.

Agricultural areas/ecosystems, including both shifting agricultural and permanent or semi-permanent agricultural areas, provide for most of the subsistence needs, and a large proportion of the cash needs, of the people of the Pacific Islands. These systems were polycultural systems that not only included staple food plants, but also a wide range of supplementary food crops, other useful cultivated and wild trees and other plants, a range of domesticated and feral animals, and served as a habitat for a wide range of culturally and ecologically valuable wild plants and animals. Today, however, increasing emphasis on the monoculture of a narrow range of cash crops (e.g., copra, cocoa, bananas, oil palm,

sugarcane, etc.), increasing monoculture of, and overdependence on, single high-yielding cultivars of food plants such as cassava, sweet potato, taro and other food crops, the increasingly widespread use of the plow, inorganic fertilizers, pesticides, and indiscriminate burning and felling of tree during the preparation of new gardens has led to widespread loss of trees, other plants and animals, the disappearance of many traditional named varieties of food plants - a serious loss of agricultural biodiversity within traditional agricultural systems. This process has been referred to as "agrodeforestation". There has also been a decline in the planting of yams, taro, sugarcane and other traditional crops, and a loss of many varieties or cultivars of yams.

The process could be stopped or reversed through the deliberate planting and protection of a wide range of fruit and multipurpose trees throughout the cropping and fallow area of bush allotments; the protection and re-establishment of small tree groves in agricultural areas; the planting of trees along boundaries or as living fencing; and the prohibition on agricultural lands of practices such as indiscriminate burning, tree felling, ringbarking, ploughing and other practices that lead to the loss of trees and the degradation of shifting agricultural areas. Practices such as pollarding, rather than felling or ringbarking, and selective weeding should also be encouraged as a mean of promoting the protection and re-establishment of trees in agricultural systems. Remaining tree groves within or near agricultural areas shoal also be protected or expanded as a means of reversing the process of agrodeforestation.

7.10 Overgrazing and Degradation of Biodiversity by Domestic Livestock

The introduction of domestic grazing animals, including beef and dairy cattle, horses and goats has led to the clearance of extensive areas of forest and shifting cultivation lands for livestock schemes. The uncontrolled husbandry of pigs has also had significant impact on areas around villages and the flora and fauna. Destruction due to animals as a result of the large number of cattle and horses, and in some cases, goats, which when left untethered or unfenced, leads to significant damage to young trees, other vegetation and associated fauna. Uncontrolled grazing by cattle has led to accelerated soil erosion and goats have been responsible for the almost total devegetation of some small offshore islands. Free ranging pigs, which root up trees and seedling, are also a very serious problems in and around villages, making it very difficult to plant and maintain tree seedlings. Pigs are also a very serious threat to ground nesting birds, a range of terrestrial invertebrates and to herbaceous understory plants, including ferns.

There is a need for improved animal husbandry in the form of improved fencing and/or tethering of animals and rotational grazing to minimize habitat destruction, soil erosion and destruction of trees, crops, and wild flora and fauna by domestic animals. There is a need to convince local communities to remove goats from small uninhabited islands and to pen pigs around villages and on small islands.

7.11 Destruction Due to Feral Animals

Although related to the introduction of domestic animals, destruction due to feral pigs, goats, dogs and cats is a very serious problem on many islands. Feral animals are responsible for habitat disturbance, devegetation and the endangerment or local extinction of ground nesting birds, reptiles and other vertebrates, insects and other invertebrates. Feral cats are particularly serious problem on uninhabited islets in Kiribati and in the Yasawa Islands of Fiji, where they are the major threat to ground nesting birds and, in the latter case, also to endangered iguana populations.

There is a critical need to implement programs to prohibit the spread to and to eradicate or control populations of feral animals, particularly on small offshore islands.

7.12 Alien Invasive Plants and Animals

In addition to domesticated and feral animals, there is a wide range of other highly competitive alien plants and animals that have been either deliberately or accidentally introduced into the fragile, disharmonic island ecosystems of the Pacific Islands and, which threaten populations of indigenous, often endemic plants and animals. These include woody and herbaceous weeds, insects, snails and other invertebrates, snakes and other reptiles, rats, mongooses, birds, toads and other vertebrates (disease organisms, some of which could be included as invasive alien organisms are included under a separate category below). In the marine environment, this would include the introduction of non-indigenous finfishes, shellfish and other invertebrates, and zooplankton and phytoplankton that are deliberately or accidentally introduced (e.g. externally, as encrusting organisms, or internally in ballast water, in ships).

The island floras and faunas, which have evolved in isolation, have become very specialized and have, in many cases, lost their defense and dispersal mechanisms. As a result, they are normally not able to compete with more competitive organisms from continental areas. The threat in the marine environment is perhaps just as great, with thousands of new, often microscopic, alien marine organisms being introduced every year, mainly in ballast water. Such organisms could lead to algal blooms and the serious disruption in marine food chains.

Particularly serious have been: 1) the brown tree snake (*Boiga irregularis*), which has brought to extinction almost all of the indigenous birds and has endangered the fruit bats of Guam (Rodda and Fritts 1993); 2) the mangoose, cats and rats, which have eliminated many ground nesting birds and amphibians from some islands; 3) a number of extremely invasive weeds, such as *Miconia calvescens*, known as the green cancer, which has invaded extensive areas of native vegetation in Tahiti (CGAPS *c.* 1997*)*, and *Wedelia biflora*, which has invaded thousands of hectares in Pohnpei and has invaded coastal and mangrove areas in Fiji, Niue and Marshall Islands (Thaman 1999b); 4) biological control agents, such as the carnivorous snail, *Euglandina rosea*, which was introduced to control another introduction, the giant African snail (*Achatina fulica*), but has brought to extinction most of the many endemic partulid land snails of the island of Moorea in the Society Islands; 5) insects, particularly ants, which have been responsible for the endangerment for of birds and an wide range of endemic or indigenous insects and other invertebrates that seem to have almost no defenses against alien ants, especially in Hawai'i, which had **no** indigenous ants! (Wetterer *et al*. 1997; CGAPS *c*. 1997); and, 6) alien fish species, such as tilapia (*Oreochromis mossambica*), which has out-competed many indigenous freshwater fish and has made the aquaculture of milkfish Kiribati and Nauru difficult (Gillett 1989; Thaman and Hassall 1999). Finally, marine invasives, most of which have been introduced accidentally either as encrusting organisms or in ballast water, are among the potentially most serious threats to marine biodiversity. These include a wide range of finfish, small crustaceans, and other marine invertebrates, dinoflagellates and algae, many of which are potential parasites, pests and disease organisms that could out-compete indigenous marine organisms and seriously disrupt marine ecosystems (Humphries 1995; Coles *et al*. 1999; Eldredge 1994).

There is an urgent need to develop regional and national protocols to control the introduction, spread and to minimize the impact of alien invasive plants and animals. International agencies, such as SPREP, the SPC and USP should cooperate to assist Pacific Island countries develop Alien Species Action Plans (ASAP) along the lines of that adopted

in Hawaii, the island group, which is the most dramatic example of the negative impact that alien species can have on the indigenous flora and fauna (CGAPS *c*. 1997). There also a need for a regional data base on invasive and potentially invasive species and the strengthening of regional and national quarantine systems that can help Pacific Islands countries protect themselves against this threat (Humphries 1995). Perhaps most important is the need for a comprehensive public awareness program to make policy makers, the general public and local communities aware of the threat posed by alien invasive organisms and the need for improved quarantine services.

7.13 Pest and Disease Infestations and Epidemics

Epidemic pest and disease infestations have a very negative impact on biodiversity, especially where monocropping or large-scale livestock operations, and indiscriminate use of pesticides by humans are concerned. As such, they are seen as cultural issues, although they in fact they may be at least partly related to natural phenomena.

In Papua New Guinea, Solomon Islands and Samoa the taro leaf blight (*Phytophthora colocasiae*) has almost eliminated the cultivation of this important staple and commercial crop. Similarly, the Alomae and Bobone virus syndrome in Papua New Guinea and Solomon Islands, and Pithium corm rot in the Cook Islands, Hawaii and Western Samoa are very serious diseases to *Colocasia* taro. In Kiribati, the Papuana taro beetle has made it very difficult to practice traditional pit excavation planting of giant swamp (Cyrtosperma) taro, the only major staple root crop on many low-lying atolls. Sweet potato cultivation has been severely restricted, at times, in Ponape, Fiji and Tonga by epidemic outbreaks of sweet potato scab (*Elsinoe batatas*) and to a lesser extent by little-leaf microplasm, and yam production is commonly limited by periodic outbreaks of rose beetle and *Anthracnose* fungus. Banana cultivation, primarily for export, but also as an extremely important local staple and fruit crop, is plagued by bunchy-top virus and black leaf-streak fungus (*Mycosphaerella* spp.) as well as by the banana scab moth and root nematodes which have severely limited production in Tonga, Fiji, Western Samoa, and the Cook Islands. Insect infestations have also led to the cessation of large-scale rice production in Fiji and the Solomon Islands.

There is a need to implement programs of Integrated Pest Management (IPM) to control pests and diseases with minimal use of pesticides. There is a need for a strengthening of regional, national and inter-island systems for quarantine and fumigation. There is also a need to return to polycultural farming systems in which there is less dependence on the monocropping, often depending on only one high-yielding cultivar.

7.14. Soil Degradation and Accelerated Soil Erosion

Thoughtless deforestation, overgrazing, excessive and inappropriate ploughing, expansion of cropping onto marginal steep lands and expanded use of inorganic fertilizers and herbicides have led to soil degradation and accelerated soil erosion throughout the Pacific. Excessive ploughing in Tonga, the Cook Islands, and Hawaii have reportedly led to accelerated erosion, leaching, oxidation, and compaction. On Niue, overuse and continual burning of organic material has caused the soil level to drop due to compaction, and in Fiji estimates of losses from accelerated soil erosion on steep lands used for intensive commercial cropping (e.g., for sugarcane and ginger) range from 30 to 300 tonnes per ha per year. Inorganic fertilizer use is rapidly expanding in the Pacific. Although greatly increasing immediate crop yields, its continued use reportedly impoverishes the soil of organic matter and destroys the natural nitrogen-fixing ability of the soil. The increasingly widespread indiscriminate use of

herbicides such as the very toxic paraquat (Gramoxone) can only serve to destroy valuable organic matter. Its use is particularly widespread in taro plantations in Fiji and Rarotonga. In the latter case, herbicide use has reportedly led to subsidence and compaction in gardens that have served Cook Islanders for centuries.

There is a need to restrict cultivation on steep lands or to develop improved methods of strip cropping or the preservation of forest on the upper slopes. Restrictions on plowing and the encouragement of mulching and restrictions on burning and indiscriminate herbicide use can also have a positive effect on soil conservation.

7.15 Fire

Uncontrolled or indiscriminate use of fire or burning for agricultural clearance, hunting, extending and renewing pasture lands, recreational burning and arson is serious widespread problem. Although evidence shows that there have always been natural fires, particularly during periods of prolonged drought and on climatically drier islands, fires of human origin have shown to have serious consequences for biodiversity on most islands and for most ecosystems. For thousands of years indiscriminate burning has been the main cause of the extension of grasslands and degraded fern lands at the expense of native forest. Grasses and fast-growing herbaceous plants are better adapted to fire than trees. Whereas fires will kill tree seedlings and many species of trees, grasses and herbs and other pioneer plants re-establish quickly. If fires are frequent enough, grasslands and degraded fernlands will eventually replace forest and savanna vegetation. Examples of this are the extensive lowland and highland grasslands of Papua New Guinea, the **niaouli** savanna grasslands of New Caledonia, the "sunburnt" **talasiga** grasslands of Fiji, and the extensive Guinea grass or **saafa** grasslands of Tongatapu in Tonga.

Whereas primary and secondary forests are composed of mainly indigenous and long-established culturally-useful trees, plants and animals, grasslands are composed mainly of recently introduced non-indigenous species. Grasslands clearly have less biodiversity than forests and most other indigenous vegetation associations. When forest is replaced by grassland, many indigenous, often endemic species, both plants and animals, are lost. Community-based surveys in both Fiji and Tonga indicated that fire and indiscriminate burning is considered to be one of the main causes of the disappearance of important trees and medicinal plants, birds, bats, reptiles and a wide range of beneficial insects and other invertebrates. Frequent burning and the replacement of forests and trees by grasslands and introduced species also leads to accelerated erosion, flooding, sedimentation of river courses and lagoons and coral reefs, a reduction in the capacity to sequester carbon dioxide and a breakdown in terrestrial food chains. In Fiji, there have also been periodic serious outbreaks of arson which have resulted in the loss of thousands of hectares of Caribbean pine plantations, which in turn leads to poverty and increasing pressure to log native forests for income and local construction materials.

There is a critical need for increased public awareness of the negative impacts of indiscriminate burning on native ecosystems, particularly on forest ecosystems, on biodiversity, and on economic and cultural sustainability. There is a need for both national legislation prohibiting indiscriminate burning and to punish arsonists and community-based efforts to minimize arson and the use of fire for agricultural clearance and other purposes. There is also a need to improve fire fighting capabilities in areas where there is a high probability of fire.

7.16 Destruction and Degradation of Productive Marine Ecosystems and Disruption or Change in the Dynamics of Marine Ecosystems

The destruction and degradation of productive marine ecosystems and disruption or change in the dynamics of marine ecosystems constitute major threats to biodiversity. This includes the destruction and degradation of coastal nearshore intertidal areas, seagrass beds, coral reefs, lagoons and reef passes as a result of reclamation or conversion to other uses, pollution, sedimentation and misuse. Activities responsible for this include the construction of harbour complexes, jetties, airstrips, breakwaters, seawalls, coastal causeways and roads, overfishing, etc. Of particular concern are activities that block or alter alongshore currents, tidal flows, the flushing of lagoons, migratory routes, etc.

The destruction and degradation of marine habitats, such as the reclamation of intertidal areas, destruction of seagrass beds, filling in of lagoons or the construction of causeways in reef passes between atoll islets that change current patterns, alongshore deposition and the tidal flushing of lagoons and upwelling in nearshore waters can bring about collapses of entire ecosystems. Changes in tidal and alongshore currents and the flushing of lagoons can have serious effects on the recruitment of a wide range of marine organisms that depend on the dispersal of their planktonic larval stages via ocean current and on nutrient availability in marine ecosystems. Evidence in Kiribati, for example, has shown that the reduced flushing of lagoons due to the construction of causeways linking atoll islets could be one of the main factors for reduced populations of bonefish, an number of species of shellfish and a number of other marine organisms.

Careful environmental impact assessment procedures must be implemented before major development projects are implemented in coastal and marine ecosystems in an attempt to avoid or minimize damage to marine ecosystems and marine biodiversity. There is a need to make developers and the general public aware of the dynamic nature and fragility of the marine environment and the options that can be taken to minimize the destruction and degradation of productive marine ecosystems and how development projects can incorporate biodiversity conservation measure into such developments.

7.17 Overuse/Overexploitation/Unsustainable Use of Terrestrial Plant and Animals Resources

Overuse/overexploitation of terrestrial plant and animal resources without restoration or allowing target populations to recover, or without systematic replanting in the case of trees and other plant resources is a major threat. Continual hunting and overharvest of terrestrial animal resources, such as a wide range of birds and their eggs, fruit bats and coconut crabs and large hermit crabs has been responsible for the severe reduction or disappearance of these animals on many islands for many years. Similarly, the overuse of a wide range of trees and other culturally valuable plants without replanting or allowing them to regenerate has also been one of the main threats to terrestrial plant resources. Major uses that have led to the disappearance of trees and other plant resources at the community level include use for firewood, medicines, dyes, construction and canoe or boatbuilding.

There is a priority need to identify those terrestrial animals and plants that are being overused and either threatened or have disappeared and in need of some form of protection, re-establishment or, in some cases, re-introduction at the local community level. There is also a need, in most island groups, for the establishment of national and local programs for the collection of planting materials of desired species, the establishment of nurseries and the propagation and replanting of a wide range of trees and other useful plants that are now

scarce or have disappeared at the village level. Efforts should always be made to identify local sources of, or communities or villages that have, planting materials that could be transferred within the local areas or within the country, rather than trying to bring in genetic material from other areas or foreign countries.

7.18 Overfishing/Overexploitation/Unsustainable Use of Marine Resources

This includes the overexploitation of fisheries resources (e.g., seaweeds, finfish, bêche-de-mer, crabs and lobsters, shellfish, corals and other marine invertebrates), formerly reserved for local subsistence consumption, for rapidly expanding local and export commercial production, often associated with the use of more efficient fishing technologies (e.g., better motorized boats, improved spearguns and line fishing methods, improved preservation/refrigeration and distribution, more efficient nets, night and SCUBA or hookah spearfishing, etc.). Increasing populations, particularly near urban areas have also put greater pressure on limited marine resources. The targeting of fish spawning aggregation sites, such as frequently occurs with the live reef fish food trade, can cause severe depletion of the target species is a relatively short time-period. There are examples from the Pacific (e.g., Palau) where spawning aggregations of groupers have been totally eliminated and have not reformed.

The overexploitation of many types of marine resources, whether for local consumption and sale or for overseas export, has led to the endangerment or scarcity of many species to the point that the exploitation of these species at the current levels appears to be unsustainable. Species most commonly mentioned by local communities to be rare, in short supply or locally extinct (extirpated) include sea turtles, large demersal finfish species such as the humphead or Napoleon wrasse, large groupers and the bumphead parrotfish, large sharks, giant clams, triton shells and a number of other shellfish, most species of bêche-de-mer, a number of crab species, some species of corals, particularly precious corals, and some species of seaweed. The reduction in the populations or elimination of some of these species will not only have serious cultural, nutritional and economic implications, but may also have very serious effects on the ecosystems in which they live. For example, the elimination of some species that are important top predators or detrivores could affect marine food chains and have very serious effects on other species.

There is an urgent need for regional, national and local community-based initiatives to identify species or groups of species (e.g., sharks, large demersal species, bêche-de-mer, etc.) that are in need of some form of protection, and to identify and implement the appropriate form of protection. At the local community level, this could take the forms or moratoria on the exploitation of some species, bans on commercial exploitation, limits on total catch (quotas), size restrictions, seasonal restrictions, gear restrictions, or protection of species within restricted areas. To achieve these objectives there is a need to establish lists of threatened species at the regional, national and local levels that can be given appropriate forms of protection. There is an associated need to gather better data on the maximum sustainable yields and biology of species of particular concern so that management efforts can be based on good scientific data. Successful programmes that have taken this approach include the development of fisheries management and monitoring plans by the Fiji Locally Managed Marine Areas (FLAMMA) network and the AusAID-funded fisheries management programme in Samoa.

7.19 Use of Destructive Fishing Technologies

Although related to overfishing, the use of destructive fishing technologies is a serious threat to marine biodiversity. This includes the use of small-mesh gill nets, dynamite, fish poisons, night diving with waterproof lights and the use of scuba or hookah apparatus for fishing.

The use of these destructive fishing technologies is believed to be directly or indirectly responsible for the scarcity or disappearance of a wide range of finfish and other marine species. The use of these technologies not only exploits the main target species, but also leads to the capture or death of a wide range of other smaller non-target finfish species, and to the death of corals, other marine invertebrates and the planktonic larval forms of finfish and a wide range of other invertebrates. The death of these organisms can lead to the severe disruption of marine food chains, ecosystem collapse, very low recruitment levels and the collapse of local fisheries. Of particular concern are the live fish trades and, in particular, the use of sodium cyanide in some areas to harvest fish for the burgeoning trade in live fish reef food fish to Hong Kong and China and, more recently, aquarium fish to the United States. Similarly, nightdiving and the use of scuba gear for spearfishing has lead to the serious overharvest of species, such as sharks and large demersal species that are easy prey at night, and, in the case of the use of scuba, has allowed divers to exploit deeper areas that formerly served as spawning reserves for the replacement of stocks harvested in shallower, more accessible areas.

There is a need for national legislation and local by-laws and associated progress for enforcement and public awareness to eliminate these highly destructive fishing practices.

7.20 Illegal Fishing

Illegal fishing, both by foreign fishing vessels and by local fishers is a serious threat to biodiversity in the region. This includes illegal fishing within the EEZs and International Waters of Pacific Island countries; use of illegal fishing techniques; fishing for restricted species; fishing out of season; or disregard for fishing limits or quotas.

Illegal fishing has led to serious declines or collapses in the populations of some threatened and economically important species, such as whales, larger sharks, sea turtles, large demersal species, giant clams, trochus and bêche-de-mer. The illegal use of oceanic drift gillnets (now prohibited in the South Pacific) is of particular concern as it leads to the reduction of non-target species, such as dolphins, sharks, turtles and sea birds. There have also been problems with illegal fishing for bêche-de mer, sharkfin, giant clams, turtle, dugong and crocodiles in various areas of the Pacific. In areas such as Papua New Guinea, there has been concern over harvests of bêche-de mer that exceeded the strict annual catch limits, which were deemed to be sustainable.

There is a need for strengthened fisheries surveillance both internationally and at the local community or island levels. Depending on the area, this could involve the continued use of observers on fishing vessels, assistance from the US Coast Guard or observers from Australia and New Zealand. Within PICs there is a need to involve members (both men and women) of local communities as fisheries wardens to help in the policing and enforcement of fisheries regulations.

7.21 Pollution of Freshwater Resources

Pollution of surface freshwater resources (e.g., rivers, streams, drainage ditches, ponds, marshes, lakes and reservoirs) and groundwater resources (e.g., wells, irrigated/excavated taro gardens) remains a serious threat to human populations and biodiversity in the Pacific Islands. Of particular concern are pollution from agrochemicals (pesticides and fertilizers),

human and animal waste and sewage, and other toxic substances. Pesticide pollution of rivers, wells and groundwater is a threat to a wide range of aquatic organisms. Eutrophication related to pollution from sewage, fertilizer runoff and leachate has lead to the infestation of surface water by aquatic plants, algae and phytoplankton and anaerobic conditions that result in the death of many aquatic organisms and the breakdown in aquatic ecosystems. The contamination of groundwater due to human and animal waste, pesticides, fertilizer leachate and the disposal and breakdown of other dangerous substances also threatens aquatic organisms and those animals that depend on them. The biological magnification of pollution levels at higher levels in the food chain (e.g., in filter feeding shellfish, aquatic birds, etc.) can also lead to loss of biodiversity and the breakdown in ecosystem community structure.

There is a need for legislation, enforcement procedures, and public awareness to prohibit the pollution of freshwater resources. There is a need for the development of appropriate toilet facilities, the location of livestock production systems away from important freshwater resources and improved waste management plans. There is also a need to development strategies to minimize pollution of freshwater bodies by mining developments and agricultural fertilizer and pesticide runoff and leachate, including appropriate fines or compensation for the loss of biodiversity or subsistence production resulting from pollution of freshwater resources (e.g., the pollution of rivers in Papua New Guinea due to mining in Ok Tedi and, in the past, Bougainville). There is also the need to improve local capability to periodically test water quality.

7.22 Solid Waste Disposal/Terrestrial pollution

The accumulation of large amounts of solid waste, including plastics, metal, glass, rubber and paper products, toxic materials, empty containers from container vessels and a wide range of other solid, often toxic, or potentially toxic, waste is an increasing problem. Throughout the Pacific Islands, the disposal of solid waste and almost ubiquitous littering of urban areas and beaches near urban areas is a serious concern, often the major focus of "environmental" programmes. Although the main concern has normally been the effects of litter and solid waste on human health and on the cosmetic appearance of the environment, there are probably serious considerations in terms of its impact on biodiversity, especially in the nearshore marine environment, where plastics and other material could have serious negative impacts on the heath of our ecosystems and biodiversity. A problem in some areas is the lack of incineration facilities for the proper disposal of toxic materials, human and animal remains, etc.

There is a need for public awareness campaigns, appropriate legislation and enforcement. There is also the need for appropriate waste management systems, which include waste reduction, recycling and reuse, and environmentally improved systems for disposal, including the development of environmentally friendly dumping sites. There is also a need, in many areas, for the development of an incineration capability to dispose of, or reduce, the volume, of some forms of solid and toxic waste.

7.23 Air Pollution

The increase in local domestic and industrial air pollution has negative impacts on human societies, ecosystems and their plant and animal communities. Throughout the Pacific, particularly in and around urban areas, there is increasing air pollution due to exhaust fumes from motor vehicles, an increasing number of industries, from cigarette smokers and from domestic sources, such as cooking over open fires. The "fallout" from air pollution has lead

to the accumulation of toxic material in soils and in terrestrial, freshwater and marine food chains. This takes the forms of "acid rain" and acidification of soils and waters and the accumulation of heavy metals, such as lead in the soil and in food chains, although the latter has been reduced since the adoption of unleaded petrol in most areas of the Pacific Islands.

Air pollution is a particularly difficult and expensive problem to assess, but may have serious long-term consequences on the function of Pacific Island ecosystems. Also of serious concern, particularly for the health of women is domestic air pollution due to cooking over open fires. Studies in India, for example, have shown that women cooking over open fires experience the equivalent pollution of smoking 20 packs of cigarettes per day!! This, plus smoking, may be major factors, in some communities of the premature death of those older people who know the most, and who are responsible for the passing on knowledge about, and the protection of our biodiversity inheritance.

There is a need for public awareness campaigns and the putting in place of enforceable regulations and legislation to minimize pollution from motor vehicles and industries, tobacco smoking, and pollution due to cooking over open fires. In the latter case, this can be through the promotion of the use of more efficient "smokeless" stoves.

7.24 Marine Pollution

Marine pollution, including industrial pollution, sewage, solid waste (e.g., plastics), mine tailings, oils spills and oil released from ships/boats near harbours/wharves and pollution due to antifoulants such as tributyl tin, have serious detrimental impacts on marine biodiversity. Sewage and other forms of industrial waste can cause accelerated algal growth and the suffocation of coral reefs and the replacement of other organisms by green algae. Toxic industrial pollution and tributyl tin kill the larval stages of shellfish, crustaceans and other marine invertebrates, and oil spills, both small and large, lead to the death of both marine invertebrates and vertebrates, such as finfish and seabirds. Toxic pollutants are also concentrated in excessive levels in marine organisms such as filter feeders and top carnivores through the process of biomagnification. This constitutes a serious threat to both marine biodiversity and to the human populations that depend on marine biodiversity.

There is a need for regional, national and local community legislation and programs to prohibit and control all forms of marine pollution and to make the public and local communities aware of the negative impacts that they have on marine biodiversity and human health.

7.25 Indiscriminate and Increasing Use of Pesticides and Herbicides

The use of a wide range of pesticides for the control of a wide range of pests in agriculture, for fumigation in quarantine operation, for domestic pest control and for the control of mosquitos and other disease vectors is a very serious threat to biodiversity. Particularly concerning in some areas is the chronic indiscriminate use of herbicides which endanger many indigenous and culturally valuable plants. Pesticides, by their very nature, are designed to kill a range of target organisms. Many, such as DDT, dieldrin and other persistent pesticides have the ability to kill, deform, mutate, and cause brain damage and cancer in living and future generations of animals, including human beings. Developing countries have become a "booming growth market" for pesticides, as well as a "dumping ground" for pesticides considered too dangerous to be used in the countries where they are manufactured. The Pacific Islands are not free from this victimization. Perhaps the more important issue is that pesticides may never be successful in the long run because of the severe ecological damage and disturbance they cause. Not only do they poison humans and cause soil and

water pollution, they also destroy beneficial plants and animals and the natural predators of the very pests the pesticide user wishes to destroy. This coupled with the incredible diversity, mobility, prolificity, adaptability, and associated genetic plasticity of insects, which has led to the development of widespread pest resistance to pesticides among arthropods, plant pathogens, weeds, and nematodes and races of "superpests", a development that has historically led to the need to use more and stronger pesticides to control them.

Epidemic pest infestations and associated problems of pesticide poisonings and pollution can best be solved through integrated pest management (IPM) which seeks maximum use of naturally-occurring pest controls, including weather, disease agents, predators and parasites, and introduced biological control programmes, with artificial controls being imposed only as required to keep a pest from surpassing intolerable population levels predetermined from accurate assessments of the pest damage potential and the economic costs of the control measure.

7.26 Hazardous/Toxic Waste Disposal

The disposal, often by industrialized countries of hazardous waste, including toxic military waste (e.g., old munitions, PCBs and other substances, the import of which into US Customs' jurisdiction is prohibited) is a threat in many areas of the Pacific. Sites that have already been used for the disposal and/or incineration of toxic waste by the US include Johnston Atoll and Wake Island. There is concern that the breakdown or incineration of such materials could seriously affect the island and ocean ecosystems of the Pacific Islands. There is concern that serious tropical cyclones, tsunamis, earthquakes or volcanic activity could cause the waste to escape into the island or ocean environment.

There is a need for a strong regional voice to resist all attempts to dispose of toxic or hazardous wastes on the islands and the oceanic environment of the Pacific Islands. There is also a need for increased public awareness among policy makers and local communities to inform them of the potential dangers to biodiversity and to human health of allowing the disposal of hazardous waste in both their local or nearby island or ocean ecosystems.

7.27 Nuclear/Radioactive Pollution and Contamination

The Pacific Islands have the longest continuous history of nuclear testing in the world. This has resulted in the radioactive contamination of a number of islands in French Polynesia, Kiribati and the Marshall Islands. Some of these islands may never again be safe for habitation by humans in the future. There is also the problem of the disposal of radioactive waste from nuclear power plants and nuclear reactors used for other purposed by developed countries such as Japan and the USA both on islands and in the oceanic environment.

Nuclear pollution and contamination on islands have led to the contamination of soils, the water table and the marine environment and the concentration of radioactivity in the tissues of animals and plants, including food plants such as coconuts and breadfruit, which after consumption by humans has led to dramatic increases of radioactivity in human tissue. This has led to extremely high incidences of a range of cancers in the Marshall Islands, where of medical information has been declassified. It can be expected that similar high incidences of cancer will be found in French Polynesia and Kiribati when time-depth information on the health status of nuclear workers and people in nearby islands or communities is made available for public and scientific scrutiny. It could be expected that there would also be long term negative somatic and genetic impacts on plants and animals that may lead to degradation or local extinction of some species. In short, nuclear contamination may be one of the most serious threats to all biodiversity, including human biodiversity, in the region.

There is a critical need at the regional level to keep the Pacific Islands a "Nuclear Free Zone" and to insist that there be no further nuclear testing or disposal in the shared island environment. There is also a need to insist that contaminated areas be made safe to the extent that this is possible, that scientific information on the impacts on biodiversity and human societies be declassified and that appropriate compensation be paid for those islands and human communities that have suffered from nuclear pollution.

7.28 Loss of Traditional and Contemporary Ethnobiological Knowledge

Many authorities believe that the loss of traditional and contemporary knowledge about the uses, beliefs, management systems and language related to biodiversity could be one of the most serious obstacles to successful biodiversity conservation in the Pacific Islands. At the local level, site-based biodiversity conservation will be problematic if the local people can not marry traditional conservation strategies with modern scientific models as part of co-management systems. If local people no longer know the local names, uses and management systems for their biodiversity, the chances are that they will **not** place a priority on its preservation. At the same time the modern scientific community is bemoaning the lack of financial support for the training of good modern taxonomists to replace those who pass away, many of the best traditional Pacific Island men and women scientists and taxonomist are dying and not being replaced by a younger generation that is less interested in the natural world. Along with them dies traditional ethnobiological information that has been accumulated over thousands of years in close contact with the island environment. It is important to stress that ethnobiological knowledge is frequently linked to and inter-dependent on a functioning culture for relevance, especially in relation to the conservation and management of biodiversity, and that simply documenting that knowledge won't be enough.

There is, thus, a critical need to put a very high priority on the preservation of traditional ethnobiological knowledge and its application to biodiversity conservation in the Pacific Islands. This should include the awarding of scholarships and training at the degree and vocational levels of biodiversity conservation practitioners who are trained in both traditional and modern scientific modes. There is also a need to finance the recording and dissemination of traditional ethnobiological knowledge that can be used as a basis for both biodiversity conservation and the development of curriculum materials for use in local schools. There is also a critical need to insure that foreign and non-local researchers are required to provide copies of all survey results, hopefully also in the vernacular, to local host comminutes where such studies are conducted. National legislation should also require that such information be provided to host communities and lodged with appropriate local repositories.

7.29 Free Trade/Globalization and Increasing International Free Trade in Biodiversity

The free trade of biodiversity, particularly the unregulated trade in threatened species and the illegal trade in species listed under CITES is a serious threat. Evidence from Southeast Asia shows that the unregulated and illegal trade in threatened species has led to the economic extinction and endangerment of a wide range of terrestrial and marine species and the breakdown in ecosystem function. The unrestricted free trade of important timber species harvested using unsustainable logging models, the unrestricted export of sandalwood from a number of countries, the uncontrolled harvest and sale of shark fin and other shark products, bêche-de-mer, giant clam, and live reef fish have put great pressure on these resources and the ecosystems in which they live. The increasing trade in ornamental marine aquarium species and living corals, if not controlled, will, undoubtedly, also led to the endangerment

of some species and ecosystem degradation. Because of the relative poverty (in cash terms) and limited opportunities for cash income in most Pacific Island rural and outer island areas, the uncontrolled exploitation of such plants and animals constitutes one of the greatest threats to biodiversity conservation in the region.

There is a critical need at the regional, national and local community levels to control international trade in endangered biodiversity. All countries should become party to the CBD and incorporate into national Biodiversity Strategies and Action Plans (BSAPs) actions that control the unregulated free trade in endangered plants and animals. All countries should become party to CITES and strongly enforce its provisions within the region. There is also great merit to the involvement of private industry in the promotion of more sustainable logging and harvest of marine ornamentals through association with organizations such as Traffic International, The Forest Stewardship Council and the Marine Aquarium Council. There is also the need, within the region, to educate local communities as to the very negative impacts that have occurred in areas such as Southeast Asia as a result of uncontrolled trade in such products, and the options that are available to them for promoting the conservation and sustainable harvest of terrestrial and marine export products.

7.30 Unforeseen Large-scale Developments

Large or mega-development projects, beyond the scale normally expected in the region, such as the development of new military bases, sea-bed mining, international waste-disposal programs, establishment of space stations (e.g., the proposed Japanese Space Agency space station on Kiritimati in Kiribati) are also of concern.

Such developments are very attractive to countries with limited opportunities to generate foreign exchange and local revenue. In most cases countries will welcome such development opportunities. Because of the scope of such projects, there is a critical need to conduct in-dept EIA studies in an effort to insure that adverse environmental impacts are minimised.

7.31 Other Social, Institutional and Infrastructural Threats

Other social, institutional and infrastructural threats that constitute “indirect threats” to Pacific Island diversity include uncontrolled population growth, breakdown in the traditional diversified subsistence economy, Inappropriate Modern Education and Curricula inadequate modern scientific baseline knowledge of the nature and status of biodiversity, inadequate systems of marine and terrestrial conservation areas, inadequate capacity to deal with terrestrial, freshwater and marine invasive species, inadequate legislation/legal instruments, inadequate infrastructure/capacity for biodiversity conservation, rapid and uncontrolled urbanization, poverty and economic deterioration, gender inequity in the control, use and management of biodiversity, and political instability and political ignorance or lack of political will to commit to conservation. It is beyond the scope of this paper to discuss each of these. Most of them will, hopefully, be discussed in other sessions and working groups at the conference in an attempt to best identify those areas that offer the most potential for mainstreaming our attempts to address the threats to Pacific Island biodiversity.

8 THE CRITICAL IMPORTANCE OF BIODIVERSITY CONSERVATION: A SUMMARY

From a global nature conservation perspective, the Pacific Islands have some of the most unique and beautiful islands and ecosystems, and some of the most unique plants and animals on Earth. For most rural and many urban Pacific Island communities, however, “biodiversity” is not just a matter of scientific, economic (in monetary terms), recreational or

ecological value. It is a capital inheritance that has been passed on, relatively intact or in some cases enhanced, by past generations to current generations. Biodiversity is not income that should be spent or destroyed. It is the "capital" needed for development and maintenance of local communities and our island nations and upon which almost all "income" (both cash and non-cash) is derived. Pacific Island communities remain part of their ecosystems and biodiversity, and depend on biodiversity for most of their cash and non-cash (subsistence) incomes. Their biodiversity remains central to the integrity of their cultures and their spirituality. Unfortunately, many Pacific Island ecosystems have been, and continue to be irreversibly degraded, and a wide range of plants and animals and the traditional knowledge of Pacific Island ecosystems, plants and animals are extinct, rare or endangered due to a wide variety of direct and indirect threats.

The predominant focus for most international biodiversity conservation includes uniqueness or endemism, scientific importance, importance as potential gene pools for genetic engineering, biotechnology, plant breeding, medicinal discoveries or other technological breakthroughs for the benefit of humankind, export or touristic potential, or the ecological benefits of biodiversity and ecosystem preservation. Although these are also important reasons for biodiversity conservation in the Pacific Islands, the focus of biodiversity conservation in the Pacific Islands, as we continue our journey into the 21st Century should be the CONSERVATION OF OUR BIODIVERSITY as the basis for ecological, cultural and economic survival of OUR local communities. Particular stress is placed on the fact that an estimated 25 to 90% of the real income of Pacific Island rural or outer island communities is in the form of non-cash income derived from local terrestrial, freshwater and marine plant and animal resources. Moreover, this income is relatively unaffected by inflation and deterioration in terms of trade which have historically caused imported goods (e.g., boats, outboard engines, petrol, medicines, flour, sugar, kerosene, clothing, fishing nets and other fishing gear, etc.) to increase in cost more rapidly than increases of wages in the cash economy or payments received in return for products exported overseas or sold locally (e.g., fish, crops, handicrafts, etc). The availability of such locally available products is also not effected by the unreliability, breakdown or non-existence of transportation networks.

Moreover, if cultural survival and sustainability (i.e., the "reproduction" of time-tested traditional systems of cultural and economic activity) is to be an important focus of biodiversity conservation programs, such programs must include not only native and endemic terrestrial and marine species (many of which do not even have local vernacular names), or larger "charismatic megafauna" (e.g., whales, dugongs, sea turtles, giant clams, humphead wrasses, birds-of-paradise, kauri trees, etc.), but must also include a wide range of endangered or ecologically and culturally important ubiquitous indigenous and exotic (non-indigenous), and wild and domesticated, species or varieties. This is seen as particularly critical in the context of smaller islands and atolls that have limited terrestrial ecosystem diversity and few if any endemic plants or animals of global scientific interest, but where the protection of often ubiquitous coastal and marine plants and animals, both indigenous and exotic, must be given at least equal priority as the protection of rare, highly endemic biota of larger islands, because it is their ONLY biota. For example, a large proportion of coastal tree species, seabirds and inshore finfish, shellfish and crustacean species of ecological, cultural and economic importance in Tonga, the Cook Islands, Kiribati and Fiji are rare or endangered due to overexploitation, destruction by cyclones or, in the case of plants, failure of the current generation to replant. As a result, these ubiquitous organisms, few of which are endemic, are in need of protection or re-establishment so they do not face extirpation (local extinction). Because of situations like this, the biodiversity of

these small islands and coastal areas is much more endangered and much more in need of management than that of the inland and mountain areas larger islands in the western Pacific, such as most of the larger islands of Papua New Guinea, Solomon Islands and Fiji where most rare and endemic plants and animals are found.

Because of the incredible richness of its marine biodiversity, the high endemism of high island biodiversity, and high potential for bioprospecting finds, the extreme and precarious state of the biodiversity of small low islands, the vulnerability of uninhabited islands, and the almost obligatory dependency that Pacific Island peoples have on the active use of biodiversity for their ecological, economic and cultural survival, if the world conservation community is really worried about the conservation of biodiversity as the basis for the survival of the Earth's biodiversity, the healthy functioning of the Earth's largest and smallest ecosystems (the Pacific Ocean and small islands), and the survival and health of perhaps the Earth's most strongly biodiversity-based cultures, biodiversity conservation in the Pacific Islands should receive extremely high priority. Even though there are arguably areas where there is greater poverty and need for biodiversity conservation and restoration, experience throughout the world has shown that the prevention (e.g., of poverty and loss of biodiversity) is far better, and far easier, than the cure. Experience in the Pacific Islands has shown convincingly that protecting a coastal or mangrove forest, for example, is far easier, in terms of technology, time and money, than replanting such forests, and recreating an old-age tropical rainforest or artificially rehabilitating a degraded coral reef is almost impossible. Perhaps, most importantly, our experiences in Hawaii, New Zealand and Australia show that the preservation, or even re-creation, of strong biodiversity-based cultures and their languages, after they have been relegated to second class status is extremely difficult. In most of the Pacific Island countries and territories, the biodiversity-use traditions and ethnobiological knowledge are still relatively intact. This, however, is changing rapidly in the face of the forces of "globalization" of economies, education systems and value systems. If the biodiversity of the Pacific Islands AND (and the AND must be stressed) the ethnobiological knowledge about the uses, beliefs, use systems, and language that Pacific Island peoples have for their ecosystems and plants and animals is not conserved, the arguably peaceful and currently relatively sustainable lifestyles of the people and plants and animals of the Pacific ("Peaceful") Islands will become unsustainable and abject poverty, both in monetary and biodiversity terms, will undoubtedly follow.

9 THE CHALLENGE OF MAINSTREAMING BIODIVERSITY CONSERVATION IN THE PACIFIC ISLANDS

The previous sections of this paper have attempted to provide a "snapshot" of the status of the status of Pacific Islands biodiversity and biodiversity conservation. It has provided information on; 1) the unique nature of our Pacific Islands biodiversity, including traditional knowledge about it; 2) the critical role that it plays as a foundation for economically, culturally and ecologically sustainable development in our islands; 3) the fact that this living bank account is now seriously threatened throughout the Pacific, and the serious nature of many of the threats to biodiversity; 4) some of the actions that are being taken or could be taken to protect this living inheritance; and, 5) why biodiversity conservation in the Pacific Islands should be a global, national and local priority. Armed with this knowledge we should all have the "ammunition" AND motivation we need to mainstream its conservation. We should also begin to see that the conservation and sustainable use of biodiversity is, perhaps, our single most important obligation we have, as the current generation, to future generations of Pacific Islanders. I we don't act now to ensure its conservation and sustainable use, future generations of Pacific Islander will have as a foundation for their development, a seriously

depleted 'skeleton" of this once rich biodiversity capital inheritance. Our generation and past generations will be seen to have squandered it for their own short-sighted, short-term development. The problem seems to been, and still is, that we are often only talking to the "converted", those who already clearly understand the critical importance of biodiversity and the healthy functioning of our island ecosystems as perhaps the only real foundation for sustainability in the long run. The challenge before us is clearly to get this message out to that ALL Pacific Island stakeholders, at all levels, and from all walks of life, get, and to get them to understand its real meaning. Hopefully, as a result, they will also take on board as individuals and as groups or institutions the protection and use wisely this living inheritance as central to their philosophies of life and theories of development. This is as we understand it the objective of "mainstreaming" biodiversity conservation, referred to more generally as 'Nature conservation", for the purposes of this conference. Pursuing this line of reasoning, the following attempts to more clearly define mainstreaming and to provide a vision of what is necessary to use our knowledge of the current state and importance of biodiversity to mainstream biodiversity conservation in the Pacific Islands.

9.1 Defining Mainstreaming Biodiversity Conservation – A Vision

To "Mainstream Biodiversity Conservation in the Pacific Islands" IS to ensure that ALL individual and institutional stakeholders involved in human development (local communities, private enterprise, government, NGOs, the aid community and other international agencies), include the conservation and sustainable use of biodiversity as a priority concern, if not THE most important precondition, for their own individual or institutional wellbeing. To make this vision a reality there is an urgent need for all stakeholders to clearly understand: 1) what biodiversity really is, its current status, and why biodiversity conservation should be a priority concern as a basis for sustainable development and the wellbeing of all stakeholders, and 2) what they can do as individuals and institutions to promote its conservation. Once this level of awareness of the issues is achieved, it is hoped that the incentives and reward systems will serve to motivate all Pacific Island stakeholders to address the increasingly serious threats to Pacific Island biodiversity, even if it requires sometimes drastic changes in the way we conduct, and with whom we conduct, international and local business.

More specifically, to promote the mainstreaming of biodiversity conservation in the Pacific Islands, ALL STAKEHOLDERS MUST:

Clearly understand what biodiversity is and what it means to the health and wellbeing of Pacific Islands peoples and their islands and waters, and that its conservation and sustainable use has been for millennia, and will continue to be in the foreseeable future, the main foundation for culturally, economically and environmentally sustainable development in the island states of the tropical Pacific Ocean.

Clearly understand that biodiversity, including the wealth of traditional knowledge that Pacific Island people have of this biodiversity, constitutes the NATURAL AND CULTURAL CAPITAL needed for the development of BOTH the present AND all future generations of Pacific Islanders; that, if protected and used wisely, this biodiversity inheritance constitutes a "living bank account" bequeathed to us by countless past generations of Pacific islanders, that will continue to grow and provide "interest" for the development and wellbeing of generations to come; and that, as such, IT MUST NOT BE SEEN AS INCOME TO BE SPENT OR DEPLETED IN THE SHORT-TERM for the benefit of the current generation, at the expense of the wellbeing of future generations, because this would be tantamount to "embezzlement" (the fraudulent conversion of money,

capital or property for personal *or* self-use and leave our children and grandchildren in a state of "BIOCULTURAL BANKRUPTCY".

See the clear signs that this foundation for sustainable island life, as we begin a new century, is now clearly threatened by an increasing number of natural and cultural factors, many of which can, and must, be addressed by all stakeholders, if they are truly interested in long-term sustainable development of their people, their islands and their seas.

Clearly see the inclusion of biodiversity conservation and appropriate actions that can address the natural and cultural threats to our biodiversity, as integral AND PRIORITY components of ALL development initiatives—whether community-based or government instigated—in terms of governance, legal structures, international treaties and agreements, recurrent funding or investment, aid packages, personnel and human development, curriculum development, advertising and public awareness, time, research and short- and long-term planning in order to promote the conservation and sustainable use of biodiversity as a foundation for their own long-term wellbeing and sustainability.

And, finally, clearly see that, if these threats are not addressed now BY THIS GENERATION OF STAKEHOLDERS, our precious biological inheritance will be lost, our islands will be "bioculturally bankrupt", which will ultimately lead to economic, cultural and environmental breakdown in the small-island states of the Pacific Ocean.

To elaborate, the basic thinking underpinning these concepts is the need to:

Ensure that all Pacific Island stakeholders, from bottom to top, across all sectors, re-establish their our links with, and understanding of, our living island environment, and clearly understand that our biodiversity - - - our terrestrial, freshwater and marine ecosystems, the diversity of species and genetic varieties of plants, animals and micro-organisms found in these ecosystems, and the wealth of traditional and modern knowledge of these ecosystems and plants and animals has been the foundation for agricultural, forestry, fisheries, health and nutritional, tourism and most other forms of cultural wellbeing for millennia. We must clearly understand that our biodiversity will continue to be a foundation on which all modern urban development must be designed to supplement or build on, rather than replace or destroy, if long-term sustainable development is the ultimate objective.

It must be accepted by all stakeholders that, if modern development destroys this living foundation, there will be a collapse of subsistence wellbeing, which will result in abject poverty as has never been seen before in the Pacific Islands. This will be followed by almost total economic, cultural and environmental breakdown in both urban and rural areas, which will, in turn, ultimately undermine the ecological foundations of all forms of development and political and economic stability. There are more than enough examples of societies in Africa, South America and Asia, that are now mired in abject poverty, corruption, social and cultural breakdown and war, much of which can be traced to the fact that they have destroyed their resources and lost their traditional respect for, and links to, their "land" and "waters" as the foundation for all long-term development. Clear signs of this are now emerging in some areas of the Pacific Islands, many of which, if we can follow the causal linkages, can be linked to loss of traditional respect for, and an understanding of biodiversity as the natural and cultural capital needed for sustainable development, on one hand AND, its short-term overexploitation for the benefit of a select minority of Pacific Islands and their overseas collaborators and exploiters.

If all stakeholders clearly realize that our island biodiversity is THE foundation, the natural and cultural capital for culturally, economically and environmentally sustainable

development in the long-term, it should then follow that a component of all funding, planned activities, associated training and human resource development, public awareness, legal structures and "governance" must include the conservation and sustainable use of biodiversity, and the protection of, and incorporation of traditional ethnobiological knowledge, into most aspects of the development project. In short, it might be possible to have a "Biodiversity Conservation Audit" (BCA) or "Biodiversity Conservation Impact Statement" (BCIA) to which all developments (e.g., infrastructural, tourism, agricultural, forestry and fisheries development projects, construction projects, educational curricula, religious/spiritual renewal initiatives, teaching, new legislation, new constitutions, joint venture developments, registration of local and foreign businesses, etc.) must be subjected to determine the short- and long-term impacts on biodiversity and whether they allocate adequate recurrent funding and personnel for environmental protection, restoration, monitoring, and so forth.

It must be stressed that the mainstreaming of biodiversity conservation is in the best long-term interest of ALL stakeholders --the international development elite, national and local politicians, law makers, leaders in the private sector, community leaders and their communities, academic and research institutions, aid agencies, local and international NGOs, religious institutions, etc.— and that it is not just in the interest of conservationists and conservation organisations!

To achieve this level of understanding of the issues, as a basis for mainstreaming, will, first and foremost, require an extensive programmes, involving all biodiversity conservation advocates, in awareness raising and education to provide the foundation for the realisation of the objectives listed above. This has been one of the objectives of this paper: to provide some of the detailed background for those people and agencies committed to mainstreaming biodiversity conservation.

In short, the success of mainstreaming is up to us. If we who live in the Pacific Islands today are successful in our efforts to MAINSTREAM the conservation of this "living foundation", our children and their children's children, will hopefully be able to walk our mountains, streams, shores and reefs, and through our towns and gardens. They will continue to marvel at the cowries, tropical fish, coral, sharks, eels, turtles, whales, birds, flying foxes, pigs, iguanas, orchids, fragrant flowers, yams, fruit trees and medicinal plants that have served as the foundation for island life for millennia. They will be able to share and benefit from the treasure chest of traditional and contemporary knowledge of Pacific Island biodiversity. If we are successful in mainstreaming biodiversity conservation this will hopefully be the future vision and long-terms development objective of ALL Pacific Island stakeholders – to pass on this living inheritance to future generations. Mainstreaming will not happen overnight, but we must start today in the halls of parliament, business houses, churches, sports stadiums, agricultural areas, classrooms, radio and TV stations and towns and villages throughout the Pacific. We must spread the word so it becomes part of all political, economic, social and spiritual messages. If we don't our islands, will, like so many areas of the Earth, face a future of biological and biocultural bankruptcy and poverty in the 21st century. Our islands and our island biodiversity are too special to let that happen!

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