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Invasive Alien Species in the Austral-Pacific Region

National Reports & Directory of Resources

Edited by Clare Shine, Jamie K. Reaser, and Alexis T. Gutierrez

The report is a product of a workshop entitled, *Prevention and Management of Invasive Alien Species: Forging Cooperation throughout the Austral Pacific*. The meeting was held by the Global Invasive Species Programme (GISP) in Honolulu, Hawai'i on 15-17 October 2002. It was sponsored by the U.S. Agency for International Development, U.S. Fish and Wildlife Service on behalf of the Aquatic Nuisance Species Task Force, U.S. Department of the Interior - Office of Insular Affairs, U.S. Department of State, and The Nature Conservancy. In-kind assistance was provided by the U.S. Environmental Protection Agency. Administrative and logistical assistance was provided by the Bishop Museum, Scientific Committee on Problems of the Environment, and the National Fish and Wildlife Foundation. The Smithsonian Institution National Museum of Natural History provided support during report production.

The workshop was co-chaired by Drs. Allen Allison and William Brown (Bishop Museum), Mr. Michael Buck (State of Hawai'i, Division of Forestry & Wildlife), and Dr. Jamie K. Reaser (Global Invasive Species Programme; GISP). The members of the Steering Committee included: Dr. Maj de Poorter (ISSG), Ms. Liz Dovey (SPREP), Dr. Lucius Eldredge (Bishop Museum), Ms. Alexis Gutierrez (GISP), Dr. Laura Meyerson (GISP/USEPA), Dr. Jamie K. Reaser (GISP), Dr. Dana Roth (U.S. Department of State), and Dr. Greg Sherley (New Zealand Department of Conservation).

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Preface

This report is one of three products of a workshop entitled, *Prevention and Management of Invasive Alien Species: Forging Cooperation throughout the Austral Pacific*. The meeting was held by the Global Invasive Species Programme (GISP) in Honolulu, Hawai'i on 15-17 October 2002. The other products include a regional statement on IAS and a workshop report (also downloadable from www.gisp.org). This document is the first country-driven effort to assess the status of invasive alien species (IAS) and share information on IAS national programs in the Austral Pacific region.

Each country that participated in the regional workshop was invited to submit a chapter that included information on known IAS, existing strategies for preventing and managing IAS, objectives and contact information for departments/ ministeries concerned with IAS, priorities for future work on IAS, list of in-country IAS experts, and a list of relevant references and websites.

Participants were asked to provide information relevant to both agriculture and environmental sectors and to work across multiple ministeries when possible. The ability of each country to provide this information varied considerably and depended upon the amount of information already available IAS problems for their country, existence of within country technical expertise, and how high a priority the IAS issue is for the government at this time. A few delegations were not able to make contributions to this document, and are in the process of assessing the status of IAS in their countries.

The data provided within this document reflects the most up-to-date information available to the authors of each country report at the time of writing. These authors and the GISP make no claim that this information is complete or scientifically accurate (e.g. scientific names may not always have been correctly assigned to non-native species). However, the authors and editors have made every effort to ensure as useful and reliable a document as possible.

GISP hopes that this document will be seen as a foundation for future work on IAS within the Austral Pacific region. Readers who are able to provide additional information or updates to specific chapters are strongly encouraged to contact the authors as well as GISP. This report is also downloadable from www.gisp.org and, if new information warrants, will be updated as appropriate.

Reports arising from GISP's workshops in other regions of the world are also available at www.gisp.org.

The Austral-Pacific Region

The Austral-Pacific region has numerous characteristics that make information sharing and other aspects of regional coordination on invasive alien species (IAS) issues particularly important. For example, 98% of its 30 million km^2 is ocean; the remaining 2% contains 7500 islands, of which just 500 are inhabited. Many islands in the three subregions - Polynesia, Micronesia and Melanesia - are small and widely scattered. Whereas the ocean once provided a natural barrier against the spread of pests and diseases, the rapid expansion of trade, travel, and transport now make the region particularly vulnerable to the devastating impacts of IAS. Furthermore, Pacific islands share trading routes, partnerships, and regional infrastructure, which can increase opportunities for introduction of IAS. The inhabitants of the Austral-Pacific region, therefore, have a mutual interest in preventing and managing IAS at the point of export and import.

Map of the Austral Pacific region.

Credit: Courtesy of Perry-Castañeda Library Map Collection, University of Texas at Austin

National Reports & Directory of Resources on IAS

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Introduction

American Samoa is a group of oceanic islands, which lie about 3,680 km southwest of Hawai'i and about 2,560 km from the northern tip of New Zealand. It is situated along 14 degrees latitude south of the equator. Its immediate neighbor is Samoa (formerly known as Western Samoa), an independent state 128 km to the west. The total land area of American Samoa is about 200 square kilometers, which is shared by five main islands, namely Tutuila, Tau, Ofu, Olosega, and Aunuu. The climate is tropical humid, with an annual rainfall ranging from 3,175 mm at sea level to more than 7,000 mm on the highest mountain, Lata on Tau island.

1. Main IAS in American Samoa

American Samoa has numerous alien species, some of which were introduced into the territory many decades ago for various purposes, including food, biological control, medicine, ornamental purposes, and conservation. Other alien species were either smuggled in, or unintentionally introduced through trade.

Like other Pacific Island countries and territories (PICTS), American Samoa is vulnerable to the effects and changes caused by invasive alien species (IAS). After habitat destruction or modification, whether by natural disaster or by man, IAS seem to be more prolific and may have caused the reduction or even extinction of other species. Some of these species have threatened to destroy American Samoa's biological heritage and have adversely affected agricultural production and natural ecosystems, leading to economic and ecological losses.

A list of American Samoa's most harmful invasive or pest species with economic or ecological impacts includes:

⇒ Fungi
- Taro leaf blight (*Phytophthora colocaisae*), which wiped out the taro industry of both Samoas in 1993-1994
- Black leaf streak of banana (*Mycosphaerella fijiensis*)

⇒ Insects
- Cluster caterpillar (*Spodoptera litura*) (Lepidoptera) (Noctuidae)
- Cotton aphid (*Aphis gossypii*) (Hemiptera) (Aphididae)
- Rhinoceros beetle (*Oryctes rhinoceros*) (Coleoptera) (Scarabaeidae)
- Fruit piercing moth (*Othreis fullonia*) (Lepidoptera) (Noctuidae)
- Diamond back moth (*Plutella xylostella*) (Lepidoptera) (Yponomeutidae)

⇒ Snails
- African snail (*Achantina fulica*) (Achantinidae)

⇒ Birds
- Common myna bird (*Acridotheres tristris*)
- Jungle myna bird (*Acridotheres fuscus*)
- Red vented bulbul (*Pycnonotus cafer*).

These three species are believed to cause population reduction of some local bird species, as well as damage to some fruit trees and vegetables.

⇒ Plants
- Sedge (*Cyperus rotundus*) (Cyperaceae)
- Grass (*Paspalum conjugatum*) (Poaceae)
- Koster's curse (*Clidemia hirta*) (Melastomataceae)
- Molucca albizia (*Paraserianthes falcataria*) (Fabaceae)
- Broad leaf vine (*Merremia peltata*) (Convolvulaceae): This has prohibited the re-growth of some local tree species which were devastated by the two great hurricanes of 1990 and 1991.

2. Summary of existing strategies and programs on IAS

American Samoa established a National Task Force on IAS in 2003. The first and most important step involved an agreement between the directors of the Department of Agriculture and the Department of Marine and Wildlife Resources to create such a joint force. This proposal was submitted to the governor and received formal approval early in 2003.

Routine programs for dealing with all alien species (known and potential invasives as well as non-invasives) entering the territory are still carried out by the Quarantine Division of the Department of Agriculture, in cooperation with other government departments (see 3 below).

In the National Park of American Samoa, an invasive plant management programme has been established (see 4 below).

3. Government departments/agencies concerned with IAS

Primary responsibility for dealing with all alien species (both invasive and non-invasive) entering the territory lies with the Quarantine Division of the Department of Agriculture. Quarantine officers are at the frontline in controlling all ports of entry and work closely with the Plant Protection Division and Veterinary Service to evaluate which species should be allowed into the country, prior to issuing permits. Marine and wildlife matters are referred by quarantine officers to the Department of Marine and Wildlife Resources whenever there is a relevant interception.

The Office of Samoan Affairs may also be involved in IAS prevention and management issues.

Specific responsibilities for IAS prevention, management and/or control are as follows:

⇒ **Department of Agriculture**

Quarantine Division: carries out border inspection to ensure that species entering the country are permitted by law.

Plant Protection Division: advises the Quarantine Division on plant species that should be allowed into the country, and monitors and controls invasive plant species in residential areas, farm lands, and forests.

Veterinary Service: advises the Quarantine Division on animals and animal products that should be permitted into the country, and monitors and controls invasive animal pests present in the country.

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⇒ **Department of Marine and Wildlife Resources**

Marine Division: monitors and manages all marine resources, including IAS, and enforces marine harvesting legislation.

Wildlife Division: monitors and manages wildlife in the forest and enforces wildlife legislation.

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⇒ **Office of the National Park of American Samoa**

This Office is responsible for the management and control of all species in the park area. Its mission is to preserve Samoan culture, save and protect mixed species old growth forest and protect ecosystems, including the coral reefs and marine components of the Park. An invasive species programme has been established. This involves students and the community in addressing invasive plant problems and reviving traditional cultural practices and language relevant to native heritage plants and their uses.

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4. Priorities identified for future work

⇒ Preventing the entry of IAS and of alien species with the potential to become invasive.

⇒ Thorough assessment of alien species already present on the islands as part of the development of a national strategy.

⇒ Public awareness and educational programmes.

⇒ Where possible, eradication of IAS.

5. List of experts working in the field of biological invasions

No information provided.

6. Bibliographic references

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1. Main invasive alien species in the Cook Islands

Invasive alien species (IAS) include giant mimosa (*Mimosa invisa*), coconut flat moth (*Agonoxena pyrogramma*), Queensland fruit fly (*Bactrocera tryoni*), and orchid weevil (*Orchidophilus aterrimus*).

2. Summary of existing strategy and programs on IAS

The Ministry of Agriculture is currently implementing the following programmes to manage or eradicate incursions of the following pests:

Pest/IAS	**Method**
giant mimosa *(Mimosa invisa)*	This serious plant invasive was introduced in the 1960s. Biological control is being used to control the plant.
coconut flat moth (*Agonoxena pyrogramma*)	Biological control is being used, as well as internal quarantine to prevent introduction to other islands
Lantana (Lantana camara)	Biological control agents are being introduced to the other islands.
Queensland fruit fly (*Bactrocera tryoni)*	The first incursion occurred in the capital, Rarotonga, in late 2001. Emergency procedures were initiated to eradicate the incursion with male trapping, spot spraying of food lures and host destruction in the incursion zone. The shipment of fruits and vegetables to other islands in the country was prohibited without a quarantine certificate. The Ministry of Agriculture has a fruit fly surveillance programme to detect fruit fly incursions, using male attractants, cue lure and methyl eugenol. No fruit flies have been trapped since February 2002.
orchid weevil (*Orchidophilus aterrimus*)	Some plants have been destroyed on the infested property to try to eradicate the pest.

The National Biodiversity Strategy and Action Plan (NBSAP) for the Cook Islands identifies Invasive Species Management as its second theme and sets two major goals: to reduce the adverse impacts of IAS on indigenous species and ecosystems and to prevent new invasions. The NBSAP was completed as part of the national assessment for the World Summit on Sustainable Development process and is now being widely promoted within government agencies (see 3 and 4 below on legislative aspects).

3. Government departments/agencies concerned with IAS

At the current time, only the Ministry of Agriculture has direct responsibilities for invasives/pests for economic reasons under the Plants Act 1973 and Animals Act 1975. The Ministry of Health has responsibility for preventing the introduction of mosquitoes and human diseases.

However, the following government agencies could also contribute to the prevention and control of invasives/pests:

⇒ Environment Service;
⇒ Cook Islands Natural Heritage Project; and
⇒ Island Governments of Aitutaki, Atiu, Mauke, Mangaia, Mitiaro, Palmerston, Pukapuka, Penrhyn, Rakahanga and Manihiki.

4. Priorities identified for future work

4.1 Agriculture and internal quarantine

In 1998, the Ministry of Agriculture's functions in all outer islands were devolved to the local governments of those islands. Some of those island governments did not consider agriculture and internal quarantine important and did not provide enough resources for those activities. During the financial year 2002-2003, the Government of the Cook Islands reversed the 1998 decision. The Ministry of Agriculture is now allocating resources for those activities, although funding is limited.

The introduction of the coconut flat moth (*Agonoxena pyrogramma*) in 1999/2000 caused serious concern in the community because of the visible damage on coconuts and the negative impact this might have on the tourism industry. The Ministry of Agriculture, with the assistance of the Secretariat of the Pacific Community, has introduced biological control agents to control this pest in Rarotonga, Atiu, and Aitutaki.

4.2 Greater coverage and awareness outside the agricultural sector

Initiatives for control, management, and eradication of IAS are much more developed for pests that affect the agriculture development sector. More effort is required to study and manage the impact of invasive species on the natural and native biodiversity of the Cook Islands. Following the completion of the study by Space and Flynn (see 6 below), priority should be given to mapping the distribution of IAS, particularly for the island of Rarotonga. Also important is the need to raise awareness of IAS and the likely pathways for their incursions. Pictorial and/or photographic materials need to be obtained for the awareness campaign. Very little is known about marine IAS.

4.3 Legislation

The Ministry of Agriculture is currently reviewing the Plants Act 1974 and Animals Act 1975. Recommendations by a consultant funded by the Food and Agriculture Organization (FAO) of the United Nations included the abolition of some provisions of these laws, which currently prohibit the introduction of certain plants and animals that are known IAS or pests. One of the co-authors of this report does not agree with the consultant.

The Environment Service administers the Rarotonga Environment Act 1994-95 which only applies to the island of Rarotonga. A National Environment Bill is due to be adopted before the end of 2003. The Bill's objective is to manage the environment of the Cook Islands in a sustainable manner: it contains a provision to manage and control the introduction of IAS, including the requirement for an environment impact assessment (IAS) for any activity that might have an adverse impact on the environment.

5. List of experts working in the field of biological invasions

⇒ **Ministry of Agriculture**
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Mr. William Wigmore, Director of Research
Mr. Ngatoko Ngatoko, Chief Quarantine Officer

⇒ **Cook Islands Natural Heritage Project**

Mr. Gerald McComack, Director

⇒ **Ministry of Health**

Ms Ngapoko Short, Director of Public Health
Mr. Tuaine Teokotai, Chief Public Health Inspector

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Fiji

Fiji was not represented at the GISP Austral-Pacific Workshop, as its delegate, Mr Aisea Waqa, Fijian National Focal Point for the International Plant Protection Convention, sadly passed away while travelling to the meeting.

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The editors and workshop participants record their sincere condolences to the Government of Fiji and to Mr Waqa's family and colleagues.

French Polynesia

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Introduction

⇒ *Characteristics of the islands of French Polynesia*

French Polynesia is a French overseas territory located in the South Pacific Ocean. It consists of 121 tropical oceanic islands and islets divided into five archipelagoes, namely the Austral, the Gambier, the Marquesas, the Society, and the Tuamotu Islands. These islands are scattered between 7° and 27° South, and 134° and 152° West over 5,030,000 km^2 of ocean (Exclusive Economic Zone). The best-known island, Tahiti, is the largest (1045 km^2) and the highest (2241m elevation).

The islands of French Polynesia are characterised by:

- significant geographic isolation (Tahiti is 6000 km from Australia, and the USA and 8000 km from Chile);
- a relatively young geological age (between 0.2 to 28.6 million years old);
- a small land area (a total of 3,520 km^2) with only 8 islands larger than 100 km^2; and
- a great diversity of habitat types (young high volcanic islands and rocky islets, old barrier-reef islands, coral limestone islands or atolls and coral islets, and raised limestone islands or "makatea").

With an endemism rate of 75% for flowering plants, French Polynesia has one of the most unique native flora in the Pacific Ocean after the Hawaiian Islands (90%) and New Caledonia (85%). It has also one of the highest number of sea-birds (27 species) in tropical regions, and some of the most endangered land birds worldwide (e.g. the Nuku Hiva pigeon, *Ducula galeata*, with 100-150 birds left and the Tahiti monarch or flycatcher, *Pomarea nigra*, with less than 50 birds).

⇒ *Human settlement and alien species introductions*

The first inhabitants of French Polynesia were Polynesian migrants who sailed from Western Polynesia (Samoa, Tonga) on their double-outrigger canoes about 2700 years ago, settling in the different archipelagoes between 700 BC and 700 AD. About 80 plant species are considered to be Polynesian or "aboriginal" introductions, including several food plants, including taro (*Colocasia esculenta* (Araceae)), fe'i or wild banana (*Musa troglodytarum* (Musaceae)), breadfruit tree (*Artocarpus edulis* (Moraceae)), Malay apple (*Syzygium malaccense* (Myrtaceae)), ritual or medicinal plants such as ti plant (*Cordyline fruticosa* (Agavaceae)), kava (*Piper methysticum* (Piperaceae)), tiare tahiti (*Gardenia tahitensis* (Rubiaceae)), and about 50 adventives or casual weeds accidentally introduced as seed contaminants.

Among these introduced plants, 24 are currently naturalized. The latter include the Tahitian chestnut (*Inocarpus fagifer* (Fabaceae)), a large buttressed tree that forms monospecific stands in the low and wet valleys, and the candle nut (*Aleurites moluccana* (Euphorbiaceae)), a tree widely naturalized on low-elevation slopes and mid-elevation plateaus up to 500 m.

The first Polynesians brought animals such as domestic chickens (*Gallus gallus*), pigs (*Sus scrofa*), dogs (*Canis familiaris*), and Polynesian rats (*Rattus exulans*), either unintentionally or intentionally as a food source. *Rattus exulans* is now found in nearly all the islands of French Polynesia. It coexists with endemic land birds, but has been documented to impact sea-bird colonies on small islets in French Polynesia. The effects of all these introduced or alien plant and animal species on the native biota were probably minor compared to the land clearing, burning, planting and irrigating, as practised by early Polynesian settlers.

The first European explorers landed in 1595 in the Marquesas Islands (Spanish captain Mendaña), 1606 in the Tuamotu Islands (Spanish captain Quirõs), and between 1767-69 in the Society Islands (English captains Wallis and Cook, French captain Bougainville). Since then, recent or "modern" introductions of alien species include more than 1500 plants (about 520 of them are currently naturalized), the carnivorous black or ship rat (*Rattus rattus*) and the brown or Norway rat (*Rattus norvegicus*), herbivorous ungulates (goat, sheep, cattle, horse), predatory cats, birds, fishes and invertebrates, including mollusks, and detrimental insects such as the mosquito (*Aedes aegypti*) which is a dengue fever vector. Feral ungulate populations rapidly began to open, degrade, and destroy upslope forests, especially in the Marquesas and Austral Islands.

Today, 76 of the 121 islands of French Polynesia are inhabited. The population is estimated to be about 240,000 in 2002, four times higher than the population 50 years ago (ca. 62,000 in 1950). Seventy-five percent of the population is restricted to the islands of Tahiti and Moorea in the Society archipelago.

1. History of harmful introductions and biological invasions in French Polynesia

The following chronology reviews the harmful or noxious invasive alien plant and animal species which have caused or currently cause significant ecological impacts and/or economical damage, or adverse health effects in French Polynesia. All these species were introduced unintentionally or intentionally by human activities. This overview is based on various bibliographical sources (scientific papers and "grey" literature) and on personal communications or observations for species introductions that have taken place during the last decade.

1767-69 Accidental introduction of black or ship rats (*Rattus rattus*) with the first European sailors. Black rats are considered to have driven endemic land birds to extinction, especially the lorikeets (*Vini* spp. (Psittacidae)), the monarchs or flycatchers (*Pomarea* spp. (Muscicapidae)) and the ground doves (*Gallicolumba* spp. (Columbidae)).

1815 Intentional introduction of the common guava (*Psidium guajava* (Myrtaceae)) by Bicknell. During his short visit to Tahiti in November 1835 on the Beagle, Charles Darwin noted that "…the species is so abundant that it is quite a weed."

1845 Intentional introduction by English marine surgeon Francis Johnston of the weedy legumes *Acacia farnesiana, Leucaena leucocephala* and *Mimosa pudica*, as well as the yellow elder (*Tecoma stans* (Bignoniaceae)) and the Chinese or strawberry guava (*Psidium cattleianum* (Myrtaceae)). They belong to the most aggressive plant invaders in native forests of French Polynesia. *Tecoma stans*, which was reported by botanist F. R. Fosberg only in a few valleys in 1934, had invaded nearly all the mesic zone of Tahiti by 1954.

1853 Intentional introduction of the weedy *Lantana* (*Lantana camara* (Verbenaceae)) to Tahiti by French Marine Captain Chappe, as an ornamental plant.

1885 The swamp harrier (*Circus approximans* (Accipitridae)) was purposely introduced and released on Tahiti by the German Consul for rat control. This predatory bird colonized all the Society Islands and is commonly found at high elevation (up to 1,500 m) on Tahiti. It is thought to have seriously affected native birds, such as the white tern (*Gygis alba* (Sternidae)), the endemic gray-green fruit dove (*Ptilinopus purpuratus* (Columbidae)), the Tahiti reed warbler (*Acrocephalus caffer* (Muscicapidae)). The swamp harrier is one of the main causes for the extinction of the Polynesian imperial pigeon (*Ducula pacifica aurorae* (Columbidae)) and the blue lorikeet (*Vini peruviana* (Psittacidae)) in Tahiti.

1887 French Marine Pharmacist J.-F. Raoul introduced about 210 plant species in the town of Papeete (Tahiti) in a place that later became known as the "Jardin Raoul."

1889 First detection of the scale insect (*Aspidiotus destructor* (Homoptera, Diaspididae)) that attacks and kills coconut trees and other palm species.

1906-10 Accidental introduction of the white sand-fly (*Stylocenops albiventris* (Ceratopogonidae)) in the Marquesas Islands, locally called the "Prussian nono" because it was brought by German boats coming from New Guinea. The "nonos" which bite both humans and animals are now a nuisance to tourism development in the Marquesas.

1906-08 Intentional introduction of the common myna (*Acridotheres tristis* (Sturnidae)) to control introduced wasps on Tahiti. This aggressive bird is thought to predate the eggs and young of the Tahiti swiftlet (*Collocalia leucophaeus* (Apodidae)) and may compete for food with the Tahiti reed warbler (*Acrocephalus caffer* (Muscicapidae)). It was also introduced to Hiva Oa (Marquesas Islands) in 1918 where it is thought to have displaced some endemic land birds such as the Marquesan warbler (*Acrocephalus caffer mendanae* (Muscicapidae)), the Marquesan swiftlet (*Collocalia ocista* (Apodidae)), and the white-capped fruit-dove (*Ptilinopus dupetitthouarsii* (Columbidae)). Despite a law enacted in 1938 prohibiting alien bird introductions, common mynas were intentionally released on two atolls of the Tuamotu archipelago (Hao and Mururoa) in 1976, and in 2002 they were observed in the town of Taihoae on the island of Nuku Hiva (Marquesas Islands) and on the raised atoll of Makatea (Tuamotu Is.).

1924 Accidental introduction of the mosquito (*Aedes aegypti* (Culicidae)) in Tahiti, the main vector insect of the dengue disease. It has spread to all the islands of French Polynesia, except on the southeastern most inhabited island of Rapa (Austral Islands). Dengue is still one of the most serious epidemic diseases in French Polynesia.

1925 First detection of the fruit fly (*Bactrocera (Dacus) luteola* (Diptera)) in Bora Bora (Society Islands) by Entomologist L. E. Cheesman.

1926 About 200 mosquito fish (*Gambusia affinis* (Poeciliidae)) were introduced to Tahiti for mosquito control, as well as 50 common carp (*Cyprinus carpio*), 30 large-mouth bass (*Micropterus salmoides*), 12 channel catfish (*Ictaturus punctatus*) and 34 frogs. Mosquito fish is responsible for disrupting aquatic ecosystems and destroying native insect species, such as damselflies.

1927 Intentional introduction of the great horned owl (*Bubo virginianus* (Strigidae)) to Hiva Oa (Marquesas Islands), where they have become well established up to 1000 m elevation. A total of eight birds from San Francisco was released by the Lord Bishop Le Cadre for rat control. They are thought to have affected all the native bird species on Hiva Oa, especially the Marquesan kingfisher (*Todiramphus godeffroyi* (Alcedinidae)) and have contributed to the extinction of the red-moustached fruit dove (*Ptilinopus mercierii* (Columbidae)).

1928 First mention of the fruit-fly (*Bactrocera (Dacus) kirkii*) in Tahiti, yet found in the Tuamotu, Society, Gambier and Austral Islands (except on Rapa), but not yet in the Marquesas yet. This species is known to attack fruits of 45 host-plant species belonging to 23 different plant families.

1932 Entomologist W. M. Wheeler documented the invasion of the tropicopolitan big-headed ant (*Pheidole megacephala*) in the Marquesas Islands, up to 1000 m elevation. In 1939, A.M. Adamson considered it the most destructive of all foreign enemies to the native entomofauna in the Marquesas. The big-headed ant is implicated in the exclusion of native and endemic spiders in Hawai'i.

1936 A "hacienda snake" (of unknown species) escaped the US ship "Director," and was captured on the docks of Papeete harbour. Introduction of the large legume tree (*Paraserianthes falcataria* (Fabaceae)), commonly planted as a shade tree for coffee plantations in the Society and the Austral Islands, now widely naturalized.

1937 Introduction of *Miconia* (*Miconia calvescens* (Melastomataceae)) in a private botanical garden (now called the Papeari or Harrison Smith Botanical Garden) as an ornamental plant by Harrison Willard Smith. This retired U.S. professor of physics planted more than 250 imported plant species between 1921 and 1944, including the currently invasive African tulip tree (*Spathodea campanulata* (Bignoniaceae)) in 1932, the trumpet tree (*Cecropia peltata* (Cecropiaceae)) in 1926, the shoebutton ardisia (*Ardisia elliptica* (Myrsinaceae)) in 1939, the Brazilian pepper (*Schinus terebinthifolius* (Anacardiaceae)) in 1927, the rose-myrtle (*Rhodomyrtus tomentosa* (Myrtaceae)) in 1928, the coco plum (*Chrysobalanus icaco* (Chrysobalanaceae)) in 1922, and the night-blooming jasmine (*Cestrum nocturnum* (Verbenaceae)) in 1936. The first dense stands of the small tree *M. calvescens* were observed in the early 1970's on the Taravao plateau in Tahiti. Nature protection groups and French and US scientists tried to raise awareness of local authorities to the potential threat, but met little success at the time. On Tahiti, about 80,000 ha have been invaded by miconia, which is sometimes called "the purple plague" or the "green cancer." *Miconia* has also invaded about 3,500 ha on Moorea (35% of the island surface) and between 350-450 ha on Raiatea (2.5%) in the Society Islands.

1948 First observation by entomologist P. Viette of the alien moth (*Othreis fullonia* (Noctuidae)). In 1969, this moth was reported to severely attack citrus on the island of Moorea (Society Islands) and eventually caused a local economic collapse.

1950 First report of the presence in Tahiti of the water hyacinth (*Eichhornia crassipes* (Pontederiaceae)), introduced as an ornamental plant. This aquatic invasive plant spread in the ponds near the Faaa International Airport in 1973, where it is being mechanically removed.

1956 Introduction of the giant sensitive plant (*Mimosa invisa*), a prickly legume weed. Its pathway of introduction may have been accidental as a seed contaminant or intentional as a fodder plant.

1957 Introduction of the predatory fish tilapia (*Oreochromis mossambicus*) as a food source.

1959 First report of the swamp sand-fly (*Culicoides belkini*), locally called the white nono, on Bora Bora. The fly was first detected in a small sandy islet or motu where the airstrip was built, and was supposedly introduced by US airplanes coming from Fiji. It has since spread to all the Society Islands and to the atolls of Rangiroa and Hao in the Tuamotu Archipelago around 1966 (the only atolls to have airstrips at that time).

1960 The coconut leaf hispa or coconut hispine beetle (*Brontispa longissima* (Chrysomelidae)) was accidentally introduced with ornamental palms from New Caledonia. It attacks and eventually kills palms and coconut trees. This beetle quickly spread to all the Society Islands, then in 1970 on Nuku Hiva (Marquesas Islands), in 1981 on Tubuai (Austral Islands), and in 1983 on Rurutu (Austral Islands) and Rangiroa (Tuamotu Islands).

1967 Intentional introduction of the giant African snail (*Achatina fulica* (Achatinidae)) on Tahiti and Moorea as a food source. It was introduced in the Marquesas Islands in 1973. This herbivorous snail rapidly became an agriculture pest, with up to 1.5 tons of snails per day collected on Tahiti.

1970 Accidental introduction of the Queensland fruit-fly (*Bactrocera (Dacus) tryoni*,) native to Australia. It was probably introduced to Tahiti from New Caledonia (where it is present since 1969) with infected fruits and is now present in all the Society, Tuamotu, Gambier and Austral Islands, except Rapa. This species attacks the fruits of 113 host-plant species.

1974 The Department of Agriculture of French Polynesia released the carnivorous or rosy-wolf snail (*Euglandina rosea* (Spiraxidae)) in Tahiti by control the giant African snail. This predator was also introduced to Moorea in 1977 where it caused the extinction of seven endemic tree snail species of the family Partulidae (Partula spp.) only ten years after its introduction. Endemic Partulids are still surviving in remote areas of Tahiti (Te Pari cliffs) and in high-elevation cloud forests above 1000 m elevation where the carnivorous snail is not present. All the Partulids of Bora Bora (two species) and Tahaa (six species) are now thought to be extinct, as well as two species on Huahine (of the four known) and 29 species on Raiatea (of the 33 known). The endemic tree snails of the Marquesas and the Austral Islands where *Euglandina rosea* is present are under threat. The same year, accidental introduction of the Chinese rose beetle (*Lepadoretus (Adoretus) sinicus* (Scarabaeidae)) from Hawai'i where it feeds on more than 350 plants, including 50 cultivated species. In four years, this defoliating insect spread 30 km from its first introduction site at the Faaa International Airport.

1977 Fraudulent introduction of young citrus plants infected by the tristeza or CTV (Citrus Tristeza Virus) transmitted by an introduced aphid insect (*Toxoptera citrida*). The virus attacks orange and lemon trees.

1979 The red-vented bulbuls (*Pycnonotus cafer* (Pycnonotidae)) are first noticed in the residential area of Papeete. This frugivorous bird is now common up to 1000 m elevation on Tahiti, and has become a pest in agriculture, as well as an active disperser of invasive alien plants. It is said to have negative interactions with the Tahiti monarch (*Pomarea nigra*).

1988 First observation in Tahiti of the thrips (*Thrips palmi* (Thripidae)) which infests a wide variety of crops, especially vegetables.

1990s Observation in Tahiti of the spiralling whitefly (*Aleurodiscus dispersus* (Aleyrodidae)), a pest of vegetables, fruit trees, ornamentals and shade trees which has spread rapidly through the Pacific after gaining establishment in Hawai'i in 1978.

1994 Two non-identified iguanas escaped from a yacht, and disappeared on the atoll of Rangiroa in the Tuamotu Islands.

1995-96 Accidental introduction of the common house gecko (*Hemidactylus frenatus* (Gekkonidae)), now widespread in the urban areas of Tahiti.

1995-97 New sightings of *Miconia calvescens* in the islands of Tahaa (Society Islands), Nuku Hiva and Fatu Hiva (Marquesas Islands), Rurutu and Rapa (Austral Islands). The plant pest was accidentally introduced with contaminated soil on car wheels, bulldozers and tractors or in gravel and soil piles imported from Tahiti.

1996 Accidental introduction of the Red Oriental fruit-fly (*Bactrocera dorsalis*) in Tahiti, first sighted on the Taravao Plateau. It spread to Moorea (Society Islands) and to the atoll of Hao (Tuamotu Islands) in 2000.

1997 Discovery of a young frog larva with ornamental fishes bought in a pet-store in Papeete. The red-billed Leiothrix, also called Pekin or Japanese robin (*Leiothrix lutea* (Muscicapidae)) were sold in a pet store in Papeete. This colourful frugivorous species is known to have spread in Hawai'i where it actively disperses invasive alien plants.

1998 Sudden invasion by a non-identified red stink bug (Heteroptera, Coreidae) on the raised limestone island of Makatea (Tuamotu Islands) which attacks fruiting trees. The Pacific fruit-fly (*Bactocera xanthodes*) was accidentally introduced to Raivavae (Austral Islands) from a boat coming from other Pacific Islands. This species is known from Cook, Fiji, Samoa, Tonga and Vanuatu. *B. xanthodes* was found on Rurutu in 2000 (Austral Islands), but has not yet spread to other archipelagoes of French Polynesia.

1999 A non-identified squirrel that escaped from a Korean fishing boat was observed on the docks of Papeete. A young green iguana (*Iguana iguana*) was found in the town of Papeete, captured, and kept in captivity where it eventually died. The Queensland fruit-fly (*Bactrocera tryoni*) was captured in the village of Taiohae in Nuku Hiva (Marquesas Islands, northern group) and in the village of Vaitahu in Tahuata (Marquesas Islands, southern group).

2000 Discovery of unidentified piranhas with other ornamental fishes bought in a pet-store in the town of Papeete. The two-spotted leafhopper (*Sophonia rufofascia*) was discovered by US entomologists during a field-trip to Tahiti. The insect is known to cause dieback of cultivated plants, as well as native plants, especially the common fern (*Dicranopteris linearis* (Gleicheniaceae)).

2001 Sudden population explosion of the glassy-winged sharpshooter (*Homalodiscus coagulata* (Cicadellidae)) in Tahiti. This insect was first reported by local entomologist R. Putoa of the Department of Agriculture (*Service du Développement Rural*) in 1999 on a *Lagerstroemia* ornamental tree (Lythraceae).

2002 Live giant cane toads (*Bufo marinus*, Bufonidae) were found in a container with wood logs shipped from Fiji. The same year, live snail (*Helix aspera*) was found by the Plant Protection Section of the Service du Développement Rural in a container from France with three live plants. Green swordtail fishes (*Xiphophorus helleri*) were first noticed by aquatic biologist R. Englund of the Bishop Museum of Honolulu in the Papenoo river in Tahiti. They are known to bring in fish parasites like leeches and internal parasites and to heavily prey on young stream native gobies in Hawai'i.

2003 Discovery of an escaped corn snake (*Elaphe guttata* (Colubridae)) above the dumping station of the town of Faaa in Tahiti.

2. Development of a strategy to combat invasive species in French Polynesia

French Polynesia was declared a French protectorate in 1842, then a French colony in 1880. It was included in the French Pacific Settlements (*Etablissements Français de l'Océanie* (E.F.O.)) in 1946 along with New Caledonia and Wallis & Futuna. It became a French Overseas Territory (*Territoire français d'Outre-Mer* (T.O.M.) in 1957. The Statute of Self-Government, enacted in September 1984, granted the Territory of French Polynesia complete responsibility for its environmental protection policy, as well as for agriculture, reef and marine environments, and associated natural resources.

The following chronology reviews the legislative texts that have been enacted to control species introductions in French Polynesia:

1936 Decree controlling the entrance of noxious insects and animals into the French Pacific Settlements. The introduction of reptiles, insects, felines, and birds of prey is prohibited under this decree and all incoming ships into harbours must declare any animals on board.

1938 Decree banning the introduction, possession, and release of any introduced birds in the French Pacific Settlements.

1971 Law N°71-195 prohibiting the introduction, transportation, and rearing of the giant African snail *Achatina fulica*. Chemical treatment of soil from infected islands to *Achatina*-free islands is obligatory.

1972 Law N°77-772 declaring the environment (including nature protection) to be within the jurisdiction of the Territory of French Polynesia.

1977 Law N°77-93 prohibiting the import of all live animals into French Polynesia, except for exemptions approved by the Government Council.

1984 Law N°84-260 nominating a Minister of Environment and establishing the Department of Environment (*Délégation à l'Environnement*) in charge of nature protection.

Decree N°985CM, voted by the Government of French Polynesia, prohibiting new importations of alien birds of the families Accipitridae (hawks and eagles), Falconidae (falcons), Strigidae (barn-owls) and Tytonidae (owls), as well as Columbidae (doves and pigeons) and Rallidae (rails).

1988 Formation of a collaborative Miconia Research and Control Program, following the recognition by the French Polynesian and French authorities of the severe ecological impacts caused by the invasive alien tree *Miconia* (*Miconia calvescens*). It was led by the French Overseas Research Organization (*Office de Recherche Scientifique et Technique d'Outre-Mer* (ORSTOM), now renamed *Institut de Recherche pour le Développement* (IRD)). The aims of the project were to conduct studies on the bio-ecology and distribution on miconia, and to find efficient control method for this invasive plant. Funds were provided by both the French Polynesian Ministry of the Environment and France.

1990 Decree N°90CM voted by the Government of French Polynesia, declaring *Miconia calvescens* a noxious plant in French Polynesia. Cultivation and transportation within and between islands is prohibited.

1991-92 The first manual and chemical control operations against Miconia were launched on the island of Raiatea, sponsored and funded by the *Délégation à l'Environnement* with the logistic support of the *Service du Développement Rural* and the voluntary participation of many local schoolchildren and their teachers.

1993 First intervention of 100 French Army soldiers (mostly French Polynesians doing their compulsory military service) to remove *Miconia* on Raiatea for one week, with the logistic support of the *Service du Développement Rural* and the participation of local schoolchildren. This *Miconia* intervention was repeated annually during the period 1997-2002.

1995 Law N°95-257AT on Nature Protection (*Délibération sur la Protection de la Nature*), prepared by the Ministry of Environment and voted by the Territorial Assembly of French Polynesia. Its objectives are to protect endangered endemic species, and natural areas with strong conservation value, and to identify and control alien species which are considered a threat to the biodiversity of French Polynesia.

1996 Law N°96-42AT on Plant Protection prepared by the Ministry of Agriculture and voted by the Territorial Assembly of French Polynesia. One of its aims is to prevent the introduction of noxious organisms (plant pathogens, alien insects, invertebrates and plants) that could become agricultural or environmental pests in French Polynesia.

1997 A collaborative agreement was signed between the French Polynesian Government and the Hawai'i Department of Agriculture for a Miconia Biological Control Program. The same year, the First Regional Conference on Miconia Control was held in Papeete (Tahiti), sponsored and funded by the Department for Research (*Délégation à la Recherche*) and by ORSTOM.

1998 Decree N°1151CM establishing an Inter-Ministerial Technical Committee to Control Miconia and other Invasive Plant Species Threatening the Biodiversity of French Polynesia, chaired by the Minister of Environment. It is composed of governmental agencies that are involved in the prevention and control of introduced species, including the Environment, Research, Agriculture, Equipment and Tourism Departments. They meet on a regular basis, and are allowed to invite other non-government participants depending on their relevance to the action plans. These may include research scientists, French Army representatives, nature protection groups, elected officials, and representatives of local communities. The main goals are to define short and long term control strategies, which may include finding manpower and supplies, and determining priorities regarding public information, education, research, and regulatory instruments.

3. Summary of existing strategy and programs on IAS

3.1 Public information and education

Several articles have appeared in the two local newspapers *Les Nouvelles* and *La Dépêche*, and several local magazines. Local radio and TV have provided educational and informational time. Illustrated posters and leaflets were recently produced. They include:

⇒ three different posters on *Miconia* prevention and control published by the *Délégation à l'Environnement* and widely distributed to the high volcanic islands of French Polynesia which could potentially be invaded. They were entitled "The Green Cancer" (*Le Cancer Vert,* 1989), "Danger Miconia" (1991), and "Stop Miconia" (*Halte au Miconia,* 1993, prepared by the author);

⇒ a poster on the flora and fauna of montane rain forests in Tahiti published by the *Délégation à l'Environnement* in 1996 in collaboration with the author, mentioning some introduced noxious species, the swamp harrier (*Circus approximans*), *Miconia* (*Miconia calvescensi*), *Lantana* (*Lantana camara*) and the thimbleberry (*Rubus rosifolius*);

⇒ an illustrated poster on biological invasion by alien plants and animals in French Polynesia, "*Les invasions biologiques: menaces pour la Polynésie française*", prepared by the author for the *Délégation à la Recherche* in 1998;

⇒ a poster illustrating the thirteen invasive alien plant species threatening the biodiversity of French Polynesia and some other potential plant invaders, prepared by the author for the *Délégation à la Recherche* in 1999. It was jointly funded and published by the *Délégation à la Recherche* and the *Délégation à l'Environnement* in 2002;

⇒ a leaflet in English entitled "Let Us Protect Our Islands" published in 2000 by the Minister of Agriculture and the *Service du Développement Rural* to build foreign tourists' awareness of the risk of introducing plant and animal species to French Polynesia, and the need to declare any plant product when they arrive in French Polynesia and when they travel between the islands; and

⇒ several leaflets on the fruit-flies present in French Polynesia (*Bactrocera dorsalis, B. kirki, B. xanthodes, B. tryonii*) were published in 2001-2002 by the Minister of Agriculture and the *Service du Développement Rural.* These show the current island distribution of the various flies and give some recommendations on prevention and control.

3.2. Recent legislation and policy efforts

Several decrees contributing to IAS management in French Polynesia. were adopted by the Council of Ministers of the Government of French Polynesia (*Conseil des Ministres*):

⇒ July 25 1996: Decree N°740 CM prepared by the *Service du Développement Rural*, prohibiting new imports of 75 alien plant species (list prepared by the author) that are current or potential noxious species. The Decree also includes a list of noxious insects such as the Chinese rose beetle (*Lepadoretus sinicus*), the coconut hispine beetle (*Brontispa longissima*), the fruit-flies (*Bactrocera spp*.) and the big headed ant (*Pheidole megacephala*) and a list of noxious fungi, arthropods, nematodes, bacteria, viruses, and mycoplamas.

⇒ December 3 1997: Decree N° 1333CM prepared by the *Délégation à l'Environnement*, declaring the carnivorous snail or rosy-wolf snail (*Euglandina rosea*) a threat to biodiversity. New importation, breeding and transportation between islands is prohibited, and destruction authorized.

⇒ February 12 1998: Decree N°244CM prepared by the *Délégation à l'Environnement*. A total of thirteen dominant invasive alien plants in French Polynesia including *Acacia farnesiana*, shoebutton ardisia (*Ardisia elliptica*), trumpet tree (*Cecropia peltata*), *Lantana* (*Lantana camara*), false-acacia (*Leucaena leucocephala*), molasses grass (*Melinis minutiflora*), *Miconia* (*Miconia calvescens*), strawberry guava (*Psidium cattleianum*), thimble berry (*Rubus rosifolius*), African tulip tree (*Spathodea campanulata*), rose apple (*Syzygium jambos*), Java plum (*Syzygim cumini*), and yellow elder (*Tecoma stans*), were declared a threat to biodiversity. New introductions, propagation and cultivation, and transportation within and between islands are strictly prohibited and the destruction of these species is authorized.

⇒ February 9 1999: Decree N°171CM prepared by the *Délégation à l'Environnement*. Four alien birds, the common myna (*Acridotheres tristis*), the red-vented bulbul (*Pycnonotus cafer*), the swamp harrier (*Circus approximans*) and the great horned owl (*Bubo virginianus*) were declared a threat to biodiversity.

3.3. Recent actions in the field

⇒ Manual and chemical *Miconia* control operations have been conducted on the island of Raiatea since 1992, Tahaa since 1996, and Nuku Hiva and Fatu Hiva since 1997. The Inter-Ministerial Technical Committee to Control Miconia and other Invasive Plants organized the Miconia control campaign in the island of Raiatea in 1999, 2000, 2001 and 2002 in collaboration with the French Army (80-90 soldiers for one week). More than 1,450,000 miconia plants including 1,600 reproductive trees were destroyed between 1992 and 2003, and the invasion was contained.

⇒ Fruit-fly chemical control conducted by the *Service du Développement Rural* in Tahiti in 1997, 1999 and 2000, and in the Austral and the Marquesas Islands since 1998 and 1999 respectively.

⇒ Rat control by poisoning is conducted by the Society of Ornithology of French Polynesia Manu since 1998 in three valleys of Tahiti for the recovery of the Tahiti monarch or flycatcher.

⇒ Botanical field surveys were recently conducted by the author for the *Délégation à la Recherche* in the islands of Bora Bora (Society Islands), Nuku Hiva and Fatu Hiva (Marquesas), Rurutu and Tubuai (Austral Islands) in 1999 and 2000. The goals are to inventory and locate both native and endemic plants and IAS.

⇒ Capture of a green iguana (*Iguana iguana*) of unknown origin (July 1999, town of Papeete) and of a squirrel introduced as a pet on a Korean ship (August 1999, docks of Papeete) by the Zoo-sanitary Section of the *Service du Développement Rural* and French Customs. In 2002, live snails (*Helix aspera*) were found by the Plant Protection Section of the *Service du Développement Rural* in a container from France.

⇒ Release in April 2000 of a *Miconia*-specific pathogen fungus (*Colletotrichum gloeosporioides forma specialis miconiae*) as a biocontrol agent in a test-zone on Tahiti.

⇒ Release in 2003 of a parasitoid wasp (*Fopius arisanus* (Braconidae)) to control fruit flies by the *Service du Développement Rural*.

⇒ Project of the *Service du Développement Rural* to release biological control insects to control the glassy-winged sharpshooter.

3.4. Prevention and monitoring efforts

⇒ The Inter-Ministerial Invasive Plants Committee notified the French Polynesian airline company Air Tahiti Nui in May 1999 of the potential accidental introduction of the brown tree snake (*Boiga irregularis*) from Guam. This airline company organized the first direct flight between Tahiti and Guam during the Pacific Games in June 1999.

⇒ Post-release monitoring of the *Miconia* biocontrol pathogen agent in Tahiti since 2000 (conducted by the author). In 2002, 10% of the inoculated *Miconia* plants died and 50% of them have serious leaf or stem damages.

4. Government departments/agencies and other organizations concerned with IAS

⇒ **Research and field surveys**

Délégation à la Recherche
Ministère de la Culture et de la Recherche
Gouvernement de Polynésie française
B.P. 20981 Papeete
Tahiti
French Polynesia

⇒ **Field Management**

Service du Développement Rural
Ministère de l'Agriculture
Gouvernement de Polynésie française
B.P. 100 Papeete
Tahiti
French Polynesia

⇒ **Legislation, information and education**

Direction de l'Environnement
Ministère de l'Environnement
Gouvernement de Polynésie française
B.P. 4562 Papeete
Tahiti
French Polynesia

⇒ **Rat control (non-governmental organization)**

Société d'Ornithologie de Polynésie "Te Manu"
B.P. 21098 Papeete
Tahiti
French Polynesia

5. Assessment of the current situation

The remote, small, and diverse islands of French Polynesia have experienced a dramatic increase in the number of alien species introductions. The number of introduced species during the last 250 years has been about 20 times higher than the number of Polynesian introductions over the previous 2500 years. The 18th century was marked by the arrival of the first Europeans; the 19th century was a period of acclimatization of new plant species (mainly as food sources, and fodder for cattle) and the first biological control attempts, most of which were unsuccessful or worse leading to ecological disasters; and the 20th century was marked by introduction of ornamental and forestry plants, and accidental introduction of fruit flies, mosquitoes, and other stowaway noxious insects on airplanes and boats. The US Army used Bora Bora as a military supplies base during WWII; the Faaa International Airport was opened in 1960, the Autonomous Port of Papeete, a major trade port in the Pacific Ocean opened in 1962; and the establishment of the Pacific Experimental Centre (*Centre d'Expérimentation du Pacifique* (CEP)) in 1963 was followed by nuclear testing between 1966 and 1996 which totally overturned the socio-economic structure of French Polynesia with an exponential increase of imports.

Today, the number of introduced flowering plant species that are now naturalized in French Polynesia includes more than 520 species that are established in the wild. It is nearly equal to the total number of the flowering native plant species (*ca.* 690). Moreover, the total number of 'exotic' plants that are cultivated in French Polynesia (more than 1,300) far exceeds the number of native species. It is increasing exponentially with the development of commercial trade (330,000 tons of goods imported by boat in 1989 to 475,000 tons in 1999), tourism (50,000 tourists in 1970 to 260,000 tourists in 2000), and the diversification of agriculture, notably through the growing success of ornamental plants and "green industry" activities related to plant nurseries, gardening, and horticulture.

New means of transport, the ease of travel to and from Tahiti with direct flight connections to Rarotonga, New Zealand, Australia, Hawai'i, Japan, USA, and Chile, the increase of passengers in transit through Tahiti (to 382,000 in 1989 to 529,000 in 1998), and the increase of plane freight between islands in French Polynesia (from 386 tons in 1988 to 1,657 in 1998) have dramatically dramatically increased the risk of species introduction or transportation by foreign tourists or local people. A new airport was constructed on Raivavae in 2002 and other airports are planned on Rimatara and Rapa in the Austral archipelago. The new ports of entry will allow unrestricted travel by people and lead to the increase of introductions of alien biota.

Despite rules and regulations, introduction of noxious species still occurs in French Polynesia. Most of the recent introductions are accidental but some are intentional resulting from a lack of law enforcement and/or public awareness. Black rats (*Rattus rattus*) and carnivorous snails were recently introduced to Fatu Hiva with the construction of a hydro-electric station; *Miconia* was introduced to the Marquesas with road construction, and to the Austral Islands with the building of water tanks. Pet animals brought by tourists on ships have escaped to the wild and there are a few cases of recently introduced pest animals, such as the common mynah to Nuku Hiva in 2002. These incidents stem from ignorance of both the law and the ecological impacts.

The greatest fears for the islands of French Polynesia are the potential introduction of:

⇒ the little fire ant or fourmi électrique (*Wasmannia auropunctata*) that has invaded New Caledonia and was recently found in Vanuatu and Hawai'i;

⇒ the brown tree snake (*Boiga irregularis*) that has caused the extinction of endemic birds on Guam;

⇒ the shrubby melastome (*Clidemia hirta*) that has invaded Fiji and the Hawaiian islands; and

⇒ crop diseases such as taro blight caused by *Phytophtora colocasiae*; banana bunchy top disease caused by the banana bunchy top virus; Moko disease caused by the bacteria (*Ralstonia (Pseudomonas) solanacearum*) which also attacks ornamental plants from the Heliconiaceae family (birds of paradise, etc.); coconut-eating insects (*Oryctes rhinoceros*) which are established in the surrounding Pacific Islands; and other fruit flies such as the papaya fruit fly (*Bactrocera papayae*).

6. Priorities for future work

There is an urgent need for:

⇒ more information/awareness on plant and animal IAS worldwide, especially in the surrounding Pacific islands;

⇒ more political support, especially for long-term control programs at local, regional and international levels;

⇒ more education of local people and foreign tourists;

⇒ more law enforcement;

⇒ more training of custom and quarantine people, a better quarantine system, and the development of early warning systems including risk assessment protocols;

⇒ more collaboration with other Pacific Islands and nearby continents;

⇒ more biological surveys in remote inhabited islands of French Polynesia where new airport and harbour constructions are being planned to quickly identify and prevent new introductions; and

⇒ more surveys of natural areas of high conservation value for early detection and eradication of newly arrived IAS, such as the recent discovery in Fatu Hiva of black rats *Rattus rattus* in 2000, and *Miconia* (*Miconia calvescens*) trees in 2002 respectively.

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Guam

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Introduction

This is a Guam profile for IAS. It includes a list of pest insect and mite species associated with plants, as well as weeds, mosquitos and other organisms considered harmful in some way, and considered either not endemic or cryptogenic. Also included is a list of management programs, governmental agencies and experts concerned with IAS, and a bibliography of sources. The list is most certainly not comprehensive and should be continually improved. Most notably, no attempt was made at this time to include all plant or animal pathogens and there are probably a number of other IAS that have been omitted.

1. List of probable IAS in Guam

ID	Scientific name	Classification	Common name
1	*Acanthograeffea denticulata* (Redtenbacher)	Phasmatodea: Phasmatidae	denticulate stick insect
2	*Achaea janata* (L.)	Lepidoptera: Noctuidae	castor semilooper
277	*Achatina fulica* (Bowdich)	land invertebrate	giant African snail
3	*Adoretus sinicus* Burmeister	Coleptera: Scarabaeidae	Chinese rose beetle
4	*Adoxophyes melia* Clarke	Lepidoptera: Tortricidae	melia tortricid
295	*Aedeomyia catasticta* Knab	Diptera: Culicidae	mosquito
293	*Aedes albopictus* (Skuse)	Diptera: Culicidae	forest day mosquito
287	*Aedes vexans* (Meigen)	Diptera: Culicidae	vexans mosquito
5	*Agathodes ostentalis* (Geyer)	Lepidoptera: Pyralidae	moth
6	*Agonoxena pyrogramma* Meyrick	Lepidopter: Agonoxenidae	coconut flat moth
7	*Agonoxena sp.*	Lepidoptera: Agonoxenidae	moth
8	*Agrilus occipitalis* (Eschscholtz)	Coleoptera: Buprestidae	citrus bark borer
9	*Agrius convolvuli* (L.)	Lepidoptera: Sphingidae	sweet potato hawk moth
10	*Aiolopus thalassinus dubius* Willemse	Orthoptera: Acrididae	brown-winged
11	*Alciphron glaucus* (F.)	Hemiptera: Pentatomidae	pentatomid bug
12	*Aleurocanthus spiniferus* (Quaintance)	Homoptera: Aleyrodidae	orange spiny whitefly
13	*Aleurodicus dispersus* Russell	Homoptera: Aleyrodidae	spiraling whitefly
14	*Aleurodothrips fasciapennis* (Franklin)	Thysanoptera: Thripidae	thrips

ID	Scientific name	Classification	Common name
15	*Aleurothrixus floccosus* (Maskell)	Homoptera: Aleyrodidae	woolly whitefly
16	*Anaballus amplicollis* (Fairmaire)	Coleoptera: Curculionidae	weevil
17	*Andaspis punicae* (Laing)	Homoptera: Diaspididae	scale
18	*Anisodes illepidaria* Guenée	Lepidoptera: Geometridae	mango shoot looper
19	*Anomala sulcatula* Burmeister	Coleoptera: Scarabaeidae	chafer beetle
20	*Anomis flava* (F.)	Lepidoptera: Noctuidae	hibiscus caterpillar
292	*Anopheles barbirostris* Van der Wulp	Diptera: Culicidae	mosquito
289	*Anopheles indefinitus* (Ludlow)	Diptera: Culicidae	mosquito
291	*Anopheles litoralis* King	Diptera: Culicidae	mosquito
301	*Anopheles subpictus* Grassi	Diptera: Culicidae	mosquito
300	*Anopheles vagus* Donitz	Diptera: Culicidae	mosquito
278	*Anoplolepis gracilipes* (Smith)	Hymenoptera: Formicidae	yellow crazy ant
254	*Antigonon leptopus* Hooker & Arnott	land plant, Polygonaceae	chain of love
21	*Antonina graminis* (Maskell)	Homoptera: Pseudococcidae	rhodesgrass mealybug
22	*Anua coronata* (F.)	Lepidoptera: Noctuidae	moth
23	*Anua tongaensis* Hampson	Lepidoptera: Noctuidae	moth
24	*Aonidiella comperei* Mckenzie	Homoptera: Diaspididae	false yellow scale
25	*Aonidiella inornata* Mckenzie	Homoptera: Diaspididae	inornate scale
26	*Aonidiella orientalis* (Newstead)	Homoptera: Diaspididae	oriental scale
27	*Aphis craccivora* Koch	Homoptera: Aphididae	cowpea aphid
28	*Aphis gossypii* Glover	Homoptera: Aphididae	cotton or melon aphid
274	*Aphis nerii* Boyer de Fonscolombe	Homoptera: Aphididae	oleander aphid
275	*Aphis spiraecola* Patch	Homoptera: Aphididae	spirea aphid
298	*Armigeres subalbatus* (Coquillet)	Diptera: Culicidae	mosquito
29	*Aspidiella sacchari* (Cockerell)	Homoptera: Diaspididae	sugarcane scale
30	*Aspidiotus destructor* Signoret	Homoptera: Diaspididae	coconut scale
31	*Asterolecanium bambusae* (Boisduval)	Homoptera: Asterolecaniidae	bamboo scale
32	*Asterolecanium miliaris* (Boisduval)	Homoptera: Asterolecaniidae	bamboo scale
33	*Asterolecanium pseudomiliaris* Green	Homoptera: Asterolecaniidae	bamboo scale
34	*Asterolecanium pustulans* (Cockerell)	Homoptera: Asterolecaniidae	oleander pit scale
35	*Asterolecanium robustum* Green	Homoptera: Asterolecaniidae	bamboo scale
36	*Atractomorpha psittacina* Haan	Orthoptera: Pygomorphidae	grasshopper
37	*Aulacophora quadrimaculata* (F.)	Coleoptera: Chrysomelidae	spotted cucumber beetle
38	*Aulacophora similis* (Olivier)	Coleoptera: Chrysomelidae	spotted cucumber beetle
39	*Bactrocera cucurbitae* Coquillett	Diptera: Tephritidae	melon fly
41	*Badamia exclamationis* F.	Lepidoptera: Hesperiidae	myrobalan butterfly
42	*Batrachedra sp.*	Lepidoptera: Colephoridae	moth
43	*Batrachomorphus atrifrons* (Metcalf)	Homoptera: Cicadellidae	leafhopper

ID	Scientific name	Classification	Common name
44	*Bemisia tabaci* (Gennadius)	Homoptera: Aleyrodidae	sweet potato whitefly
255	*Bidens pilosa* L.	land plant, Asteraceae	Spanish needles
279	*Boiga irregularis* (Merrem)	land reptile	brown tree snake
45	*Bolacidothrips orizae* Moulton	Thysanoptera: Thripidae	thrips
46	*Brachyplatys insularis* Ruckes	Hemiptera: Plataspididae	black island stink bug
302	*Brontispa chalybeipennis* (Zacher)	Coleoptera: Chrysomelidae	Pohnpei coconut leaf beetle
47	*Brontispa palauensis* (Esaki & Chujo)	Coleoptera: Chrysomelidae	Palau coconut leaf beetle
48	*Capelopterum punctatellum* ? Melichar	Homoptera: Issidae	planthopper
49	*Cerataphis lataniae* (Boisduval)	Homoptera: Aphididae	latania aphid
50	*Ceresium unicolor* (F.)	Coleptera: Cerambycidae	longhorn beetle
51	*Ceroplastes ceriferus* Anderson	Homoptera: Coccidae	Mexican wax scale
52	*Ceroplastes floridensis* Comstock	Homoptera: Coccidae	Florida was scale
53	*Ceroplastes rubens* Maskell	Homoptera: Coccidae	red wax scale
54	*Chaetocnema confinis* Crotch	Coleoptera: Chrysomelidae	sweet potato flea beetle
55	*Chanithus gramineus* (F.)	Homoptera: Dictyopharidae	grass snout hopper
56	*Chloriona formosella* (Matsumura)	Homoptera: Delphacidae	planthopper
57	*Chlorophorus annularis* (F.)	Coleoptera: Cerambycidae	bamboo longhorn
58	*Chloropulvinaria psidii* Maskell	Homoptera: Coccidae	green shield scale
256	*Chromoleana odorata* (L.) R.M. King & H. Robinson	land plant, Asteraceae	Siam weed
59	*Chrysobothris costata* Kerremans	Coleptera: Buprestidae	wood borer
60	*Chrysodeixis chalcites* (Esper)	Lepidoptera: Noctuidae	green garden looper
61	*Chrysomphalus dictyospermi* (Morgan)	Homoptera: Diaspididae	dictyospermum scale
62	Cicadulina bipunctella (Matsumura)	Homoptera: Cicadellidae	leafhopper
257	*Coccinia grandis* (L.) Voigt	land plant, Cucurbitaceae	ivy gourd
63	*Coccus hesperidum* L.	Homoptera: Coccidae	brown soft scale
64	*Coccus longulus* (Douglas)	Homoptera: Coccidae	long brown scale
65	*Coccus moestus* De Lotto	Homoptera: Coccidae	coccid scale
66	*Coccus viridis* (Green)	Homoptera: Coccidae	green scale
67	*Colasposoma metallicum* Lefevre	Coleoptera: Chrysomelidae	leaf beetle
68	*Conocephalus longipennis* (Haan)	Orthoptera: Tettigoniidae	long-horned grasshopper
69	*Cosmopolites sordidus* (Germar)	Coleoptera: Curculionidae	banana root borer
70	*Creontiades pallidifer* (Walker)	Hemiptera: Miridae	sweet potato yellow bug
71	*Crocidolomia pavenana* Zeller	Lepidoptera: Pyralidae	cabbage cluster caterpillar
72	*Cryptophlebia ombrodelta* (Lower)	Lepidoptera: Tortricidae	litchi fruit moth
73	*Cryptophlebia peltastica* (Meyrick)	Lepidoptera: Tortricidae	tortricid moth
74	*Cryptorhynchus mangiferae* (F.)	Coleoptera: Curculionidae	seed weevil
299	*Culex fuscanus* Wied.	Diptera: Culicidae	mosquito

ID	Scientific name	Classification	Common name
290	*Culex fuscocephalus* Theobald	Diptera: Culicidae	mosquito
288	*Culex quinquefasciatus* Say	Diptera: Culicidae	southern house mosquito
294	*Culex sitiens* Wied.	Diptera: Culicidae	mosquito
296	*Culex tritaeniorhynchus* Giles	Diptera: Culicidae	mosquito
258	*Cuscuta sp.*	land plant, Convolvulaceae	dodder
75	*Cylas formicarius* (F.)	Coleoptera: Curculionidae	sweet potato weevil
76	*Cyrtopeltis tenuis* (Reuter)	Hemiptera: Miridae	tomato bug
273	*Dialeurodes citrifolii* (Morgan)	Homoptera: Aleyrodidae	whitefly
77	*Dialeurodes kirkaldyi* (Kotinsky)	Homoptera: Aleyrodidae	Kirkaldy whitefly
78	*Diaphania hyalinata* (L.)	Lepidoptera: Pyralidae	melonworm
79	*Diaphania indica* (Saunders)	Lepidoptera: Pyralidae	cucurbit leafroller
80	*Diaspis bromeliae* (Kerner)	Homoptera: Diaspididae	pineapple scale
81	*Diocalandra frumenti* (F.)	Coleoptera: Curulionidae	coconut weevil
82	*Dudua aprobola* (Meyrick)	Lepidoptera: Tortricidae	tortricid moth
83	*Dymicoccus boninsis* (Kuwana)	Homoptera: Pseudococcidae	grey sugarcane mealybug
84	*Dysmicoccus brevipes* (Cockerell)	Homoptera: Pseudococcidae	pineapple mealybug
85	*Dysmicoccus neobrevipes* Beardsley	Homoptera: Pseudococcidae	grey pineapple mealybug
86	*Dysmicoccus* saipanenis (Shiraiwa)	Homoptera: Pseudococcidae	Saipan mealybug
259	*Eichhornia crassipes* (Martius) Solms-Laubach	aquatic plant, Pontederiaceae	water hyacinth
87	*Eotetranychus cendanai* Rimando	Acari: Tetranychidae	citrus leaf mite
88	*Epilachna 26punctata philippensis* (Dieke)	Coleoptera: Coccinellidae	Philippine lady beetle
89	*Epitrix hirtipennis* (Melsheimer)	Coleoptera: Chrysomelidae	tobacco flea beetle
90	*Erionota thrax* (L.)	Lepidoptera: Hesperiidae	banana leafroller
91	*Etiella zinckenella* (Treischke)	Lepidoptera: Pyralidae	lima-bean pod borer
92	*Euconocephalus nasutus* (Thunberg)	Orthoptera: Tettigoniidae	Grasshopper
93	*Eudocima fullonia* (Clerck)	Lepidoptera: Noctuidae	fruit-piercing moth
280	*Euglandina rosea* (Ferussac)	land invertebrate	rosy wolf snail
94	*Euploea leucostictos* Eschscholtz	Lepidoptera: Nymphalidae	blue-spotted king crow
95	*Euscepes postfasciatus* (Fairmaire)	Coleoptera: Curculionidae	West Indian sweet potato weevil
96	*Eusyphax bivittatus* (Metcalf)	Homoptera: Derbidae	derbid planthopper
97	*Exitianus capicola* (Stål)	Homoptera: Cicadellidae	leafhopper
98	*Exitianuz plebeius* (Kirkaldy)	Homoptera: Cicadellidae	leafhopper
99	*Ferrisia virgata* (Cockerell)	Homoptera: Pseudococcidae	striped mealybug
100	*Fulvius angustatus* Usinger	Hemiptera: Miridae	mirid
101	*Furcaspis oceanica* Lindinger	Homoptera: Diaspididae	cocount red scale
102	*Gonocephalum sp.*	Coleoptera: Tenebrionidae	darkling beetle
103	*Grammarodes gemetrica* (F.)	Lepidoptera: Noctuidae	geometric noctuid

ID	Scientific name	Classification	Common name
104	*Gryllotalpa sp.*	Orthoptera: Gryllotalpidae	mole cricket
105	*Halticus insularis* Usinger	Hemiptera: Miridae	island fleahopper
106	*Halticus tibialis* Reuter	Hemiptera: Miridae	black garden fleahopper
107	*Helicoverpa armigera* (Hübner)	Lepidoptera: Noctuidae	old world bollworm
108	*Heliothrips haemorrhoidalis* (Bouché)	Thysanoptera: Thripidae	greenhouse thrips
109	*Hemiberlesia lataniae* (Signoret)	Homoptera: Diaspididae	latania scale
110	*Hemiberlesia palmae (*Cockerell)	Homoptera: Diaspididae	palm scale
111	*Hippotion celerio* (L.)	Lepidoptera: Sphingidae	taro sphinx-moth
112	*Hypolimnas bolina* (L.)	Lepidoptera: Nymphalidae	blue moon butterfly
276	*Hysteroneura setariae* (Thomas)	Homoptera: Aphididae	aphid
113	*Icerya aegyptiaca* (Douglas)	Homoptera: Margarodidae	Egyptian fluted scale
114	*Icerya purchasi* Maskell	Homoptera: Margarodidae	cottony cushion scale
260	*Imperata conferta* (Presl) Ohwi	land plant, Poaceae	blady grass
115	*Ischnaspis longirostris* (Signoret)	Homoptera: Diaspididae	black thread scale
116	*Kallitaxila crini* (Matsumura)	Homoptera: Tropiduchidae	green tropiduchid
117	*Karnyothrips melaleuca* (Bagnall)	Thysanoptera: Thripidae	thrips
118	*Kilifia acuminata* (Signoret)	Homoptera: Coccidae	acuminate scale
119	*Lallemandana phalerata* (Stål)	Homoptera: Cercopidae	spittlebug
120	*Lamenia caliginea* Stål	Homoptera: Derbidae	derbid planthopper
121	*Lamenia numitor* Fennah	Homoptera: Derbidae	derbid planthopper
122	*Lampides boeticus* (L.)	Lepidoptera: Lycaenidae	bean butterfly
123	*Lamprosema diemenalis* (Guenée)	Lepidoptera: Pyralidae	bean leaf-roller
261	*Lantana camara* L.	land plant, Verbenaceae	lantana
124	*Lepidosaphes beckii* (Newman)	Homoptera: Diaspididae	purple scale
125	*Lepidosaphes esakii* Takahashi	Homoptera: Diaspididae	armored scale
126	*Lepidosaphes laterochitinosa* Green	Homoptera: Diaspididae	armored scale
127	*Lepidosaphes palauensis* Beardsley	Homoptera: Diaspididae	Palau scale
128	*Lepidosaphes similis* Beardsley	Homoptera: Diaspididae	scale
129	*Lepidosaphes tokionis* (Kuwana)	Homoptera: Diaspididae	croton mussel scale
130	*Lepidosaphes sp.*	Homoptera: Diaspididae	scale
131	*Leptocentrus taurus* (F.)	Homoptera: Membracidae	eggplant horned planthopper
132	*Leptocorixa acuta* (Thunberg)	Hemiptera: Alydidae	rice bug
133	*Leptoglossus australis* (F.)	Hemiptera: Coreidae	leaf-footed plant bug
134	*Leptynoptera sulfurea* Crawford	Homoptera: Psyllidae	kamani psyllid
262	*Leucaena leucocephala* (Lam.) de Wit	land plant, Mimosaceae	leucaena
135	*Lipaphis erysimi* (Kaltenbach)	Homoptera: Aphididae	turnip aphid
136	*Liriomyza brassicae* (Riley)	Diptera: Agromyzidae	cabbage serpentine leafminer

ID	Scientific name	Classification	Common name
137	*Liriomyza sativae* Blanchard	Diptera: Agromyzidae	vegetable leafminer
138	*Locusta migratoria manilensis* (Meyen)	Orthoptera: Acrididae	migratory locust
139	*Lophothetes hirsuta* Zimmerman	Coleoptera: Curculionidae	short-nosed weevil
140	*Lophothetes inusitata* Zimmerman	Coleoptera: Curculionidae	short-nosed weevil
142	*Lophothetes sp.*	Coleoptera: Curculionidae	short-nosed weevil
143	*Lophothetes sp.*	Coleoptera: Curculionidae	short-nosed weevil
144	*Lophothetes sp.*	Coleoptera: Curculionidae	short-nosed weevil
141	*Lophothetes vulgaris* Zimmerman	Coleoptera: Curculionidae	short-nosed weevil
145	*Maconellicoccus hirsutus* (Green)	Homoptera: Pseudococcidae	Egyptian hibiscus mealybug
297	*Mansonia uniformis* (Theobald)	Diptera: Culicidae	mosquito
146	*Marasmia trapezalis* (Guenée)	Lepidoptera: Pyralidae	Maize leafroller
147	*Marasmia venilialis* (Walker)	Lepidoptera: Pyralidae	grass leaf-folder
148	*Maruca testulalis* (Geyer)	Lepidoptera: Pyralidae	bean pod borer
149	*Melanaspis bromeliae* (Leonardi)	Homoptera: Diaspididae	brown pineapple scale
150	*Melanitis leda* (L.)	Lepidoptera: Satyridae	evening brown butterfly
281	*Merremia peltata* L. Merrill	land plant, Convolvulaceae	vine
151	*Mesohomotoma hibisci* (Froggatt)	Homoptera: Psyllidae	hibiscus psyllid
152	*Metriona circumdata* (Herbst)	Coleoptera: Chrysomelidae	green tortoise beetle
263	*Mikania scandens* (L.) Willd.	land plant, Asteraceae	mile-a-minute vine
264	*Mimosa (invisa) diplotricha* C. Wright ex Suavalle	land plant, Mimosaceae	creeping sensitive plant
265	*Miscanthus floridulus* (Labill.) Warburg	land plant, Poaceae	sword grass
266	*Momordica charantia* L.	land plant, Cucurbitaceae	wild bitter melon
153	*Myndus bifurcatus* Metcalf	Homoptera: Cixiidae	planthopper
154	*Myndus dibaphus* Fennah	Homoptera: Cixiidae	planthopper
155	*Myndus irreptor* Fennah	Homoptera: Cixiidae	planthopper
156	*Myndus palawanensis* Muir	Homoptera: Cixiidae	planthopper
157	*Mythimna loreyi* (Duponchel)	Lepidoptera: Noctuidae	rice armyworm
158	*Neomaskellia bergii* (Signoret)	Homoptera: Aleyrodidae	sugarcane whitefly
159	*Neotermes connexus* Snyder	Isoptera: Kalotermitidae	forest tree termite
160	*Nephotettix apicalis* (Motschulsky)	Homoptera: Cicadellidae	green rice leafhopper
161	*Nesophrosyne argentatus* (Evans)	Homoptera: Cicadellidae	leafhopper
162	*Nezara viridula* (L.)	Hemiptera: Pentatomidae	southern green stink bug
163	*Nymphula fluctuosalis* Zeller	Lepidoptera: Pyralidae	rice caseworm
164	*Nysius pulchellus* (Stål)	Hemiptera: Lygaeidae	lygeid bug
165	*Ophiomyia phaseoli* (Tryon)	Diptera: Agromyzidae	bean fly
166	*Orthotylellus pallescens* Usinger	Homoptera: Miridae	mirid

ID	Scientific name	Classification	Common name
167	*Ostrinia furnacalis* (Guenée)	Lepidoptera: Pyralidae	Asian corn borer
168	*Oxycarenus bicolor* Fieber	Hemiptera: Lygaeidae	stainer bug
169	*Pagria signata* (Motschulsky)	Coleoptera: Chrysomelidae	leaf beetle
267	*Panicum maximum* Jacquin	land plant, Poaceae	Guinea grass
170	*Papilio polytes* L.	Lepidoptera: Papilionidae	black citrus swallowtail
171	*Paracoccus marginatus* Williams	Homoptera: Pseudococcidae	papaya mealybug
172	*Parasaissetia nigra* (Nietner)	Homoptera: Coccidae	nigra scale
173	*Parlatoria cinerea* Hadden	Homoptera: Diaspididae	tropical grey chaff scale
174	*Parlatoria proteus* (Curtis)	Homoptera: Diaspididae	proteus scale
268	*Passiflora foetida* L.	land plant, Passifloraceae	wild passion fruit
175	*Penicillaria jocosatrix* Guenée	Lepidoptera: Noctuidae	mango shoot caterpillar
269	*Pennisetum polystachyon* (L.) Schultes	land plant, Poaceae	mission grass
176	*Pentalonia nigronervosa* Coquerel	Homoptera: Aphididae	banana aphid
177	*Peregrinus maidis* (Ashmead)	Homoptera: Delphacidae	corn planthopper
178	*Pericyma cruegeri* (Butler)	Lepidoptera: Noctuidae	poinciana looper
179	*Perkinsiella thompsoni* Muir	Homoptera: Delphacidae	sugarcane leafhopper
180	*Phaneroptera furcifera* Stål	Orthoptera: Tettigoniidae	Philippine katydid
282	*Pheidole megacephala* (F.)	Hymenoptera: Formicidae	bigheaded ant
181	*Phenacaspis inday* (Banks)	Homoptera: Diaspididae	inday scale
182	*Phenacoccus madeirensis* Green	Homoptera: Pseudococcidae	mealybug
183	*Phyllocnistis citrella* Stainton	Lepidoptera: Phyllocnistidae	citrus leaf miner
184	*Phyllophaga bipunctata* (Brenske)	Coleoptera: Scarabaeidae	Mindanao June beetle
185	*Physomerus grossipes* (F.)	Hemiptera: Coreidae	large spined-footed bug
186	*Phytorus lineolatus* Weise	Coleoptera: Chrysomelidae	phytorus leaf beetle
187	*Piezodorus hybneri* (Gmelin)	Hemiptera: Pentatomidae	shield bug
188	*Pinnaspis buxi* (Bouché)	Homoptera: Diaspididae	ti scale
190	*Pinnaspis sp.*	Homoptera: Diaspididae	white scale
189	*Pinnaspis strachani* (Cooley)	Homoptera: Diaspididae	lesser snow scale
270	*Pistia stratiotes* L.	aquatic plant, Araceae	water lettuce
191	*Planococcus citri* (Risso)	Homoptera: Pseudococcidae	citrus mealybug
192	*Planococcus lilacinus* (Cockerell)	Homoptera: Pseudococcidae	lilac mealybug
193	*Planococcus pacificus* Cox	Homoptera: Pseudococcidae	mealybug
194	*Plutella xylostella* (L.)	Lepidoptera: Plutellidae	diamondback moth
195	*Polyphagotarsonemus latus* (Banks)	Acari: Tarsonemidae	broad mite
196	*Polytus mellerborgi* (Boheman)	Coleoptera: Curculionidae	banana corm weevil
283	*Pomacea canaliculata* (Lamarck)	aquatic invertebrate	golden apple snail
197	*Prays endocarpa* Meyrick	Lepidoptera: Yponomeutidae	citrus rind borer
198	*Proboscidocoris malayus* Reuter	Homoptera: Miridae	mirid bug

ID	Scientific name	Classification	Common name
199	*Protaetia fusca* (Herbst)	Coleoptera: Scarabaeidae	mango flower beetle
200	*Protaetia orientalis* (Gory & Percheron)	Coleoptera: Scarabaeidae	oriental flower beetle
201	*Protalebrella braziliensis* (Baker)	Homoptera: Cicadellidae	leafhopper
202	*Proutista moesta* (Westwood)	Homoptera: Derbidae	erect-winged blue planthopper
203	*Pseudaulacaspis pentagona* (Targiona-Tozzzetti)	Homoptera: Diaspididae	white peach scale
204	*Pseudococcus microadonidum* Beardsley	Homoptera: Pseudococcidae	mealybug
205	*Pseudoloxops bifasciatus* (Usinger)	Hemiptera: Miridae	mirid bug
206	*Pseudonapomyza spicata* (Malloch)	Diptera: Agromyzidae	maize leafminer
284	*Rattus norvegicus* (Berkenhout)	mammal	Norway rat
285	*Rattus rattus* (L.)	mammal	ship rat
207	*Rhabdoscelus obscurus* (Boisduval)	Coleoptera: Curculionidae	new guinea sugarcane weevil
208	*Rhopalosiphum maidis* (Fitch)	Homoptera: Aphididae	corn leaf aphid
209	*Saccharicoccus sacchari* (Cockerell)	Homoptera: Pseudococcidae	pink sugarcane mealybug
211	*Saissetia coffeae* (Walker)	Homoptera: Coccidae	hemispherical scale
212	*Saissetia miranda* (Cockerell & Parrott)	Homoptera: Coccidae	mexican black scale
213	*Saissetia neglecta* DeLotto	Homoptera: Coccidae	carribean black scale
214	*Saissetia nigra* (Nietner)	Homoptera: Coccidae	nigra scale
210	*Saissetia oleae* (Bernard)	Homoptera: Coccidae	black scale
215	*Selenothrips rubrocinctus* (Giard)	Thysanoptera: Thripidae	redbanded thrips
216	*Sitophilus oryzae* (L.)	Coleoptera: Curculionidae	rice weevil
217	*Sogatella furcifera* (Horváth)	Homoptera: Delphacidae	grass planthopper
286	*Solenopsis geminata* (F.)	Hymenoptera: Formicidae	tropical fire ant
271	*Spathodea campanulata* P. de Beauvois	land plant, Bignoniaceae	African tulip tree
218	*Sphenarches caffer* Zeller	Lepidoptera: Pterophoridae	plume moth
219	*Spodoptera litura* (F.)	Lepidoptera: Noctuidae	rice cutworm
220	*Spodoptera mauritia* Guenée	Lepidoptera: Noctuidae	lawn armyworm
221	*Steatococcus samaraius* Morrison	Homoptera: Margarodidae	steatococcus scale
222	*Stenocatantops splendens* (Thunberg)	Orthoptera: Acrididae	white-banded grasshopper
223	*Sternochetus mangiferae* (F.)	Coleoptera: Curculionidae	mango seed weevil
224	*Sundapteryx biguttula* (Ishida)	Homoptera: Cicadellidae	indian cotton jassid
225	*Susumia exigua* (Butler)	Lepidoptera: Pyralidae	rice leafroller
226	*Swezeyaria viridana* Metcalf	Homoptera: Tropiduchidae	planthopper
227	*Swezeyia zephyrus* Fennah	Homoptera: Derbidae	derbid hopper
228	*Tarophagus proserpina* (Kirkaldy)	Homoptera: Delphacidae	taro leafhopper
229	*Teleogryllus oceanicus* (Le Guill.)	Orthoptera: Gryllidae	oceanic field cricket

ID	Scientific name	Classification	Common name
272	*Tetraleurodes acaciae* (Quaintance)	Homoptera: Aleyrodidae	whitefly
230	*Tetranychus cinnabarinus* (Boisduval)	Acari: Tetranychidae	carmine spider mite
231	*Tetranychus neocaledonicus* André	Acari: Tetranychidae	vegetable mite
232	*Tetranychus sp.*	Acari: Tetranychidae	spider mite
233	*Tetranychus truncatus* Ehara	Acari: Tetranychidae	spider mite
234	*Tetranychus tumidus* (Banks)	Acari: Tetranychidae	spider mite
235	*Theretra pinastrina* (Martyn)	Lepidoptera: Sphingidae	narrow-winged sphinx moth
236	*Thrips palmi* Karny	Thysanoptera: Thripidae	melon thrips
237	*Thrips tabaci* Lindeman	Thysanoptera: Thripidae	onion thrips
238	*Tiracola plagiata* (Walker)	Lepidoptera: Noctuidae	cacao armyworm
239	*Toxoptera aurantii* (Boyer de Fonscolombe)	Homoptera: Aphididae	black citrus aphid
240	*Toxoptera citricida* (Kirkaldy)	Homoptera: Aphididae	brown citrus aphid
242	*Trigonops hirsuta* Zimmerman	Coleoptera: Curculionidae	weevil
243	*Trigonops inusitata* Zimmerman	Coleoptera: Curculionidae	weevil
241	*Trigonops sp.*	Coleoptera: Curculionidae	weevil
244	*Trigonops vulgaris* Zimmerman	Coleoptera: Curculionidae	weevil
245	*Trissodoris guamensis* Busck	Lepidoptera: Cosmopterigidae	moth
246	*Trochorhopalus strangulatus* (Gyllenhal)	Coleoptera: Curculionidae	strangulate weevil
247	*Ugyops annulipes* (Stål)	Homoptera: Delphacidae	delphacid planthopper
248	*Valanga excavata* Stål	Orthoptera: Acrididae	large short-horn grasshopper
249	*Xyleborus ferrugineus* (F.)	Coleoptera: Curculionidae	black twig borer
250	*Xyleborus morigerus* Blandford	Coleoptera: Curculionidae	black twig borer
251	*Xyleborus perforans* (Wollaston)	Coleoptera: Curculionidae	coconut shot-hole borer
252	*Xyleborus similis* Ferrari	Coleoptera: Curculionidae	shot-hole borer
253	*Zanchius fragilis* Usinger	Hemiptera: Miridae	mirid bug

2. Government departments/agencies and experts concerned with IAS

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Hawai'i

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Introduction

The "silent invasion" of Hawai'i by insects, disease organisms, snakes, weeds, and other pests is the single greatest threat to Hawai'i's economy and natural environment and to the health and lifestyle of Hawai'i's people. Pests already cause millions of dollars in crop losses, the extinction of native species, the destruction of native forests, and the spread of disease. But many more harmful pests now threaten to invade Hawai'i and wreak further damage. Even one new pest--like the brown tree snake (*Boiga irregularis*)--could forever change the character of our islands. Stopping the influx of new pests and containing their spread is essential to Hawai'i's future well being.

Despite the efforts of more than 20 State, federal, and private agencies, unwanted alien pests are entering Hawai'i at an alarming rate. In 1993, the federal Office of Technology Assessment (OTA) declared Hawai'i's alien pest species problem the worst in the nation. Hawai'i's evolutionary isolation from the continents, and its modern role as the commercial hub of the Pacific make these islands particularly vulnerable to destruction by alien pests. Gaps in current pest prevention systems and a lack of public awareness add further to this serious problem. New partnerships are finding ways to fill in the gaps between agency mandates and insufficient State funding.

1. Summary of existing strategy and programs on IAS

1.1 Leadership and coordination

In May, 2002 the Governor of Hawai'i signed an Executive Order forming the Hawai'i Invasive Species Council (HISC). The members of HISC will include a representative from the Governor's office and the chairs from the Hawai'i State agencies, and the President of the University of Hawai'i, with other members of government, profit and non-profit sectors invited to participate by consensus of the Council. This group will provide executive level leadership for invasive species issues in Hawai'i. Voluntary coordination on a staff level takes place within the Coordinating Group on Alien Pest Species that has spent the last several years developing projects to improve Hawai'i's response to IAS.

1.2 Prevention

The Hawai'i Department of Agriculture acquired a $300,000 grant from the U.S. Federal Aviation Administration to conduct an Airport Risk Assessment at Kahului, Maui. Inspection activities for incoming aircraft were dramatically increased during seven inspection blitzes lasting three-four weeks: these led to the discovery that 125 insect species new to Hawai'i had arrived with cargo. There were 1,401 interceptions during this period compared to the 782 interceptions recorded during normal inspection activities each year for the entire state.

A Weed Risk Assessment system adapted from the West Australian system has been developed and applied to a local tree-planting guide. The results were presented to local plant industry members. A resolution adopting a code of conduct for growing and imported plants is expected later this year.

1.3 Early detection and rapid response

Island Invasive Species Committees (ISCs) have been developed on all of the main Hawaiian Islands. These groups are partnerships between State, Federal and private groups that eradicate incipient invasive species and provide effective control for other spreading established species. These groups along with agencies charged with conservation and land management are working to increase the effectiveness of spending to control IAS. Current funding levels for these programs is approximately $1.5 million.

1.4 Control and management

Statewide control of *Miconia* - the greatest plant threat to Hawaiian forests – has been carried out over more than 600,000 acres during the past 18 months. For other widespread IAS, a total of 20 biocontrol projects have been carried out by the Hawai'i Department of Agriculture. Many additional projects are planned by a Biocontrol Working Group whose goal is to expand the effort to more wild-land weeds.

1.5 Restoration

Hawai'i's two large National Parks along with the State Department of Land and Natural Resources, and private groups such as The Nature Conservancy of Hawai'i are working to restore land. Recently Watershed Partnerships have been formed that include these groups as well as adjacent landowners in an attempt to improve landscape-scale management and preserve intact and functioning forests. There are now partnerships on every island.

1.6 International cooperation

In 2002, State officials from the Hawai'i Department of Agriculture and representatives from the Coordinating Group on Alien Pest Species travelled to New Zealand to tour quarantine and inspection facilities. Application of the Weed Risk Assessment benefited from the expertise of Australian officials who helped present the system to local plant industry representatives. Hawai'i's Brown Tree Snake prevention program relies on site-of-origin federal inspections at military bases throughout the Pacific.

1.7 Research

The Research Corporation of the University of Hawai'i has been able to provide an umbrella organization for hiring field staff for the Invasive Species Committees as well as supporting research on alien pest species. Local Pacific Island Ecosystem Research Center staff continue to support IAS research and collaborative projects, such as biocontrol research, with institutions in the countries where our IAS originate.

1.8 Information management and public outreach

The Coordinating Group on Alien Pest Species sponsored a Public Information and Outreach specialist for the state this year. The specialist has drafted a summary of Hawai'i's needs to address IAS and provide direction to outreach efforts. Public attention to IAS issues has been high due to the rapid

spread of the extraordinarily loud Coqui frog and the loss of public access to a popular freshwater fishing reservoir due to an infestation of giant water fern (*Salvinia molesta*).

2. Government departments/agencies and experts concerned with IAS

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The Hawai'i Department of Land and Natural – Division of Forestry and Wildlife manages 800,000 acres of public land for watershed protection, forestry, conservation, public hunting and recreation. The Division was formed 99 years ago to address the loss of forests to land uses, feral animals and their resultant impact on the state's water supply for agriculture and human consumption. Current efforts to address invasive species include funding Invasive Species Committees and landscape level Watershed Partnerships. The urban forestry program is working with the horticulture industry and the US Forest Service to develop a weed risk assessment to prevent new IAS from being introduced through forestry or the nursery trade. Predator control of rats, cats, and mongoose occurs in natural areas that support rare and endangered native birds and in coastal areas that support seabird colonies. Introduced game mammals and birds are managed through public hunting programs and funding fencing and control projects to exclude animals from conservation areas.

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⇒ **Maui Invasive Species Committee**

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⇒ **CGAPS/ISC**

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⇒ **Useful websites**

Hawaiian Ecosystems at Risk Project (HEAR)
http://www.hear.org

Pacific Island Ecosystems at Risk (PIER)
http://www.hear.org/pier/index.html

Hawai'i's Most Invasive Horticultural Plants
http://www.state.hi.us/dlnr/dofaw/hortweeds/

Republic of the Marshall Islands

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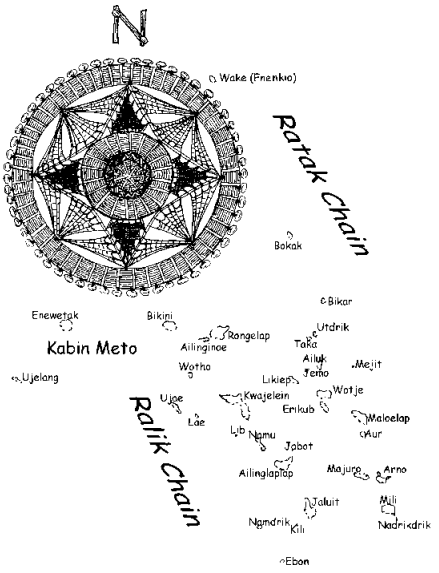
Introduction[1]

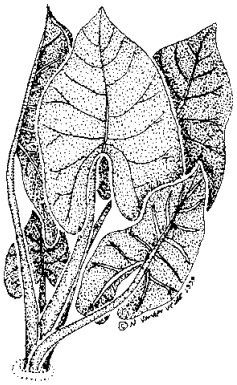
⇒ *Location and characteristics*



The Republic of the Marshall Islands is made up of 29 atolls and 5 solitary coral islands, comprised of approximately 1,225 individual islands and islets. They are situated from approximately 160 degrees to 173 degrees longitude East, and 4 degrees and 14 degrees latitude North. They cover 750,000 square miles of the Central Pacific Ocean, but their combined land area is only about 73 square miles: in other words, they are 99.99% water.

The average elevation of the islands is about 7 feet above sea level. The climate is tropical, the air temperature ranging between 76 and 90 degrees Fahrenheit (average 82 degrees). Rainfall ranges from 160 or more inches a year in the south, to very little (and in some years, none at all) in the north. Tropical storms are rare, but when they do hit, the effects are devastating. In the context of IAS, this could actually be beneficial (see below).

Aside from material such as pumice or volcanic rock lodged in the roots of a floating log, which occasionally drifts in, all the land is biologically derived.

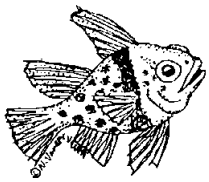


Only about 85 species of plants are considered to be native. There is only one native resident land bird: all other birds are resident or migrant shore or sea birds. There are no native land mammals, 18 species of native lizards, and probably only a few hundred - or fewer - native insects and other land invertebrates.

In contrast, the sea is rich, with over 1000 species of fishes, hundreds of corals and other invertebrates and numerous cetaceans.

[1] Most of this background information is based on NBTRMI. 2000. The Marshall Islands- Living Atolls Amidst the Living Sea.

The land is considered to have been sufficiently stabilized to allow human habitation only around 2000 years ago. From the start, inhabitants made changes in the environment. About two dozen species of plants were probably introduced either intentionally or inadvertently. These probably included several species of weeds, such as the beach morning glory (*Ipomoea littoralis*), and the only resident snake, the Brahminy blind snake (*Ramphotyphlops braminus*, see above) which came with the soil of useful plants such as giant swamp taro (*Cyrtosperma chamissonis,* see right) and breadfruit (*Artocarpus* spp.).



Less information is available about aboriginal introductions of marine species, although there is some indication that this may have occurred. Legend tells of the orbiculate cardinal fish (*Sphaeramis orbicularis*, see left) being brought in from the mythical land of "Eap."

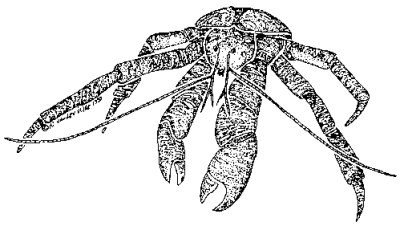
In the late 1800s, Germany began extensive trade with the atolls of the Marshall Islands, with copra as the major commodity. Eventually, a regional capital was established on Jabwor Island, Jaluit Atoll and many new species of plants and animals were introduced. When the Japanese took over the administration of the country, more species were brought in, including a number known to be invasive.

World War II brought another change of administration. The Americans transferred the capital from Jaluit to Majuro, where it has remained. There is also a military base on Kwajalein Atoll. With modern air transportation to the international airports on these atolls, the rate of introductions of new species has not only continued but also accelerated.

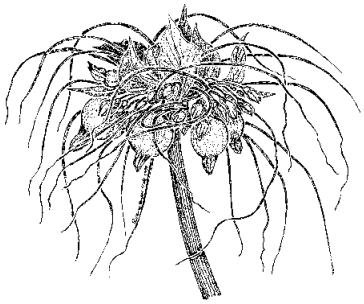
⇒ ***Nuclear Testing Program***

No discussion of the Marshall Islands is complete without a consideration of the nuclear testing program. Between 1946 and 1958, 67 nuclear devices were detonated at Bikini and Enewetak Atolls. One of these, which was codenamed "Bravo," was the biggest explosion of any device up to that time. This 15-megaton blast literally vaporized islands and left fall-out in its wake that contaminated several nearby atolls. The inhabitants of Rongelap and Utdrik had to be quickly evacuated.

The immediate environmental impacts of these tests were obviously intense and unfortunately, the atolls were too “hot” to allow much scientific work to be done soon afterwards. As soon as feasible, though, teams of scientists came in to document the changes. Even years later, environmental after-effects have been noted.



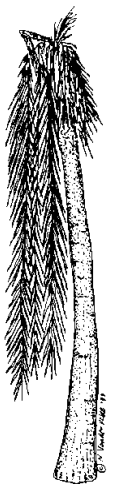
Most of the studies have dealt with the impact on humans. Coconut crabs (*Birgus latro*, see right) are a popular traditional food of the Marshallese people, but they have some of the highest buildups of radiation.



One species about which local people have expressed concern is the Polynesian arrowroot (*Tacca leonpetaloides,*see left). Anecdotal reports consistently state that before the nuclear testing program, it was healthier and produced larger corms. To date, however, no thorough scientific investigative study has been made.

The limited studies carried out on birds, fishes, other animals, and plants have shown generally that the aftereffects are no longer significant. But further study is probably still warranted because so many questions still remain unanswered.

⇒ ***Climate change***



In recent years, climate change has become a high profile environmental issue in the Marshall Islands. Many people equate climate change with sea level rise and because of the low elevation of the Marshall Islands, this has generated significant concern. Sea level rise has been documented in the Marshalls, but not to the extent that the average person can detect it.

However, the other manifestations of climate change could actually pose as great a risk in their own right. If the sea temperature were to rise by less than 2° F., coral bleaching and die-off could occur. If the coral died, the reef would not be able to provide any protection against sea level rise.

Similarly, climate change could mean more El Niño generated storms and subsequent droughts. These have already had serious impacts on the food crops of some of the outer islands, causing valuable coconut trees (see right) to die. These storms and droughts could also lead to contamination of the all-important underground freshwater resources.

1. Main IAS in the Marshall Islands

With attention usually focused on more spectacular threats to the environment, IAS have often been ignored. But their threat is real and unlike nuclear fall-out, they do not have a known half-life rate at which they will dissipate on their own. As has been well documented in many other studies around the world, when a biological invasion occurs, the environmental impacts may be irreversible.

1.1 Preliminary list of IAS

In a preliminary list of IAS of the Marshall Islands (see table), over eighty species were found to be of significance. This list is of course subjective, but includes several species which were not known to be in the Marshall Islands when the National Biodiversity Report was done in 1998-2000.

Significant IAS of the Marshall Islands	
Invasive alien mammals	
Canis familiaris	domestic dog
Felis catus	domestic cat
Mus musculus	house mouse
Rattus norvegicus	Norway rat
Rattus rattus	ship rat
Suncus murinus (?)	house shrew
Sus scrofa	domestic pig
Invasive alien birds	
Passer montanus	Eurasian tree sparrow
Pycnonotus cafer	red-vented bulbul

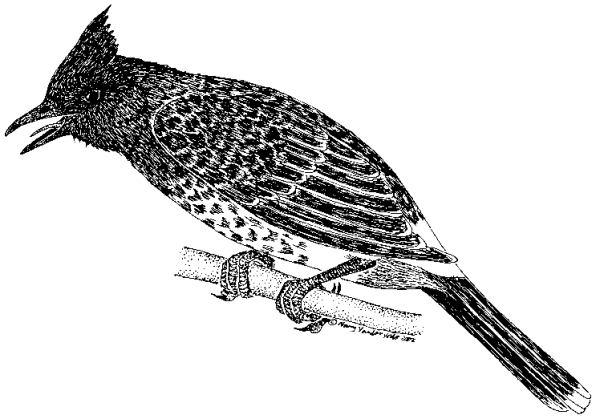
Invasive alien reptiles	
Anole carolinensis	green anole
Chamaeleo jacksonii	Jackson's chameleon
Invasive alien fishes	
Gambusia affinis	Western mosquito fish
Invasive alien insects	
Aleurodictus dispersus	spiraling whitefly
Anoplolepus gracilipes	long-legged ant
Aonidiella inornata	inornate scale
Aspidiotus destructor	coconut scale
Bactrocera frauenfeldi	mango fruitfly
Dysmicoccus brevipes	pineapple mealybug
Dysmicoccus cocotis	mealybug
Furcaspis oceanica	coconut red scale
Icerya egyptiaca	Egyptian fluted scale
Musa domesitica	housefly
Palmicultor palmarum	palm mealybug
Pseudococcus orchidicola	orchid mealybug
Pulvinaria psidii	green shield scale
Pulvinaria urbicola	urbicola soft scale
Invasive terrestrial invertebrates (other than insects)	
Tetranychus spp.	spider mites
Actina fulica	giant African snail
Invasive marine invertebrates	
Obelia spp.	hydroids
Invasive alien plants	
Antigonon leptopus	chain-of-love
Asystasia gangetica	Chinese violet
Bidens pilosa	beggar's ticks
Bothriochloa bladhii	blue grass
Casuarina equisetifolia	she oak
Cenchrus brownii	burr grass
Cenchrus echinatus	burr grass
Chloris barbata	swollen fingergrass
Chromolaena odorata	Siam weed
Clerodendrum quadriloculare	bronze-leaf cherodendrum
Chrysopogon aciculatus	Mackie's pest
Coccinia grandis	ivy gourd
Cuscuta campestris	golden dodder
Cynodon dactylon	Bermuda grass
Cyperus lingularis	rocket sedge
Desmodium incanum	Spanish clover
Digitaria ciliaris	Henry's crabgrass

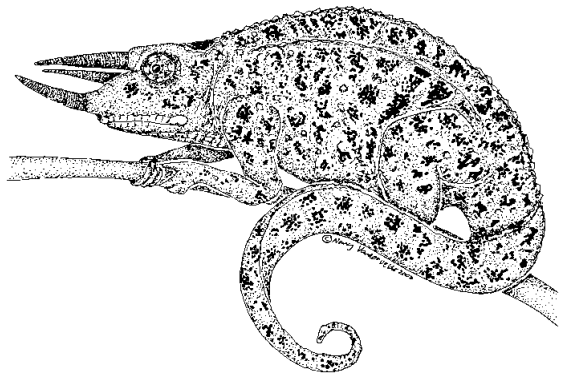
Digitaria insularis	cottongrass
Eleusine indica	goosegrass
Kyllinga brevifolia	green water sedge
Kyllinga nemoralis	white water sedge
Lantana camara	Lantana
Leucaena leucocephala	tangan-tangan
Merremia peltata	Merremia
Moringa oleifera	horseradish tree
Paspalum diticum	salt grass
Paspalum conjugatum	T-grass
Pennisetum polystachion	mission grass
Pennisetum purpureum	elephant grass
Pluchea carolinensis	sour bush
Pluchea indica	Indian fleabane
Ricinus communis	castor bean
Sporobolus indicus	Indian dropseed
Stachytarpheta cayennensis	deep blue rat's tail
Stachytarpheta jamaicensis	blue rat's tail
Tecoma stans	yellow bells
Tradescantia spathacea	Moses-in-a-boat
Turnera ulmifolia	yellow elder
Wedelia (=Sphagneticola) trilobata	Singapore daisy
Invasive alien algae	
Cephaleuros virenscens	algal leaf spot red rust
Sargassum duplicatum	sargassum kelp
Invasive alien fungi of plants	
Cercospora ipomoeae	leaf spot
Cercospora taccae	Polynesian arrowroot blight
Cochliobolus heterostrophus	southern leaf blight
Corynespora cassiicola	leaf spot
Elsinoe sacchari	white rash
Glomerella cingulata	dieback, fruit rot
Mycosphaerella fijiensis	black sigatoka, black leaf streak
Oidium sp.	powdery mildew
Pestalotiopsis palmarum	grey leaf spot
Pseudoepicoccum cocus	brown leaf spot
Rhizoctonia sp.	leaf rot, web blight
Uromyces vignae	rust
Invasive alien animal/human pathogens	
dengue virus	dengue fever virus
Entamoeba histolytica	dysentery amoeba
Giardia lamblia	giardia protozoa

As noted, this table includes a few known IAS that were not known to be in the Marshall Islands when the National Biodiversity Report was compiled and which could spread rapidly if prompt mitigation measures are not put in place. Three examples are given below.

Siam weed (*Chromolaena odorata*, see left) is a major pest in Guam and other areas of Micronesia. A small patch of this plant was located near the village of Laura in late 2001 by a visiting pest expert. Since it has a resemblance to the native beach sunflower (*Wollansia biflora*), it is unlikely that most people would have recognized it. An effort is being made to eradicate it, but it is too soon to know if this will succeed.

Another recent arrival is the red-vented bulbul (*Pycononus cafer*, see right). It is unknown how this bird was introduced, but as it was first sighted in 2000 near the major commercial dock of Majuro and has been known to hitchhike on ships in other areas, it would seem logical that the bird also came to the Marshall Islands in this way. The bird now seems to have become well entrenched with at least several breeding populations (Vander Velde 2002).





Immediately after the GISP Austral-Pacific Workshop on Prevention and Management of IAS (Hawai'i, 15-17 October 2002), another IAS was detected. The local radio station ran a news story about the GISP Workshop on 23 October 2002. That very afternoon, information and digital photos of a chameleon, probably a Jackson's chameleon (*Chamaeleo jacksonii*, see left) were sent to the author. Both participants at the GISP Workshop were notified. By the next day, the story was on the radio and the photo and article were printed in the Marshall Islands Journal (MIJ 2002).

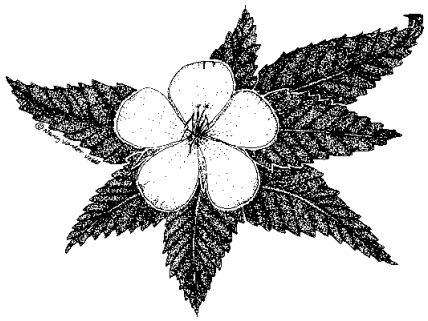
1.2 Advantages and disadvantages of atolls with regard to biological invasions

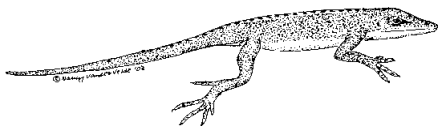
In a sense, all the atolls - and even all the small islands - of the Marshall Islands, have built-in quarantines. Most terrestrial species, including IAS, do not easily travel on their own from one landmass to the next.

Another factor that limits the spread of species is the constant battering of the land by salt-laden winds. Many plants, in particular, just cannot survive in this environment.

As undesirable and devastating as tropical cyclonic storms are to low-lying atolls, they have served in the past as a natural “reset” button for the environment. Jaluit Atoll, which had been the center of many alien plants for decades, was ravaged in the late 1960s by a series of typhoons. Now, only a few of those alien plants remain and none of these are considered to be invasive.

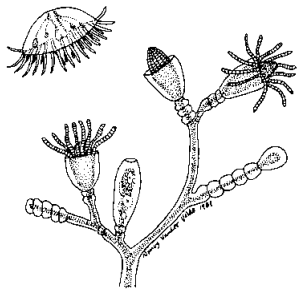
On the other hand, the atoll environment is also sufficiently different from the experience of high, volcanic islands to make it hard to predict what will happen when a new species is introduced. A good example is that of the showy garden plant, *Turnera ulmifolia* (see right). In other areas of Micronesia, it has remained a fairly docile species, but it has become a major IAS in the Marshall Islands.





More recently, the American blueheart (*Buchera americana*) and the green anole (*Anole carolinensis*, see left) have appeared. They are spreading rapidly and showing undesirable invasive characteristics. They should be monitored or, better yet, eradicated before they spread any further.

Because the Marshall Islands have such a high percentage of ocean, they are highly vulnerable to marine IAS. A few have been identified so far and further study will undoubtedly reveal many more. The well-known fouling hydroid, *Obelia* spp. (see right) is considered to have been inadvertently introduced during the nuclear testing program.



Another possible marine invasive is the brown kelp, *Sargassum duplicatum*. Traditional thinking was that sargassums are not to be found on any atoll of the Marshall Islands (Tsuda 1976). Yet both the author and one of the instructors at the College of the Marshall Islands have collected specimens of *S. duplicatum* from Majuro lagoon.

2. Summary of existing strategy and programs on IAS

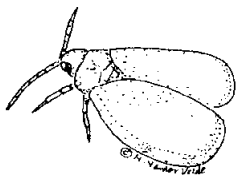
There is no formal coordination mechanism for action on IAS. However, a tentative Invasive Weeds Task Force has been set up following the visit of Konrad Englberger (South Pacific Commission Plant Protection Programme, Pohnpei) to work on the weed poster (see 2.2 below). This task force is still very much in its infancy.

2.1 Eradication and control programs

In the past, only a limited amount of effort has been done in controlling or eradicating IAS. Fosberg (1955) reports that on Likiep Atoll, the star-of-Bethlehem (*Hippobroma longiflora*) was established in 1946. The residents were informed of the noxious nature of this plant and on a subsequent visit five years later, none of this species were seen, and it seems to be gone from the entire country.

As mentioned above, an effort is underway to rid the country of Siam weed (*Chromoleana odorata*) before it spreads.

The Division of Agriculture has under taken a program to control the destructive spiraling whitefly (*Aleurodictus dispersus*) and the coconut scale (*Aspidiotus destructor*). Predators were brought in, a technique which always carries its own risks, but seems to be working so far.



2.2 Public awareness

In the past, public awareness of the dangers of IAS has been limited. The National Biodiversity Report of the Republic of the Marshall Islands, which is now being distributed and is due to be adopted as part of the public school curriculum, identifies the problem clearly. Some items in the local newspaper in recent months have also highlighted the problem. A large colorful poster, *Mar Ko Renana ilo Marshall Islands. Invasive Weed Species In Marshall Islands*, has just been released. This should help promote some public awareness to the problem: ten of the most problematic species, such as beggar's tick (*Bidens pilosa*, see left) are included. However, there certainly are more than ten species that should be of concern.

Without stronger public awareness, it is unlikely that measures to control the spread of IAS will be taken. In a recent survey of the flora of Majuro, 563 species were identified. Of these, only 56 were figured to be native: many more than that figure had the potential to become invasive. (Thaman and Vander Velde 2002). However, without any means for intra-island quarantine, the spread to the outer island of many of these species, especially the attractive decorative plants and the plants otherwise considered to be useful, seems inevitable.

3. Government departments/agencies concerned with IAS

In the Republic of the Marshall Islands, the two principal agencies concerned with IAS are:

⇒ **Quarantine (Ministry of Resources and Development)**

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⇒ **Marshall Islands Environmental Protection Authority (RMIEPA)**

The Marshall Islands Biodiversity Team, which is coordinated by the RMIEPA, has been most active in dealing with IAS. The National Biodiversity Report, *The Marshall Islands -- Living Atolls Amidst the Living Sea*, and the accompanying National Biodiversity Strategy and Action Plan, are the best documents available which discuss IAS.

The delegate to the GISP Austral-Pacific Workshop was:

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⇒ **Other agencies affected by the impacts of IAS**

Division of Agriculture of the Ministry of Resources and Development; Customs and Revenue; Marshall Islands Marine Resources Authority; Marshall Islands Visitor Authority; Public Health, Ministry of Transportation and Communication; Marshall Islands Airport Authority; Historic Preservation Authority; and the various local governments.

Funding and manpower available for combating the problem of IAS in all of these agencies is limited.

The College of the Marshall Islands has a number of instructors who are concerned about IAS.

4. Conclusion

IAS in the Marshall Islands have long been ignored, but as they become more and more prevalent, they are showing that they need to be dealt with. While IAS have often been given a lower priority compared with better-known environmental issues such as the nuclear testing program and climate change, it is becoming apparent that IAS are complicating features of these other environmental problems.

Now that clean-up projects are underway on some of the irradiated atolls, these projects bring with them the possibility of introducing many IAS.

As the climate changes, that means more niches for alien species to take hold. The ones that will probably come in to fill these new niches are most likely going to be the more aggressive species or IAS.

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Federated States of Micronesia

No report has been submitted.

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Introduction

New organisms have come to New Zealand in several ways. Some, such as birds, insects, and microbes, have been self introduced, mainly from Australia. Others have been assisted by humans either intentionally (legally or illegally imported) or unintentionally as passenger and/or associated organisms. Some new organism hybrids or varieties have been created in New Zealand by traditional plant and animal breeding techniques or through genetic modification (GM). The cost of introduced weeds and pests [e.g. hieracium (*Hieracium* spp.), old man's beard (*Clematis vitalba*), brushtail possum (*Trichosurus vulpecula*), European rabbit (*Oryctolagus cuniculus*), stoat (*Mustela erminea*), wasp (*Vespula* spp.), microbes (e.g. powdery mildew *Podosphaera leucotricha*)] is considerable to New Zealand.

Possible implications of hybridisation between crops and wild plants are difficult to predict at the best of times because it may take decades before adverse effects become apparent. According to Williams and Lee (2001), New Zealand is one of the few countries in the world with databases of its entire flora, both cultivated and wild, including the important stage of naturalisation, i.e. forming self-sustaining populations in the wild. An analysis of nursery catalogues indicating when a plant species was first offered for sale in New Zealand, and the time a species was first collected as an established population in the wild, gives an indication of the time between importation and establishment. The average period for bird-dispersed woody species was about 50 years after introduction. From the above it is apparent that it may be a long time before the potential for likely adverse effects of an introduced plant can be realised.

It is noted that in less than 150 years, the size of the national flora of New Zealand has increased more than tenfold through the importation and establishment of alien plant species. Approximately 10% of the world's flowering plants are growing here, on a land area comprising less than 0.2% of the world's total. The rate of entry into New Zealand of alien plant species, based on the time since European settlement and the size of the alien flora (domestic and naturalised) has been approximately one species every two days, or 144 species per year. From this pool there are likely to be 3-5 potential new agricultural or environmental weeds per year, based on the proportion of species that have naturalised so far (Williams and Lee 2001).

1. Legislative framework for assessing "new organisms"

The Hazardous Substances and New Organisms (HSNO) Act provides a framework for assessment and approval of applications to import, develop, field test, or release microorganisms, plants and animals that are new organisms including genetically modified organisms (GMOs). The Act focuses on effects of new organisms on people and the environment. The purpose of the Act is to protect the environment,

and the health and safety of people and communities, by preventing or managing the adverse effects of hazardous substances and new organisms (section 4).

In achieving the purpose, there are principles to be recognised and provided for, for example, safeguarding of the life-supporting capacity of air, water, soil, and ecosystems; and maintenance and enhancement of the capacity of people and communities to provide for their own economic, social, and cultural wellbeing and for the reasonably foreseeable needs of future generations (section 5). While assessing effects the decision making Authority is required to use a consistent methodology (section 9).

The decision making Authority is required to take into account the need for caution in managing adverse effects where there is scientific and technical uncertainty about those effects (section 7). The Act requires that assessment of applications always take place. In making a decision on new organisms, the Act requires the Authority to consider what could be called an environmental bottom line in the form of minimum standards (section 36).

2. Process for risk assessment

Given the need for an assessment, it is also important to recognise that not all new organisms require the same level of scrutiny. The level of assessment should therefore be based on the level of risk. In this context, risk is concerned with the potential of an organism to have a detrimental impact for example on economic activity, human health, or the environment generally.

Flexibility is important. The HSNO Act provides a two-tiered approach for import and release of all new organisms; a rapid assessment process for those new organisms that are low risk (section 35) and a full assessment process for those that do not qualify for low risk consideration (sections 37 and 38).

In some cases when an application is received to import a new organism into New Zealand it will be recognised very quickly that the organism either poses unacceptable risks from pests, parasites, or diseases, or that it has significant environmental risks associated with it which are too great to allow its presence in New Zealand. However, in most cases an application is likely to lie in the grey area between the obviously unacceptable and the absolutely no risk. In these cases a weighing-up of risk and benefit is necessary.

It is important to be able to connect these criteria with the information that is available on the biological characteristics of the organism. For plants, this can be done by using the weed risk assessment (WRA) tool in conjunction with the risk assessment required under the HSNO Act. The difficulty with other groups of organisms is the lack of a pest risk assessment framework as it exists for plants. However, similar principles can be applied to other groups on a case-by-case basis.

Section 35 (for rapid assessment considerations) and section 38 (for full assessment considerations) of the HSNO Act ask a number of questions. The answers to these questions are based on analysis of relevant information about the organism. In order to use the available biological information, and indeed to indicate the information that is required, these questions are expanded on and, where appropriate, are used in the WRA model. In addition, information required for most of the Minimum Standards in section 36 of the Act is also relevant to the various sections of the WRA. However, answering these questions alone is not sufficient as the matters in Part 2 of the Act, particularly sections 5 & 6, must also be included in the decision-making process. These matters do not lend themselves as readily to alignment with the WRA and its scores.

The WRA, developed by the Landcare Research Institute, is based on a system originally developed for the Australian Quarantine and Inspection Service (AQIS) and is being considered for use in the HSNO Act framework. It is a spreadsheet-based model that looks at the information and gives it a "score" according to the characteristics of the plant species. The WRA analysis includes the information required for the purpose of the HSNO Act as well as information that will be directly relevant for a WRA by the Landcare Research Institute. The WRA represents the analysis or score for a particular attribute or attributes that relate to the questions asked for a plant risk assessment. According to Williams and Lee (2001), the assessment sheet for each plant species involves entering information on two major areas. Each question is given a score and the total score for weediness places the species in one of three classes: reject, accept, or requiring further evaluation.

The biogeographical and historical information focuses on the characteristics of the species' native range, particularly climate, and its history of domestication, spread and weediness elsewhere. Factors such as a species' origins and history, weediness of its relatives, and its own biological characteristics are all taken into consideration when assessing weed potential in New Zealand. The biological and ecological information uses attributes known to be associated with competitive ability, persistence, and reproductive vigour. In early tests, the WRA model clearly placed all current major weed species in New Zealand in either the reject/evaluate further category.

Williams and Lee (2001) add that much of the research is focussed on improving the information on attributes to detect weeds amongst species not yet in New Zealand, or weeds present only in cultivation/low population densities. This involves comparative investigations of weedy/non-weedy species in several large families renowned for weed species [Pinaceae (pine, fir, larch, spruce), Fabaceae (legumes), Rosaceae (the rose family - includes roses, strawberry, cherry, apple etc.)].

3. Criteria for risk assessment

3.1 Criteria for rapid assessment of risk for importation of new organisms (Section 35 of the HSNO Act)

As noted in the Introduction, the HSNO Act provides a two-tiered approach for import and release of all new organisms, a rapid assessment process for those new organisms that are obviously low risk and a full assessment process for those that do not qualify for low risk consideration. The Act requires the decision making Authority to consider the following for a rapid assessment application for release of an organism into the environment.

According to the HSNO Act a rapid assessment of adverse effects of importing a new organism can be made if the Authority is satisfied on a number of counts, including the following provisions:

⇒ Section 35(2)(a), which requires consideration of whether the organism has been declared an unwanted organism under the Biosecurity Act 1993, administered by the Ministry of Agriculture and Forestry (MAF). The purpose of the Biosecurity Act 1993 is to enable New Zealand to exclude, eradicate or effectively manage pests and unwanted organisms already in the country. The Act has two major components. The prevention of introduction of unwanted organisms not already established in New Zealand through border control and the management of unwanted organisms established in New Zealand through the development of pest management strategies on regional or national basIslands Information on the status of pests and diseases can be found on MAF website http://www.maf.govt.nz. If the organism has been declared an unwanted organism then it is unlikely to be considered for rapid assessment under the HSNO Act. This information is not used in the WRA.

⇒ Section 35(2)(b)(i), which requires the consideration of whether it is highly improbable that the organism could after release form self-sustaining populations anywhere in New Zealand while taking into account the ease with which the organism could be eradicated if so required. The ability to form self-sustaining populations refers to the ability of continued existence in the uncontrolled environment without human intervention. The continuation of population in the long term is likely to be a result of the reproductive viability of the organism and this information is what is required to enable the questions in sections 6, 7 and 8 of the WRA to be answered.

⇒ Section 35(2)(b)(ii) & (iii), which envisages that an approval for an organism's release is unlikely to be given under the rapid assessment provisions of the Act if the organism is likely through competition to displace or markedly reduce the numbers of an existing valued species so as to cause deterioration to natural habitats. The relevant information for these criteria will be that which enables sections 2, 3 and 4 of the WRA to be analysed.

⇒ Section 35 (2)(b)(iv) & (v), which contemplates that a release application is also unlikely to succeed if the organism is likely to be disease-causing or be a parasite, or be a vector or reservoir for human, plant, or animal disease. Section 4 of the WRA has questions relevant to these matters.

Addressing these criteria is important because they provide a means to determine whether an organism offers very little risk after importation into New Zealand. Such an organism is unlikely to require further evaluation of its effect and may be approved for release, subject to any quarantine requirements under the Biosecurity Act. These quarantine requirements ensure that pests or diseases associated with the new organism are not imported with it.

To summarise, the following Table presents a hypothetical evaluation of a circumstance where rapid assessment may be a possibility.

Item	**Criteria in the HSNO Act**	**Probability**	**Remarks**
(i)	Form self-sustaining populations Ease of eradication	Possibility in extreme north of New Zealand Medium to high	Risk of becoming a pest negligible Easily controlled with biocide or other means
(ii)	Could displace or reduce valued species	Very low	Risk of becoming a pest negligible
(iii)	Cause deterioration of natural habitats	Very low	Risk of becoming a pest negligible
(iv)	Disease causing to humans, animals, or plants	Low	Non-toxic to predator
(v)	Adverse effects on human health and safety or the environment	Low	Non-pathogenic to humans and other mammals

In reaching the conclusion to invoke ease of eradication to approve the application, the decision-maker would have to be satisfied that effects identified are negligible/insignificant.

If effects are not negligible/insignificant, then the decision-maker may have to consider declining the application under section 35 of the HSNO Act and indicating to the applicant that the applicant may

wish to re-submit the application under section 34 of the Act after fulfilling the information and other requirements of the process section 34 requires for determination under section 38 of the Act.

3.2 Minimum standards (Section 36 of the HSNO Act)

The minimum standards are in a way environmental bottom lines. Any organism to be imported has to meet each of the criteria set down as minimum standards in the Act. The Authority is required to decline the application, if the organism to be imported is likely to:

⇒ ***cause any significant displacement of any native species within its natural habitat***

Here the consideration should be an assessment of real and substantial effects on a native species where the native species occurs naturally (its natural habitat, i.e. without human intervention).

⇒ ***cause any significant deterioration of natural habitats***

This criterion requires consideration beyond species level of real and substantial effect of new organism introduction on assemblages of organisms (microorganisms, plants, and animals) in a natural situation where the organism is to be introduced.

⇒ ***cause any significant adverse effects on human health and safety***

The criterion is for the consideration of real and substantial effect on human health and safety.

⇒ ***cause any significant adverse effect to New Zealand's inherent genetic diversity***

Inherent genetic diversity is the genotypic diversity of an organism and the criterion is for the consideration of real and substantial effects of an introduced organism on the existing diversity of organisms in the environment where the organism is likely to establish. Biotic communities often exhibit phenotypic similarities but genetic diversity may still exist. This diversity may be advantageous in maintaining resilience of populations against adverse effects caused by external factors such as disease, drought etc.

In these contexts, genotype is the genetic constitution of an organism as opposed to its physical appearance (phenotype). Usually, genotype refers to the specific allelic composition of a particular gene or set of genes in each cell of an organism, but it may also refer to the entire genome. A Phenotype is what the genetic trait looks like or the kind or type of organism produced by the reaction of a given genotype with the environment. In other words it is the observable manifestation of a specific genotype exhibiting properties of an organism produced by the genotype in conjunction with the environment. Organisms with the same overall genotype may have different phenotypes because of the effects of the environment and of gene interaction. Conversely, organisms may have the same phenotype but different genotypes, as a result of incomplete dominance, penetrance, or expressivity, or in brief, a group of individuals similar in appearance but not necessarily in genetic constitution.

⇒ ***cause disease, be parasitic, or become a vector for human, animal, or plant disease, unless the purpose of that importation or release is to import or release an organism to cause disease, be a parasite, or a vector for disease***.

This criterion excludes the introduction of organisms that are likely to affect other organisms unless the intention for the organism is to do so. These considerations are likely to be more relevant to importations of organisms that could affect other organisms that may be pests (i.e., introduction of biological control agents).

In general, a question is often asked as to how much is "significant." In view of the variable nature of biological material, one explanation based on value judgement of a particular case is substantial displacement, deterioration, and adverse effect resulting from an introduced organism.

To summarise, the following Table presents a hypothetical evaluation of minimum standards where rapid assessment may be a possibility.

Item	Criteria in the HSNO Act	Probability	Remarks
(a)	Significant displacement of native species	Very low	Risk of becoming a pest negligible
(b)	Significant deterioration of natural habitats	Very low	Risk of becoming a pest negligible
(c)	Significant adverse effects on human health and safety	Nil	No effects predicted
(d)	Significant adverse effects on genetic diversity	Low	Potential for hybridisation low
(e)	Cause disease, be parasitic, or become a vector, etc.	Low to medium	Non-toxic to mammals

3.3 Matters relevant to purpose, principles, and matters of the HSNO Act

In addition to the specific criteria discussed above, consideration of an application is to include matters relevant to the purpose (section 4), principles (section 5) and matters (section 6) of the Act. Of key importance are the matters in section 6 and information that is necessary considers these matters as follows.

⇒ ***The sustainability of all native and valued introduced flora and fauna***

The criteria are aimed at consideration of the effect new introductions may have on the continued survival at or close to population densities that existed prior to the introduction. The key element is the sustainability of existing biota meaning that organisms need a certain threshold of population density to be able to continue unaided existence in the environment. This population density is to be at a level that would sustain the effects of natural population fluctuations and perturbations as a result for example of fluctuations in breeding performance, food supply, or environmental variability. Population densities naturally fluctuate between years and are at times affected by abiotic factors such as climatic variables of temperature and rainfall. However, resilient populations normally sustain these fluctuations and perturbations and therefore it is anticipated that new introductions if approved would not affect the existing native and valued populations in such a way as to jeopardise their continued existence.

The attributes that could be used as a guide to determining whether a particular new organism could become a problem by affecting New Zealand's inherent biodiversity are dispersal ability, sexual and vegetative reproductive capacity, life expectancy, population size, niche requirements, geographical

distribution, ability to hybridise, history of domestication and cultivation, competition, climatic requirement, and presence of predators.

The evaluation of the above attributes with respect to WRA will depend on the availability of information on the following characteristics:

- *Taxonomy.* Taxonomic classification of the species including reference to common names and history of any recorded name change, general information and attributes concerning the family the proposed plant belongs to, and general information concerning the genus. Include name, year, and reference of the authority attributed to describing the species.

- *Natural distribution of the plant.* Does the organism occupy montane, lowland, tropical, sub tropical, cool temperate, or warm temperate area? Information is likely to include whether they could displace native species or detrimentally change their habitat or block or impede water flow and whether they are bog, swamp or water margin species that could smother other plants or significantly alter that habitat.

- *Habitat requirements of the plant.* Includes specific habitat requirements, for example, terrestrial, aquatic, pasture, forest, scrub, mountain, arable land, and wasteland.. Whether the species has any undesirable traits such as spines, thorns, burrs, allelopathic, parasitic, or unpalatable to herbivores. Information on plants that:

    - are toxic or cause allergies;
    - spread by vegetative means;
    - produce seed and could establish in pasture (including longevity of seed and mechanism of seed dispersal);
    - are host for pests and pathogens;
    - create a fire hazard in natural ecosystems;
    - are shade tolerant at any stage of their life cycle including climbers that grow in the shade yet form a dense canopy in the light that could smother native and other protected bush or forestry
    - are vines and thicket forming; and
    - tolerate a wide range of soil conditions.

- *Seed Production.* The ability and characteristics for persistence, for example, seed production (>1000/m^2), evidence that a persistent propagule bank is formed (>1 yr).

- *Enemies.* Whether known natural enemies present in New Zealand.

- *Basic description of the structure of the plant.* For example, leaves, fruit, flowers, and branches of plants, and morphology, sexual dimorphism, and height and spread.

- *Life history and life cycle information.* For example, mode of reproduction, evidence of reproductive potential in native habitat, and whether the plant:

    - produces viable seed;
    - hybridises naturally and its potential of breeding with New Zealand flora to produce hybrids; and
    - is self- or cross-pollinating and requires specialist pollinators.

- *Mode of dispersal.* For example, whether propagules are likely to be dispersed unintentionally from plants growing in heavily trafficked areas or propagules likely to be dispersed as a produce contaminant. Whether propagules are adapted to wind dispersal, water dispersed, dispersed by birds, dispersed by other animals by being externally attached to them, and whether propagules can survive passage through the gut.

- *Affinities with New Zealand biota.* Information on whether the plant has close taxonomic relatives in New Zealand.

- *Factors limiting distribution.* For example information on, altitude, temperature, humidity, wind resistance, rainfall, nutrient requirements, soil type, and water quality preferences of the plant. Comment on whether the species is suited to New Zealand climate, and how compatible is climatic data between where it occurs and that of New Zealand.

- *Introduction history*. Does the species has a history of repeated introductions outside its natural range, is it naturalised beyond its native range (e.g. in areas such as garden, amenity, disturbed, agriculture, forestry, and horticulture).

- *Competitors and browsers.* Information on whether the plant is likely to compete with other New Zealand flora for space and whether it is likely to be browsed by herbivores in managed and natural environments.

- *Special characteristics and behavioural patterns.* Information on any special features such as weedy potential, toxicity, spines, aggressive behaviour, or offensive odour. Information is required on characteristics such as:

    - prickly leaved rosette forming plants that may successfully compete with pasture species especially in low rainfall areas;
    - plants with extensive rhizomes or stolons that may invade arable land, pasture, or native habitats; or
    - plants that could compete effectively in the New Zealand cropping systems and be difficult to selectively control.

- *Potential uses.* Includes the purpose for which the plant is likely to be used, for example, increased productivity, value as food/product/herb/medicinal/ornamental/forage.

- *Other factors*. Information on whether the species is highly domesticated, becomes naturalised where grown, and has weedy relatives. With respect to terrestrial grass species information on their ability to produce seed that can invade pastures and devalue wool, hides, or meat would be useful. Information on whether the plant:

    - can be controlled by herbicide; and
    - tolerates or benefits from mutilation, cultivation, or fire.

⇒ ***The intrinsic value of ecosystems***

The HSNO Act defines “intrinsic value” with respect to ecosystems as those aspects of ecosystems and their constituent parts which have value in their own right, including their biological and genetic diversity and the essential characteristics that determine an ecosystem's integrity, form, functioning, and resilience. In this context, constituent parts are the biotic microorganisms, plants and animals and

abiotic water, air and substrate such as soil that are an integral part of the ecosystem. Biological and genetic diversity is the different biological entities and their genetic variation that may be manifest in their phenotypic size, form, colour.

Integrity, form, and functioning can be exemplified by the differences that are found between for example forest and grassland ecosystems. A particular forest ecosystem may have a defined integrity and form by virtue of forest species composition. For example, lowland podocarp forests show a greater diversity of species than do montane beech forests. In integrity of form they have different canopy strata and introduction in these ecosystems of a plant that has the ability to dominate the canopy strata would have a marked effect on the existing structure. This structural change could have an effect on the functioning of the ecosystem through likely changes in nutrient cycling and energy flow. A similar scenario is likely in the grasslands ecosystem. Resilience in this context means the ability of ecosystems to withstand biotic and abiotic fluctuations and perturbations such as those mentioned above under the sustainability of all native and valued introduced biota.

Ecosystems function within a range of energy flow parameters of its primary producers (e.g. plants), primary consumers (e.g. herbivores), decomposers (e.g. bacteria and fungi), saprophytes (e.g. earthworms and insects), and predators (e.g. predatory insects, spiders, lizards, birds, and mammals). Any marked change in these parameters resulting from new introduction is likely to be considered as affecting the ecosystem's intrinsic value.

⇒ ***Public health***

This relates to the effects that for example a plant to be imported may have directly if it is consumed or indirectly through for example inhalation of pollen. New Zealand's Environmental Risk Management Authority (ERMA New Zealand) has prepared a technical guide that outlines aspects to be considered when addressing issues of human health under the HSNO Act (refer to Technical Guide – Assessment of Effects of Hazardous Substances and New Organisms on Human Health. Written by Deborah Read, ERMA New Zealand, January 2000).

⇒ ***The relationship of Māori and their culture and traditions with their ancestral lands, water, sites, waahi tapu, valued flora and fauna, and other taonga***

This provision is for the consideration of the effects that the proposed organism introduction is likely to have on the value of Māori way of life. It is therefore important that Māori are consulted for their views on the proposal to import new organisms into New Zealand. ERMA New Zealand has developed guidelines on Māori consultation and prospective applicants are advised to familiarise themselves with these documents and also talk to ERMA New Zealand. ERMA New Zealand has prepared a technical guide that outlines aspects to be considered when addressing cultural issues under the HSNO Act (refer to Technical Guide – Taking Account of Cultural, Ethical and Community Issues. ERMA New Zealand, August 2000).

⇒ ***The economic and related benefits to be derived from the use of a particular hazardous substance or new organism***

This provision is for the economic costs and benefit of the proposed importation of a new organism into New Zealand. The applicants are required to present their analysis and conclusions in support of their case for the importation.

⇒ ***New Zealand's international obligations***

With respect to new organisms in general New Zealand is a party to many international agreements and therefore obliged to comply with their requirements. In respect of new organisms, New Zealand is signatory or party to the following.

- The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which restricts trade in endangered species of plants and animals.
- The International Convention for the Protection of New Varieties of Plants (UPOV). The organisation responsible for this convention is UPOV or the International Union for the Protection of New Varieties of Plants. UPOV is a sister organisation of WIPO or the World Intellectual Property Organisation.
- The International Plant Protection Convention (IPPC).
- The Plant Protection Agreement for the South East Asia and Pacific Region.
- The Convention on Conservation of Biological Diversity (CBD).
- The International Plant Protection Convention (IPPC).
- European Plant Protection Organisation.
- Organisation International Epizootic (OIE).
- Organisation for Economic Co-operation and Development (OECD) Seed Schemes.
- OECD Fruit and Vegetable Schemes.
- International Board of Plant Genetic Resources (IBPGR).
- The Union for Protection of Varieties of Plants.
- The FAO, or the Food and Agricultural Organisation's, Convention on International Undertaking on Plant Genetic Resources. New Zealand did sign this FAO convention with reservation on aspects that conflict with plant breeders' rights.

These international agreements may in future be influenced by the outcome of the October 1991 claim to the Waitangi Tribunal (WAI-262) relating to Māori rights in relation to indigenous flora and fauna. The claimants represent a number of iwi throughout the country and the issues they raise are relevant to all iwi. The claim is broad in scope and relates to the protection, control, conservation, management, treatment, propagation, sale, dispersal, utilisation, and restriction on the use of and transmission of the knowledge of New Zealand flora and fauna and the genetic resource contained therein.

4. Conclusion: comparison of weed risk assessment and legislative criteria

Information based on the above regime can be directly used for the WRA model of Landcare Research. A comparison of the Landcare Research WRA model criteria and the information requirement under the HSNO Act as discussed above in this document is presented in the Table below.

WRA model criteria	**HNSO Information requirement**
1 **Domestication/Cultivation**	
1.01 Is the species highly domesticated?	The species must have been cultivated and subjected to substantial human selection for at least 20 of the species' generations. Domestication generally reduces the weediness of a species by breeding out noxious characteristics.
1.02 Has the species become naturalised where grown?	Is the domesticated species growing, reproducing and maintaining self-sustaining population in the area it is growing in?
1.03 Does the species have weedy races?	Whether the domesticated species has sub-species, cultivar, or a registered variety.
2 **Climate and Distribution**	
2.01 Species suited to New Zealand climates	Applies to any one or more than one of the climate types in New Zealand and the deduction is likely to be drawn from a recognised climate matching analysIslands
2.02 Quality of climate match data	Climatic analysis is likely to consider factors limiting distribution, for example, altitude, temperature, humidity, wind resistance, rainfall, nutrient requirements, soil type, water quality etc.
2.03 Broad climate suitability	Whether the species is suited to New Zealand climate, how compatible is climatic data between where it occurs and in New Zealand.
2.04 Native or naturalised in regions with equable climates	Is it native or naturalised in regions with equable climates, does the species have a history of repeated introductions outside its natural range.
2.05 History of repeated introductions outside its natural range.	Does the species have a history of repeated introductions outside its natural range?
3 **Weed elsewhere**	
3.01 Naturalised beyond native range	Is it naturalised beyond its native range?
3.02 Garden, amenity, or disturbance weed	Is it present in areas such as garden, amenity, disturbed?
3.03 Agricultural, forestry or horticultural weed	Is it present and a weed in agriculture, forestry, and horticulture?
3.04 Environmental weed	Is the species known to alter the structure or activity of a natural ecosystem, including whether the species has spines, aggressive behaviour, or offensive odour.
3.05 Congeneric weed	Is there evidence of weediness among species of the genus?

WRA model criteria		HNSO Information requirement
4	**Undesirable traits**	
4.01	Produces spines, thorns or burrs	Information on the basic structure of the plant. For example, leaves, fruit, flowers, and branches, and morphology, sexual dimorphism, and height and spread. Whether the species has any undesirable traits such as spines, thorns, or burrs.
4.02	Allelopathic	Whether the species is well documented as a suppressor of the growth of other plants.
4.03	Parasitic	Does the species have parasitic characteristics?
4.04	Unpalatable to grazing animals	Whether the species is unpalatable to herbivores or if palatable to herbivores could they keep it under control?
4.05	Toxic to animals	Whether the species is toxic to animals and does it spread by vegetative means and by seed and could it establish in pasture. Consideration should be given to whether there is likelihood that the toxin would reach animals by grazing or contact. Species may be mildly toxic but palatable and could cause problems if heavily grazed.
4.06	Host for recognised pests and pathogens	Whether the species is host pathogens or an alternative host of crop pest and diseases.
4.07	Causes allergies or is otherwise toxic to humans	Whether the species has allergic properties through physical contact by inhalation of pollen.
4.08	Creates a fire hazard in natural ecosystems	Does the species have growth characteristics that could lead to the rapid accumulation of combustible material?
4.09	Is a shade tolerant plant at some stage of its life cycle	Is the species shade tolerant at any stage of its life cycle?
4.10	Tolerates a wide range of soil conditions	Does the species tolerate a wide range of soil conditions or have specific requirements?
4.11	Climbing or smothering growth habit	Is the species a climber and grows in shade yet forms a dense canopy in the light that could smother native and other protected bush or forestry?
4.12	Forms dense thickets	Is the species a vine and thicket forming? Could it obstruct passage or access, or exclude other species?
5	**Plant type**	
5.01	Aquatic	Is the species likely to grow in or near streams, rivers, ponds, lakes, or estuarine systems?
5.02	Grass	Does the species belong to the families Poaceae or Gramineae?
5.03	Nitrogen fixing woody plant	Does the species belong to the families Leguminosae or Fabaceae?
5.04	Geophyte	Is the species perennial with tubers, corms, or bulbs?
6	**Reproduction**	
6.01	Evidence of substantial reproductive failure in native habitat	Comment on predators or disease that may be responsible for reduction in reproductive capacity. Reproductive potential could increase in the absence of limiting factors.
6.02	Produces viable seed	Does the species produce viable seed and do the seeds

WRA model criteria	HNSO Information requirement
	require special dispersal aids or have special mechanisms?
6.03 Hybridises naturally	Documented evidence is to be provided if interspecific hybrids are known without human intervention.
6.04 Self-compatible or apomictic	Whether the species is capable of self-seeding and can spread from seed produced by an isolated plant?
6.05 Requires specialist pollinators	This requirement is important in determining the species' invasive potential as invasiveness may be reduced in the absence of special pollinator(s).
6.06 Reproduction by vegetative propagation	Is the species capable of increasing its numbers by vegetative means such as by rhizomes, stolons, suckers, stem or root fragments, or from cuttings?
6.07 Minimum generative time (years)	Information on germination to production of viable seed or the time taken for a vegetatively reproduced species to duplicate itself.
7 **Dispersal mechanism**	
7.01 Propagules likely to be dispersed unintentionally (plants growing in heavily trafficked areas)	Whether propagules (any structure, sexual or asexual, which serves as a means of reproduction), unintentionally dispersed as a result of human activity.
7.02 Propagules dispersed intentionally by people	Whether the propagules have characteristics that make it attractive or desirable, such as an edible fruit or are ornamental.
7.03 Propagules likely to disperse as a produce contaminant	Whether propagules can be dispersed for example as weed seed in bulk grain shipment.
7.04 Propagules adapted to wind dispersal	Evidence of whether wind increases the dispersal ability and range of the propagule.
7.05 Propagules water dispersed	Whether propagules are buoyant.
7.06 Propagules bird dispersed	Whether propagules can be transported and/or consumed by birds, and could grow after passage through the gut.
7.07 Propagules dispersed by other animals (externally)	Whether the species has adaptations, such as burrs, and/or grows in situations that make it likely that propagules become temporarily attached to animals or humans.
7.08 Propagules survive passage through the gut	Whether propagules eaten by animals other than birds, dispersed and will grow after passing through the gut.
8 **Persistence attributes**	
8.01 Prolific seed production (>1000/m^2)	The ability and characteristics for persistence, for example, seed production (>1000/m^2).
8.02 Evidence that a persistent propagule bank is formed (>1 yr)	Evidence that a persistent propagule bank is formed (>1 yr).
8.03 Well controlled by herbicides	Whether the plant can be controlled by herbicides.
8.04 Tolerates, or benefits from, mutilation, cultivation, or fire	Tolerates, or benefits from, mutilation, cultivation, or fire, and effective natural enemies present in New Zealand.
8.05 Effective natural enemies present in New Zealand	Whether natural enemies of the species are present in New Zealand.

5. *Government departments/agencies working in the field of biological invasions*

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Senior Scientific Advisor
Environmental Risk Management Authority
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New Zealand
Tel: (64) 4 918 4834
Fax: (64) 4 914 0433
Email: abdul.moeed@ermanz.govt.nz

Executive Co-ordinator
MAF Biosecurity Authority
Ministry of Agriculture and Forestry
P.O. Box 2526, Wellington
New Zealand
Tel: (64) 4 470 2754
Fax: (64) 4 498 9888

6. *Bibliographic references and useful websites*

Williams, P.A. and W.G. Lee. 2001: Why screen for weediness? Garden Journal 4: 19-23.

⇒ Environmental Risk Management Authority (ERMA)
http://www.ermanz.govt.nz

⇒ Hazardous Substances and New Organisms (HSNO) Act 1996
http://hsno.govt.nz/no.shtm

⇒ Ministry of Agriculture and Forestry (Biosecurity Authority)
http://www.maf.govt.nz/biosecurity/index.htm
http://www.maf.govt.nz/biosecurity/legislation/index.htm

Niue

Mrs. Crispina F Konelio
Senior Plant Protection & Quarantine Officer
Department of Agriculture, Forestry & Fisheries
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Niue Island
Tel: 683 4032
Fax: 683 4079
Email: quarantine@mail.gov.nu

Introduction

Niue Island is very isolated from the rest of the Pacific region but is nevertheless very vulnerable to the movement and impact of invasive alien species (IAS). It is now well known that IAS represent a very serious risk to biodiversity and could degrade the island's native ecosystems. Many surveys carried out by regional experts have concluded that after habitat modification and destruction, invasive species are responsible for the extinction of more indigenous species than any other natural or human-made cause. Invasive alien species have already caused severe and ongoing damage and accelerated the extinction of many native species on Niue Island.

1. Main IAS in Niue

The following list includes ten IAS categorised and prioritised as the most noxious invasive species on Niue.

⇒ Singapore daisy, *Wedelia* (*Wedelia (=Sphagneticola) trilobata*)
⇒ Chain of hearts/chain of love (*Antigonon leptopus*)
⇒ *Lantana* (*Lantana camara*)
⇒ Honolulu rose (*Clerodendrum chinense*)
⇒ Feral pigs (*Sus scrofa*),
⇒ Money plant/pothos (*Scindapsus aureus*)
⇒ Wood rose (*Merremia tuberose*)
⇒ African tulip tree (*Spathodea campanulata*)
⇒ Crown of thorns starfish (*Acanthaster planci*)
⇒ Rats

Two other IAS of current concern are Giant Sensitive plants (*Mimosa diplotricha*) and Blue rats tail (*Stachytarpheta urticifolia*).

Wedelia, chain of hearts, *Lantana*, Honolulu rose, wood rose, and money plant were all introduced as ornamental plants for gardens. Giant sensitive plants and blue rats tail are believed to have been introduced with cattle imported from overseas. Some of these invasive species are only found in very specific areas. The Department of Agriculture, Forestry & Fisheries, in cooperation with the Secretariat for the Pacific Community (SPC) has made several recommendations for funding assistance from SPC to develop and establish eradication campaign to control these invasive species (see 2 below).

Wedelia, chain of hearts and giant sensitive plants have a broad ecological tolerance range and are equally suited to dry and moist sites. They grow well on almost all soil, including bare limestone and nutrient poor sandy areas, and are tolerant to inundation and high levels of salinity. If *Wedelia* and chain of hearts become established in plantations, they will compete with agricultural crops for nutrients, light, and water and eventually reduce crop yield. If these species are not eradicated now, they will have very significant impacts on agricultural plantations, livestock, forestry and the environment. Surveys carried out by consultants visiting Niue (Space and Flynn, 2000; Thaman, 1999; Wilco Liebrets, Secretariat of the Pacific Community) have strongly recommended eradication of *Wedelia*, chain of hearts, and giant sensitive plants. Space and Flynn (2000) also identify weed species that are of high risk to Niue but are not present on the island.

For the crown of thorns starfish, there is no information on how this was introduced into Niue. The starfish does not appear to be causing a problem yet, as there are no noticeable changes to the community structure and no species that appear to be overtaking others on a large scale.

2. Summary of existing strategy and programs on IAS

In 2001, the Department of Agriculture, Forestry & Fisheries established a National Invasive Species Committee consisting of representatives from the Community Affairs Department (Environment), Plant Protection, Forestry and Fisheries, and the private sector. The role of the Committee is to develop a National Plan for Invasive Species for Niue to identify, eradicate, control, contain, and mitigate IAS that are currently damaging Niue's natural and semi-natural ecosystems, and also to develop activities for the conservation of native biodiversity, land, and seawater on Niue.

Another of the Committee's tasks is to identify and prioritize plant, animal, and marine species regarded as IAS (e.g. known to be a problem elsewhere and capable of spreading widely) that are not yet present in Niue and which could be a major problem if introduced here. To effectively implement this Plan, Quarantine and Conservation Officers need to be trained to identify IAS already present on Niue and what threat they pose to natural ecosystems. It would also be of great assistance to identify other noxious IAS not yet present on the island.

The Plant Protection and Quarantine Division of the Department of Agriculture, Forestry & Fisheries is carrying out an eradication programme for Singapore daisy (*Wedelia (=Sphagneticola) trilobata*), giant sensitive plant (*Mimosa diplotricha*) and chain of hearts (*Antigonon leptopus*), with the financial and technical assistance of the Secretariat of the Pacific Community (SPC). The eradication campaign started in March 2001 with the first visit of the SPC Consultant (Wilco Liebrets) to assist and develop activities for the eradication of these three species. The species are sprayed with Round Up when necessary, hand weeded or burned for easier identification purposes. In order for the campaign to a success, it is very important to keep up regular monitoring of sites infested with these weeds and and through spraying and hand-pulling, keep these weeds to a manageable level. Public awareness materials are currently being developed (for Singapore daisy, leaflets and television coverage; for giant sensitive plants, a leaflet).

The Plant Protection Division has also drawn up programs for the monitoring, managing of other invasive species on the island. Some years ago, biological agents received from GTZ/SPC were released in order to control Lantana: recently updated monitoring of progress shows that control of lantana has produced good results.

In 1999, Niue participated at the Regional Invasive Species Workshop funded by AusAID and SPREP in Nadi, Fiji and shared its concerns with IAS specialists. These concerns have been notified to the

Forest Service International Forestry Office and it is hoped that funds will be made available for a consultancy to assess forest invasive species issues for Niue.

For feral pigs (*Sus scrofa*), Niue has tried many different control methods over a long period but progress has been very slow and control not sufficiently effective. The government has set up an awareness campaign to encourage the public to carry out pig trapping and shooting and, for each pig tail submitted (as proof), a payment of US$15.00 per tail is made. Records show very good results from the common lands in which feral pigs are found and it is now very rare to receive complaints from those areas. In addition, legislation has been enacted to provide for regular monitoring of pig farms. Pig farmers to required to ensure that all pigs are in their pens and to prevent their pigs from wandering, as they could then destroy crops and property. If escaped pigs are found, farmers can be prosecuted and are liable to a fine of up to US$1000 or two years imprisonment.

3. Government departments/agencies concerned with IAS

⇒ **Department of Agriculture, Forestry & Fisheries (Plant Protection, Livestock, Fisheries, Forestry)**

The Plant Protection and Quarantine Division plays a major role in carrying out the control of imports (e.g. plants, animal, meat, fruits, vegetables, stored products, building materials) at all ports of entry to ensure nothing imported will cause a major threat and risk to the island's native biodiversity.

⇒ **Community Affairs Department (Environment Unit)**

⇒ **National Training Unit**

⇒ **Public Works Department**

⇒ **Natural Disaster Management Unit**

4. Priorities identified for future work

The Niue Government has now published the Niue National Biodiversity Strategy and Action Plan. The section on Alien and Invasive Species sets out four specific objectives:

⇒ Objective 1: Prevent the introduction of new IAS
⇒ Objective 2: Reduce and eliminate the impacts of existing pest species
⇒ Objective 3: Raise awareness of the risks posed by IAS
⇒ Objective 4: Build the capacity required to manage the threats posed by IAS

To help implement these objectives, the National Invasive Species Committee has produced Guidelines for the prevention, introduction and mitigation of impacts of IAS that threaten Niue's Biodiversity (see Annex to this report).

Recommended priority actions include:

⇒ development of guidelines for the establishment of effective Emergency Response Plans for IAS in Pacific islands;

⇒ coordination with the South Pacific Regional Environment Programme to support national workshops in member Pacific Island Countries and Territories: these should target both Conservation Officers and Quarantine Officers as these are the people working most closely with plants and other species;

⇒ implementation of the recommendations made by Space and Flynn in their report to the Niue Government, notably the development of a risk assessement scheme for Niue, with assistance as necessary from the Global Invasive Species Programme (GISP).

5. List of experts working in the field of biological invasions

⇒ **Department of Agriculture, Forestry & Fisheries (DAFF)**
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Tel: 683 4032
Fax: 683 4079
Email: quarantine@mail.gov.nu

Colin Etuata (Quarantine Officer)
Cris F. Konelio (Senior Plant Protection & Quarantine Officer)
B. Tauasi (Quarantine Officer)
C. Poumale (Field Officer)
I. Mamaia (Contractor)
V. Tauevihi (Contractor)
Taliu Alapaki (Senior Extension Officer)

⇒ **Community Affairs Department (Environment Unit)**
Alofi
Niue Island

Fapoi Akesi (Director)
Sione Talagi (Environment Officer)
Judy Nemaia (Biodiversity Officer)

⇒ **Police Department (Natural Disaster Management Unit)**
Alofi
Niue Island

Robert Togiamana (Co-ordinator)

6. Bibliographic references

Thaman, R.R. 1999. *Wedelia trilobata*: daisy invader of the Pacific Islands. Adapted from a discussion paper prepared for the SPREP Regional Invasive Species Strategy for the South Pacific Islands Region: Regional Workshop, Nadi, Fiji, 26th September 1999 – 1 October 1999.

Space, J.C and T. Flynn. 2000. Report to the Government of Niue on Invasive Plant Species of Environmental Concern. USDA Forest Service, Pacific Southwest Research Station, Institute of Pacific Islands Forestry, Honolulu, Hawai'i, USA. 34pp

Government of Niue (DAFF – Forestry Division). 2000. Volume 1 National Forest Policy Statement.

Government of Niue. 2001. Niue National Biodiversity Strategy and Action Plan.

Government of Niue. 2001. Draft National Action Plan for Invasive Species (September 2001).

Acknowledgements

I would like to thank the Global Invasive Species Programme, U.S. Embassy, and Bishop Museum for their invitation to the Pacific Islands to participate in this very important Workshop on Prevention and Management of IAS: Forging Cooperation throughout the Austral Pacific Region. I hope to collect and contribute to the best of my ability regarding our concerns about the impact of IAS on environment, agriculture, and health.

Annex
Guidelines for the prevention, introduction and mitigation of impacts of IAS that threaten Niue's Biodiversity

A. GENERAL

1. Precautionary approach

Because of the unpredictability of the pathways and impacts on biological diversity by invasive alien species (IAS), efforts to identify and prevent unintentional and international introductions should be based on the precautionary approach.

2. Three stage approach (eradication, containment and control)

Prevention is far more cost effective and environmentally desirable. Priority should be given to preventing the introduction of IAS. If an IAS has been introduced, the preferred response is often to eradicate the species (e.g. *Wedelia*) as soon as possible. In the event that the eradication is not feasible due to limited resources then containment is necessary. Before long-term control methods are implemented it is crucial that cost benefit analysis is undertaken first.

3. Ecosystem approach

Measures to deal with IAS should be based on the ecosystem approach.

4. State responsibility

Island states should recognized the risk that they may pose to other islands states as a potential source of IAS, and should take all necessary steps to minimize that risk (e.g. fruit flies).

5. Research and monitoring

In order to develop an adequate knowledge base to address the problem, it is important to undertake research and monitoring of IAS.

6. Education and public awareness

Raising public awareness of the IAS is crucial to any successful management of IAS. When mitigation measures are required, education and public awareness programmes should include all stakeholders within the local community.

B. PREVENTION

7. Border control and quarantine measures

Niue should implement border controls and quarantine measures for species that have or could become invasive to ensure that international introductions of alien species are subject to appropriate authorization and within the law of Niue. Unintentional and unauthorized introduction of alien species is minimized. Measures should be based on scientific assessment of the risk posed by the alien species and their potential pathway of entry.

8. Exchange information

Develop a database and exchange and dissemination of information with other countries on the incident list, potential threat etc.

9. Cooperation, including capacity building

Agreement between countries bilateral or multilateral should be developed to regulate trade in certain alien species. Niue to support capacity building program

C INTRODUCTION OF SPECIES

10. Intentional introduction

A risk assessment, including environment impact assessment must be undertaken as a condition of whether or not to authorize a proposed introduction of animal, plant, plant products, and animal products (etc). This involves the assessment of the risk of the commodity when imported on the environment, human health, and agriculture.

11. Unintentional introductions

Niue should have in place provisions to address unintentional introduction (e.g. Quarantine Act and associated regulations for sufficient operational resources) to allow for a rapid and effective action.

Common pathway leading to intentional introductions needs to be identified and appropriate provision to minimize such introductions should be in place. Promote sectoral activities (e.g. fisheries, agriculture, forestry, shipping, tourism, and transportation).

D MITIGATION

12. Mitigation of impacts

Once the establishment of an IAS has been detected, Niue should take appropriate steps such as eradication, containment, and control, to mitigate adverse effect technique used for eradication, containment and control should be safe to the environment, human and agriculture, as well as socially, cultural acceptable.

13. Eradication

Where it is practical and affordable often is the best course of action to deal with the introduction and establishment of eradication plan for IAS. The best opportunity for eradication of invasive species is in the early stages of invasion; when populations are small and localized. Community support is often essential and necessary to achieve eradication work.

14. Containment

When eradication is not appropriate, limit the spread of IAS is often the best strategy. Regular monitoring outside the control boundaries is essential and need to be linked with quick action to eradicate any new outbreaks.

15. Control

Measures should focus on reducing the damage caused rather than merely reducing the number of IAS. Effective control will often rely on a range of integrated management techniques, including mechanical control, chemical, bio-control and habitat management. Most control methods measures will need to be regularly applied, resulting in a long term recurrent and operating costs.

Commonwealth of the Northern Mariana Islands

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and

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Invasive Species Rangers, Project Manager
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MP 96950
Email: dlnrdoa@gtepacifica.net

Contributor (brown tree snake)

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Introduction

The Commonwealth of the Northern Mariana Islands archipelago consists of 14 islands in a 685-kilometer (500-mile) chain. Pursuant to constitutional mandates, the island of Managha must be maintained as an uninhabited place and used only for cultural and recreational purposes. The islands of Maug, Uracas, Asuncion, Guguan, and other islands must be maintained as uninhabited places and used only for the preservation and protection of natural resources, including but not limited to bird, wildlife and plant species. Land use on the other nine islands is laid down by law and includes places of importance to the culture, traditions and history of the people of the Northern Mariana Islands, public utilities, and infrastructures, forest, conservation, agricultural farmland, homesteading, and economic urban development. The islands of Saipan, Tinian, and Rota are the developed and most populated islands equipped with modern urban development and infrastructure settings. An estimated 9-15 people are settled in the island of Anatahan, but the population fluctuates on a yearly basis due to the lack of any urban development and infrastructure.

The islands are located between 13 and 31°N latitude and between 144 and 146°E longitude in the Western Pacific Ocean. The total land area of the Northern Mariana Islands is estimated at 176.5 square miles. All of the islands are volcanic, but the southern islands of Rota, Aguijuin, Tinian, Saipan, and Farallon de Medinilla are older and primarily limestone with level terraces and fringing coral reefs. The nine northern islands are younger and primarily volcanic-several contained active volcanoes. The highest island in this archipelago is Agrihan (3,166 feet).

The Guinness Book of Records cites the Northern Marianas as having the most equitable climate in the world. The average year round temperature is 85 degrees Fahrenheit, and annual rainfall averages between 67 inches and 98 inches. Beginning in December and running through March, these islands are cooled slightly as the northeast trade winds bring comfortable breezes to the islands.

⇒ ***Geographic location and land area by island***

• Farallon de Pajaros	20^{o} 33 Minutes North and 144^{o} 54 Minutes East	80.0square miles
• Maug	20^{o} 02 Minutes North and 144^{o} 14 Minutes East	80.0square miles
• Asuncion	19^{o} 39 Minutes North and 145^{o} 23 Minutes East	2.8square miles
• Agrihan	38^{o} 44 Minutes North and 145^{o} 45 Minutes East	18.3square miles
• Pagan	18^{o} 07 Minutes North and 145^{o} 45 Minutes East	18.7square miles
• Alamagan	17^{o} 35 Minutes North and 145^{o} 50 Minutes East	4.4square miles
• Guguan	17^{o} 20 Minutes North and 145^{o} 51 Minutes East	1.6square miles
• Sariguan	16^{o} 43 Minutes North and 145^{o} 46 Minutes East	1.9square miles
• Anatahan	16^{o} 22 Minutes North and 145^{o} 38 Minutes East	12.5square miles
• Farallon de Medinilla	16^{o} 00 Minutes North and 146^{o} 04 Minutes East	0.4square miles
• Saipan	15^{o} 05 Minutes North and 145^{o} 50 Minutes East	47.5square miles
• Tinian	14^{o} 58 Minutes North and 145^{o} 35 Minutes East	39.3square miles
• Aguijan	14^{o} 53 Minutes North and 145^{o} 35 Minutes East	2.8square miles
• Rota	14^{o} 08 Minutes North and 145^{o} 12 Minutes East	32.9square miles

⇒ ***Geographic Map***

1. Main invasive species in the Commonwealth of the Northern Mariana Islands

Invasive alien species (IAS) have been introduced into our islands over a very long period. Not all such species are considered harmful: some are considered beneficial and some are used as a medicinal and food source. However, known IAS on the islands are now being evaluated prior to being replanted. To the extent possible, replanting of IAS is being discouraged.

Annexes 1-3 to this report contain photographs and detailed lists of IAS present in the Commonwealth of the Northern Mariana Islands (CNMI). The report itself focuses on strategy and action to control the two most serious IAS in the CNMI.

⇒ **Brown tree snake (*Boiga irregularis*)**

The brown treesnake (BTS) has had a devastating effect on the economy and on the diversity of wildlife in Guam. It has extirpated most of the native forest bird species and costs local utility companies (power outages) and businesses millions of dollars annually. The nearby CNMI has a vital interest in the interdiction and control of the spread of the BTS. Eleven BTSs have been captured on Saipan since 1982: three were found in the interior of the island (Chalan Kanoa, 1991; As Teo, 1992; Capital Hill, 1998) while eight were associated with ports of entry. The CNMI has developed a multi-faceted BTS Program which targets quarantine, active interdiction (trapping and night searches) and education (see 2 below).

⇒ **Ivy or scarlet fruited gourd (*Coccinia grandis*)**

Since its introduction about 11 years ago, the ivy or scarlet gourd is estimated to have covered 35% of the vegetation on the island of Saipan and has made its path to the islands of Rota and Tinian. This noxious cucurbit vine forms a thick canopy over the ground, shrubs and trees, blocking sunlight to vegetation below. It generates a range of very serious impacts: 1) destroys plant life; 2) weighs down utility and power lines, causing power outages and communication disruptions; 3) acts as host for the melon fly (*Bactrocera cucurbitae*) and the papaya mealybug (*Paracoccus marginatus* Williams); 4) destroys and displaces wildlife habitats; and 5) destroys natural and human-made landscape features.

Because of its adaptability and ability to grow in any given environmental conditions, the ivy gourd is considered to be the most threatening noxious weed in the CNMI. In addition to birds eating its fruits and seeds and distributing them widely, this vine can easily be propagated from a stem or root cutting.

2. Summary of existing strategy and programs on IAS

2.1 General information

The CNMI is vulnerable to introductions of IAS due to its close proximity to the neighboring island of Guam and to Asian countries, as well as the frequent maritime and air transportation activities. The DLNR considers that agriculture quarantine inspectors at ports of entry play the key role in preventing further introduction of IAS. It is therefore imperative to provide regular training to improve the inspectors' skills and knowledge and to ensure that information on IAS are readily available and accessible.

The rapid growth of the ivy or scarlet gourd and the high number of sightings of the brown tree snake has prompted the Department of Lands and Natural Resources (DLNR, see also 3) to strengthen its

commitment to improve its management programs. Emphasis is now being placed on conducting thorough assessment, providing control and prevention measures, improving management, increasing awareness campaigns, providing legislation, and taking measures to ensure that infestations are controlled within the affected islands and that introduction to other islands is prevented.

The DLNR recognizes that the campaign against IAS cannot be successfully handled alone. It is also essential to forge partnership with our stakeholders: local, state, federal, national, and international organizations, as well as the community at large. DLNR finds it necessary to continuously improve upon the relationship of our stakeholders now involved in dealing with IAS and continues to pursue other stakeholders that may contribute to the program.

2.2 Brown tree snake programs

This information is taken from Hawley's Summary of Existing Programs and Respected Contact Information, funded by Department of the Interior-Office of Insular Affairs and the CNMI Government. In addition to the contacts for specific programs listed below, information on any aspect of BTS programs may be obtained from:

CNMI-DLNR-DFW BTS
Lower Base, P.O. BOX 10007, Saipan, MP 96950
Tel: (670) 664 6000
Fax: (670) 664 6060
Email: nbhawley@hotmail.com

⇒ **Brown Tree Snake Detector Dog Program**

The program is a collaborative effort between the CNMI Division of Fish and Wildlife and the Division of Agriculture (DOA). Six BTS Detector Dogs, each paired with a quarantine inspector, inspect high-risk cargo at the Saipan International Airport and Seaport.

CNMI-DLNR-DOA
Kagman Agriculture Station
P.O. Box 10007, Saipan, MP 96950
Tel: (670) 256 3317/18
Fax: (670) 256 7154
Email: dlnrdoa@gtepacifica.net

Asia Pacific Canine
P.O. BOX 504174, Saipan, MP 96950
Tel: (670) 288 9792

⇒ **BTS Containment Barrier**

A BTS Containment Barrier is currently under construction at the Saipan Seaport. This containment barrier will act as a quarantine area for high-risk cargo (e.g. construction supplies/equipment, used vehicles) in-coming from Guam. Rota and Tinian Containment Barriers are in the planning stages with expected completion in FY2003.

Rocky Mountain Pre-Stress Concrete
GU 96932
Tel: (671) 653 4701
Fax: (671) 653 4704

⇒ **BTS Trapping Program**

Snake specific traps are hung on the fence lines surrounding all cargo staging areas at all CNMI airports and seaports. Each trap is inspected and maintained three times a week. Additional traps are used in response to BTS sightings in which 20-50 traps will be placed around the high-risk area in efforts to capture the sighted snake.

⇒ **Public communications**

We utilize numerous media vehicles to increase public awareness, education, and assistance in reporting BTS sightings immediately. Local newspapers, magazines, television, and school presentations have all been used in the past. However, despite our efforts, we are still receiving snake sightings 2-3 weeks after the sighting. The result of this disturbing delayed response rate has prompted a marketing/advertising campaign. Glimpses of Guam is designing a multi-faceted advertising campaign strategy based on media consumption information and public surveys.

Glimpses of Guam Advertising
Hagatna, GU 96932
Tel: (671) 649 0883
Fax: (671) 649 8883
Email: glimpses@kuentos.guma.net

2.3 Ivy gourd or scarlet fruited gourd programs

The rapid growth and spread of the ivy gourd prompted the DLNR to implement a control and prevention program, build awareness and work closely with stakeholders at the University of Guam (College of Agriculture) for the biological control of this gourd by the leafmining weevil (*Acythopeus cocciniae*) and the ivy gourd vine borer (*Melittia oedipus*).

⇒ **Invasive Species Rangers**

The Rangers were established by the Secretary of Lands and Natural Resources on 1 April 2002 with a mandate to develop strategy and plans, conduct assessments, and implement control measures, management and awareness campaigns to address problems associated with invasive trees, weeds and herbs. Their work involves cooperation between different agencies. In addition to the specific contacts listed below, general information on the Rangers' work can be obtained from:

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Email: dlnrdoa@gtepacifica.net

⇒ **Invasive Species Rangers Control and Eradication Team**

The control and eradication team is a collaborative effort between the various agencies under the auspices of DLNR and the Saipan Mayor's Office to provide for a mechanical and chemical form of control of the ivy gourd, applying direct uprooting of ivy roots and using Garlon 3A chemical application.

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P.O. Box 10007, Saipan, MP 96950
Tel: (670) 256 3318/19
Fax: (670) 256 7154

James N. Babauta
Invasive Species Rangers Field Supervisor
Division of Agriculture
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Tel: (670) 256 3318/19
Fax: (670) 256 7154

⇒ **Invasive Species Rangers Poster and Campaign Awareness Team**

The poster and campaign awareness team has been established as a collaborative effort with the Secretary's Office, the Division of Fish and Wildlife and the Division of Agriculture Forestry Section. It is developing a poster on the different types of IAS as well as poisonous plants and trees. The poster is to be used for awareness campaigns to be disseminated in schools, public and private places, and to be used for public education.

Marianne C. Teregeyo
Chairperson, Invasive Species Poster Committee
Department of Lands and Natural Resources
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Tel: (670) 322 9830/34
Fax: (670) 322 2633

3. Government departments/agencies concerned with IAS

3.1 General

Through enabling legislation, the Department of Lands and Natural Resources (DLNR) is the responsible government agency to provide for the protection, conservation, preservation, and enhancement of the Commonwealth of the Northern Mariana Islands land and marine resources.

DLNR has had programs to address IAS. The Division of Agriculture (Forestry Section) and the Division of Fish and Wildlife (Wildlife Section) are the principal agencies under the DLNR responsible to develop plans, create strategy, conduct assessment, provide control and prevention measures, management and awareness campaigns to address problems and issues on IAS.

3.2 Brown tree snake: collaborating entities and potential collaborators

Collaborators	**Potential collaborators**
Department of the Interior –Office of Insular Affairs	CNMI Public School System
CNMI Office of the Governor	CNMI Rotary
CNMI DLNR Office of the Secretary	CNMI Shippers Association
CNMI DFW Office of the Director	Department of Finance- Customs
CNMI DOA Office of the Director	CNMI Hotel Association
Asia Pacific Canine	CNMI Commonwealth Health Center
Glimpses of Guam Advertising	CNMI Commonwealth Utilities Corporation
United States Geological Survey	CNMI Northern Marianas College
United States Fish and Wildlife Service	United States Post Office-CNMI
United States Department of Agriculture – Wildlife Services	
Guam Division of Aquatic and Wildlife Resources	
CNMI-Commonwealth Port Authority	
Saipan Stevedores	
Rota Terminal and Transfer	
Tinian Office of the Mayor	
Rota Office of the Mayor	
Colorado State University	
CNMI Coastal Resource Management Office	
CNMI Division of Environmental Quality	
CNMI Emergency Management Office	
CNMI Department of Public Safety	

3.3 Ivy gourd or scarlet fruited gourd: collaborating entities and potential collaborators

Collaborators	**Potential collaborators**
CNMI Legislature	CNMI Public School System
CNMI Office of the Governor	CNMI Rotary
CNMI DLNR Office of the Secretary	CNMI Shippers Association
CNMI DFW Office of the Director	Department of Finance- Customs

Collaborators	Potential collaborators
CNMI DLR&S Office of Director	CNMI Commonwealth Health Center
CNMI DOA Office of the Director	CNMI Commonwealth Utilities Corporation
CNMI-DOA Agriculture Quarantine Section	CNMI-Department of Public Works
CNMI-DOA Forestry Section	CNMI-Department of Public Safety
Office of Saipan Mayor, Saipan Mayor	United States Post Office-CNMI
Tinian Office of the Mayor	CNMI Cable Vision
Rota Office of the Mayor	CNMI Verizon
Office of Northern Island Mayor, Northern Island Mayor	
Northern Marianas College (Cooperative Research Extension and Education Services)	
University of Guam (College of Agriculture)	
USDA Forestry Service – Institute of Pacific Islands Forestry	
USDA Animal and Plant Health Inspection Services – Plant Protection Quarantine	
USDA Agriculture Research Service	
Secretariat of the Pacific Community Forests and Trees Programme	
United States Fish and Wildlife Service	
Saipan Nursery Association	

4. Priorities identified for future work

4.1 Brown tree snake

⇒ implement BTS Detector Dog Program on Tinian and Rota;
⇒ construct BTS Containment Barriers on Tinian and Rota;
⇒ implement standard operating procedures for all containment barriers that will require 72 hour quarantine of high-risk cargo;
⇒ impose a penalty for shippers in violation of quarantine procedure as related to the BTS;
⇒ monitor prey-base populations to determine incipient BTS populations; and
⇒ form a working group with other biogeographic regions at risk to evaluate control and interdiction programs.

4.2 Ivy gourd or scarlet fruited gourd

⇒ continue the mechanical and chemical control measures on Saipan, Tinian, and Rota islands;
⇒ construct a barrier or defense line to prevent further infestation;
⇒ implement legislation for prevention measures from further introduction of IAS;
⇒ get more public participation and involvement in the control measures; and
⇒ continue with the awareness campaigns and education to the general public.

5. List of experts working in the field of biological invasions

5.1 Brown tree snake: experts working on control and interdiction

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5.2 Experts working on ivy gourd or fruited scarlet gourd

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6. Bibliographic references and useful websites

6.1 Brown tree snake

Please refer to website: http://www.mesc.usgs.gov/resources/education/bts/resources/bibliography.asp

6.2 Ivy gourd or scarlet fruited gourd

U.S. Forest Service Institute of Pacific Islands Forestry (Pier CD Version 3.0)

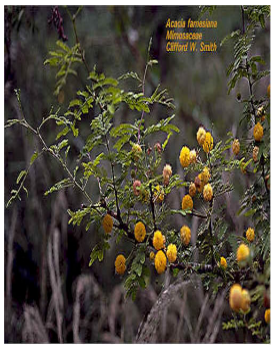
Wittenberg, R. and M.J.W. Cock. 2001. Invasive Alien Species: a Toolkit of Best Prevention and Management Practices. CAB International, Wallingford, Oxon, UK (available on http://www.cabi-bioscience.ch/wwwgisp/gt1goto.htm and www.gisp.org).

⇒ http://www.hear.org/pier/
⇒ http://www.aphIslandsusda.gov/invasivespecies/

Annex 1
Selected invasive alien plants in the Northern Mariana Islands

(source: U.S. Forest Service, Institute of Pacific Islands Forestry,Pacific Island Ecosystems at Risk (PIER) CD Version 3.0)

English: **Formosa acacia**
Chamorro: **sosigi**
Carolinian: **serepa**
(Acacia confusa)



English: **sweet acacia**
Local: **popinac, kandaroma**

(Acacia farnesiana)

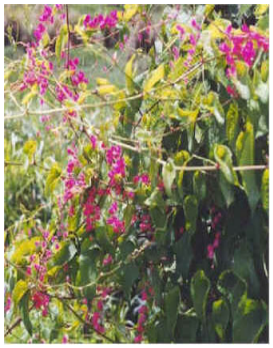
English: **sandalwood tree**
Local: **kulales**

(Adenanthera povinina)

English: **East Indian walnut**
Chamorro: **kalaska**
Carolinian: **Schepil Kalaska**
(Albizia lebbek)

English: **soursop**
Local: **syasyap**

(Annona muricata)



English: **chain of love**
Local: **flores ka'dena**

(Antigonon leptopus)

English: **bamboo**
Chamorro: **pi'ao**
Carolinan: **bwai**
(Bambusa spp.)

English: **orchid tree**
Local: **flores mariposa**

(Bauhinia monandra)

English: **beggar's tick**
Chamorro: unknown
Carolinian: unknown
(Bidens pilosa)

English: **perfume tree**
Local: **alang-ilang**

(Canaga odorata)

English: **ironwood**
Chamorro: **gagu**
Carolinian: **weighu**
(Casuarina equisetifolia)

English: **silk cotton tree**
Local: **atgodon**

(Ceiba pendantra)

Annex 2
Invasive alien plants in the Commonwealth of the Northern Mariana Islands

Scientific name	Common names		Family	Habit	Locale
	English	Local			
Acacia confusa	Formasa koa, Formosa acacia	sosigi (Chamorro), serepa, soschghi (Carolinian)	Fabaceae	tree	Saipan-Tinian-Rota
Acacia farnesiana	Ellington curse, klu, sweet acacia	aroma, popinac, kandaroma	Fabaceae	shrub	Saipan
Adenanthera pavonina	Coral been tree, sandalwood tree, red bead tree, lopa, bead tree, false wilwili, peacock flower-fence	colales, culalis, kulales, kulalis	Fabaceae	tree	Saipan-Rota
Albizia lebbeck *[Acacia lebbeck, Mimosa lebbeck]*	siris-tree, rain tree, East Indian walnut, kokko, woman's-tongue tree, soros-tree, roam tree	kalaska, trongkon-kalaska (Chamorro), schepil kalaska (Carolinian)	Fabaceae	tree	Saipan-Tinian-Rota
Annona muricata	soursop, prickly custard apple	syasyap	Annonaceae	tree	Saipan-Tinian-Rota-Northern Islands
Antigonon leptopus	Mexican creeper, mountain rose, Confederate vine, chain-of-love, hearts on a chain, love-vine, coral bells, coral vine, queen's jewels, kadena de amor, corallita	Flores ka'dena	Polygonaceae	vine	Saipan-Tinian
Bambusa **spp.**	bamboo	pi'ao, pi'ao palaoan (Chamorro), bwai (Carolinian)	Poaceae	tree	Saipan-Tinian-Rota-Northern Islands
Bauhinia monandra	orchid-tree, St. Thomas-tree, Napoleon's plume	flores mariposa	Fabaceae	tree	Saipan-Tinian-Rota-Northern Islands
Bidens pilosa *[Bidens alba]*	beggar's tick, Spanish needle, cobbler's pegs		Asteraceae	herb	Saipan-Tinian-Rota
Canaga odorata	perfume tree	ilang-ilang, alang-ilang	Annonaceae	tree	Saipan-Rota

Scientific name	Common names		Family	Habit	Locale
	English	Local			
Casuarina equisetifolia *[Casuarina litorea, Casuarina littorea]*	casuarina, ironwood, Australian pine, she-oak, horsetail tree, beefwood	gagu, gago (Chamorro), weighu (Carolinian)	Casuarinaceae	tree	Saipan
Ceiba pendantra	kapok, kapok tree, silk-cotton tree, pacae	koata, atgodon	Bombacaceae	tree	Saipan-Rota
Cestrum diurnum	inkberry, day jessamine, day cestru, China berry	tentanchinu, tintan China	Solanaceae	shrub	
Chromolaena odorata *[Eupatorium odoratum]*	Siam weed, triffid weed, bitter bush, Jack in the bush	masigsig	Asteraceae	herb	Saipan-Tinian-Rota
Clerodendrum quadriloculare	bronze-leaved clerondendrum		Verbenaceae	shrub	Saipan
Clitoria ternatea	butterfly pea, Asian pigeonwings	putitainubia	Fabaceae	vine	Saipan-Tinian-Rota
Coccinia grandis *[Bryonia grandis, Coccinia cordifolia]*	ivy gourd, scarlet-fruited gourd		Cucurbitaceae	vine	Saipan-Tinian-Rota
Delonix regia *[Poinciana regia]*	flame tree, flamboyant, poinciana	atbot, atbut (Chamorrow), nfayarbaw (Carolinian)	Fabaceae	tree	Saipan-Tinian-Rota-Northern Islands
Eichlorinia crassipes	water hyacinth		Pontederiaceae	aquatic herb	Saipan
Ficus microcarpa	Chinese banyan, Malayan banyan, Indian laurel	nunu	Moraceae	tree	Saipan-Rota
Lantana camara	*Lantana*		Verbenaceae	shrub	Saipan-Tinian-Rota
Leucaena leucocephala *[Leucaena glauca]*	*Leucaena*, wild tamarind, lead tree	tangantangan	Fabaceae	tree	Saipan-Tinian-Rota-Northern Islands
Mikania micrantha	mile-a-minute weed, Chinese creeper, American rope, bittervine		Asteraceae	vine	Saipan-Tinian-Rota
Mimosa invisa *[Mimosa diplotricha]*	giant sensitive plant, nila grass	singbiguin sasa	Fabaceae	shrub	Saipan-Tinian-Rota
Momordica charantia	balsam-apple, bitter melon, bitter gourd, balsam pear, squirting cucumber, cerasee, peria	atmagoso	Cucurbitaceae	vine	Saipan-Rota

Scientific name	Common names		Family	Habit	Locale
	English	Local			
Mucuna pruriens *[Dolichos pruriens, Stizolobium pruriens]*	cow itch, velvet bean, Bengal bean, Mauritius bean	akangkang dangkulo	Fabaceae	vine	Saipan
Muntingia calabura	jam tree, strawberry tree, Jamaican cherry, Singapore cherry, Panama cherry, Panama berry, ornamental cherry, calabura, sirsen	mansanita	Tilaceae	tree	Saipan-Rota-Northern Islands
Pithecellobium dulce *[Mimosa dulcis]*	Madras thorn, Manila tamarind	kamchili (Chamorro), ghamasiligh (Carolinian)	Fabaceae	tree	Saipan-Tinian-Rota-Northern Islands
Psidium guajava	guava	abas guayaba	Myrtaceae	tree	Saipan-Tinian-Rota-Northern Islands
Samanea saman *[Albizia saman, Pithecellobium saman]*	monkeypod, rain tree, saman	trongkon mames (Chamorro), filinganga (Carolinian)	Fabaceae	tree	Saipan-Rota
Spathodea campanulata	African tulip tree, fireball, fountain tree	apar	Bignoniaceae	tree	Saipan
Syzygium cumini *[Eugenia cumini]*	Java plum	duhat	Myrtaceae	tree	Saipan
Trema orientalis *[Trema cannabina]*	charcoal tree, gunpowder tree	agaunai, banahl, tal amama	Ulmaceae	tree	Saipan

Annex 3

Table of IAS in the Commonwealth of the Northern Mariana Islands

CNMI List of Invasive Alian Species (by Alejandro Badilles, NMC-CREES Rota)

NO	CLASS	INSECT ORDER	FAMILY	SUBFAMILY	COMMON NAME	*GENUS*	*SPECIES*	STAGE CAUSING DAMAGE
1	Insecta	Lepidoptera	Pyralidae		Cabbage webworm	*Hellula*	*undalis* (F.)	Caterpillar (larva)
2		Lepidoptera	Pyralidae		Head Cabbage Caterpillar	*Crocidolomia*	*binotalis* (Zeller)	Caterpillar (larva)
3		Lepidoptera	Pyralidae	Pyraustinae	European Corn Borer	*Ostrinia*	*nubilalis* (Hubner)	Caterpillar (larva)
4		Lepidoptera	Pyralidae		Asiatic corn borer	*Ostrinia*	*furnacalis* (Hubner)	
5		Lepidoptera	Noctuidae		Corn Earworm	*Heliothis*	*zea* (Boddie)	Caterpillar (larva)
6		Lepidoptera	Noctuidae		Tomato fruit worm	*Heliothis*	*armigera* (Hubner)	Caterpillar (larva)
7		Lepidoptera	Noctuidae		Armyworm	*Pseudaletia*	*unipuncta* (Haworth)	Caterpillar (larva)
8		Lepidoptera	Noctuidae		Armyworm	*Spodoptera*	*litura* (F.)	Caterpillar (larva)
9		Lepidoptea	Yponomeutidae		Diamond Backmoth	*Plutella*	*xylostella* (L.)	Caterpillar (larva)
10		Lepidoptera	Geometridae		Cabbage looper	*Trichoplusia*	*ni* (Hubner)	Caterpillar (larva)
11		Lepidoptera			Flat moth	*Agonoxena*	*argaula*	Larva
12		Lepidoptera	Pieridae		Imported Cabbage worm	*Pieris*	*rapae* (L.)	Caterpillar (larva)
13	Insecta	Diptera			Melon Fly	*Bactrocera*	*cucurbitae* (Coquillett)	Maggots
14		Diptera			Melon Fly	*Dacus*	*cucurbitae* (Coquillett)	Maggots
15		Diptera	Agromyzidae		Bean flies	*Ophiomyia*	*phaseoli* (Tryon)	Maggots
16					Bean flies	*Ophiomyia*	*centrosematis* (de Meijere)	Maggots
17	Insecta	Coleoptera	Apionidae		Sweet potato weevil	*Cylas*	*formicarius* (F.)	Larva and adult
18					Sweet potato weevil	*Cylas*	*puncticollis* (Bohemann)	Larva and adult
19					Sweet potato weevil	*Cylas*	*brunneus* (F.)	Larva and adult
20		Coleoptera	Curculionidae		West Indian sweet potato weevil	*Eucepes*	*postfasciatus* (Fairmaire)	Larva and adult
21		Coleoptera			Pumpkin Bettle/Cucumber Beetle	*Aulacophora*	*similis*	Adult

CNMI List of Invasive Alian Species (by Alejandro Badilles, NMC-CREES Rota)

22		Coleoptera			Epilachna beetles 12 spotted	*Epilachna*	*duodecastigma* (Mulsant)	Larva and adult
23		Coleoptera			Brontispa Beetle	*Brontispa*	*longisima*	Larva and adult
24					Epilachna beetles 28 spotted	*Epilachna*	*vigintioctopunctata* (F.)	Larva and adult
25		Coleoptera	Scarabaeidae	Melolonthinae	Rose Chafer Beetle	*Macrodactylus*	*subspinosus* (Fabricius)	Adult
26	Insecta	Homoptera	Aphididae		Black legume aphid	*Aphis*	*craccivora* (Koch)	Adult and nymph
27					Cotton aphid	*Aphis*	*gossypii* (Glover)	Adult and nymph
28		Homoptera	Eriococcidae		The citrus mealy bug	*Pseudococcus*	*citri* (Risso)	Adult and nymph
29		Homoptera		Aleyrodidae	Whiteflies	*Bemisia*	*argentifolia*	Nymph and adult
30	**PHLYLUM**							
31	Mollusca	Molluscs			Slugs - are snail that lack shells			
32					African snail - presence of shell			
33	**RAT**				Norway Rat	*Rattus*	*norvegicus*	
34					Roof rat	*Rattus*	*rattus*	
35					House mouse	*Mus*	*musculus*	
36	**PLANT**				Scarlet Gourd	*Coccinia*	*grandis*	
37					Masiksik	*Chromolaena*	*odorata*	
38					Dodder	*Cuscuta*	*campestris* (Yuncker)	
39					Purple nutsedge	*Cyperus*	*rotundus* (L.)	

Republic of Palau

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Introduction

The Republic of Palau recognizes the seriousness of the global invasive alien species (IAS) problem. IAS are the second greatest threat to biodiversity worldwide, second only to habitat destruction. Across the globe, many IAS have totally altered ecosystem structure and function. Many have caused enormous economic and environmental damage and some are a threat to human health. Invasions are in many cases irreversible and the problem is getting worse. In the Pacific, many experts now recognize IAS as the greatest threat to biodiversity. The majority of the world's recent extinctions have occurred on islands as a result of IAS.

Scientists agree that there can be benefits from introductions of new species for agriculture, the environment and/or development. However, each new introduction needs to be evaluated for its potential to cause problems. There is often a time lag between initial introduction and evidence of invasiveness. We cannot predict which organisms will become successful invaders nor can we predict where and when invasions will occur. We do not know what an organism will do to an ecosystem before it is introduced; therefore we must use the precautionary principle. Invasiveness in a similar environment elsewhere is a stong indicator of a species' potential to cause ecological change. One thing we know for sure is that new introductions, whether intentional or accidental, will continue to occur. Humans are rapidly accelerating introductions and the costs and benefits are not always evenly distributed.

⇒ *Geography, climate, population, and biodiversity*

The Republic of Palau is an archipelago in the Western Pacific Ocean between 7^{o} North latitude and 134^{o} East longitude. Palau is the westernmost island cluster of the six major island groups that make up the Caroline Islands. Palau is located approximately 800 km east of the Philippines and 800 km north of Papua New Guinea. Although recognized as part of the Caroline island group which features both volcanic and coralline islands, the Western Caroline Islands are exposed peaks of undersea ridges stretching between Japan and New Guinea and are not located on the Pacific Plate. The Palau islands originated on the now dormant southern section of the volcanic Palau-Kyushu Ridge, which formed about 43 million years ago in a complex series of rifting and boundary shifts of the Pacific Plate margin during the formation of the Philippine Basin (Kroenke 1984).

Part of the Oceania group, Palau is located on the eastern edge of the Philippine tectonic plate close to the western edge of the Pacific plate. The Palau, Yap, and Marianas Trenches that mark the subduction zone, where the Pacific plate is being driven under the Philippine plate, are some of the deepest waters on earth. When the islands that make up Palau first emerged above sea level is unknown. However, the oldest organic limestones have been dated to the early Miocene, which suggests that the volcanics were emergent sometime before that, perhaps by the late Oligocene, some 30 million years ago (Crombie 1999).

The Palau archipelago stretches over 400 miles in a north-south direction from the atoll of Kayangel to the islet of Hatohobei. Palau consists of 586 islands, of which only twelve are continuously inhabited. Total land area is 535 km^2, with 25% of Palau's landmass under ten meters above sea level (MoA 2001).

Map of the Republic of Palau

The islands of Palau represent five geological island types, volcanic, high limestone, low limestone, atolls, and a combination of volcanic and limestone (Crombie 1999). The largest islands were formed by Eocene volcanic activity and are composed of basalt and andesite. They tend to have a high profile, well-developed perennial stream systems, and a high diversity of terrestrial flora. Babeldaob island has severely leached and highly acidic soils, unsuited for large-scale agriculture. The world famous "Rock Islands" are of limestone formation. Peleliu and Angaur islands, located at the southern end of the main archipelago, are low platform and reef islands. The Southwest group of islands, located approximately 200 km from the capitol, is made up of reef flats that have been subject to uplift. Kayangel Island, at the northernmost tip of archipelago, is a classic coral atoll.

Babeldaob island is the largest in the Palau island chain and the second largest island in Micronesia. Babeldaob constitutes 75% of Palau's total landmass. At its greatest width, Babeldaob reaches fifteen miles across (APCC 2001). With the exception of Kayangel, Angaur, and the Southwest islands, all of the Palau islands are located within one barrier reef. Palau's exclusive fishing zone is 12 nautical miles, 3 nautical mile territorial seas, with a 200 nautical mile extended fishing zone, which comprises an area of approximately 600,900 km^2 (Sant/Hayes 1996).

⇒ ***Climate***

The Republic of Palau boasts a maritime tropical rainy climate. Its mean temperature is 82°F and fluctuates on a daily basis no more than 10°F. Annual mean humidity level is 82% and annual mean rainfall is about 3810mm per year with seasonal variation (National Climatic Data Center et al. 1996). Palau has two seasons during the year, wet and dry. The wet season typically begins in May and peaks in September. Dry season prevails from February to April and October to December. February, March, and April are the driest months of the year (NOAA 1991). January and February are generally the coolest months but differ from the warmest month, April, by only 1°C. Seawater temperatures in the main harbor, Malakal, averaged approximately 29°C for 2000 and 2001.

⇒ ***Population***

Palau's current population is 19,129 with an annual growth rate of 2.3%. The 2002 estimates for average rate of natural increase is 1.2%. Infant mortality is 16.2 for every 1,000 births and the population density per square mile is 110 (MoA 2002).

⇒ ***Biological diversity***

The Republic of Palau is best known for its marine diversity though it also hosts a wide variety of terrestrial flora and fauna, including many endemics. Numerous marine ecosystems exist, including mangrove forests, seagrass beds, fringing reefs, patch reefs, barrier reefs, and marine lakes. These ecosystems provide a plethora of marine habitats and even more niches for a huge variety of species to inhabit. There are over 300 species of soft corals and 400 species of hard corals. Palau is home to over 1400 species of reef fish and 46 species of freshwater fish, eleven of which are endemic. Terrestrial habitats include nine types of forests and savannah (Otobed and Maiava 1994, Cole et al. 1987). There are approximately 1260 species and varieties of plants in Palau, of which about 830 are native and nearly 200 are endemic. The numerous ecosystems found in Palau provide many goods and services that are crucial to rural communities dependent upon food, fiber, fuel and energy, medicines, clean water, as well as the spiritual, aesthetic, and recreational values derived from nature.

There are still many unknowns as to the number of marine and terrestrial organisms that reside in and around the Palauan archipelago. This information gap is mainly due to inaccessibility and the lack of

capacity for further research. Palau's natural resources, especially its wealth of biodiversity, are subject to many anthropogenic and natural pressures. These pressures include increased demand for resources, selective exploitation of species, land-use and land-use changes, anthropogenic nitrogen disposition, soil and water pollution, introduction of IAS, and fragmentation of ecosystems. Climate change is an added pressure on Palau's ecosystems.

1. Main IAS in the Republic of Palau

The following tables list species in Palau that have been identified as harmful, invasive or pests. They cover include plants, agricultural pests, animals, and marine pests respectively.

1.1 Invasive and potentially invasive plant species present in the Republic of Palau

The information is taken from the Pacific Island Ecosystems at Risk (PIER) project website (http://www.hear.org/pier/). See Annex 1 for more detailed tables contained in the draft *Report to the Republic of Palau on Invasive Plant Species of Environmental Concern* (Space et al. 2003). These tables include information about invasive plants not yet present in Palau.

Naturalized or cultivated plant species

Scientific name	**Family**	**Habit**
Abelmoschus moschatus	Malvaceae	herb
Acacia auriculiformis	Fabaceae	tree
Acacia confusa	Fabaceae	tree
Adenanthera pavonina	Fabaceae	tree
Agave sisalana	Agavaceae	herb
Albizia lebbeck	Fabaceae	tree
Allamanda cathartica	Apocynaceae	shrub
Alpinia purpurata	Zingiberaceae	herb
Angiopteris evecta	Marattiaceae	fern
Annona muricata	Annonaceae	tree
Annona squamosa	Annonaceae	tree
Antigonon leptopus	Polygonaceae	vine
Arundo donax	Poaceae	grass
Asystasia gangetica	Acanthaceae	herb
Axonopus compressus	Poaceae	grass
Bambusa spp.	Poaceae	tree
Bauhinia monandra	Fabaceae	tree
Bidens pilosa	Asteraceae	herb
Blechum pyramidata	Acanthaceae	herb
Bothriochloa bladhii	Poaceae	grass
Brachiaria mutica	Poaceae	grass

Scientific name	Family	Habit
Brachiaria subquadripara	Poaceae	grass
Breynia disticha	Euphorbiaceae	shrub
Bryophyllum pinnatum	Crassulaceae	herb
Calamus spp.	Arecaceae	shrub (palm)
Calliandra haematocephala	Fabaceae	shrub
Calopogonium mucunoides	Fabaceae	vine
Cananga odorata	Annonaceae	tree
Ceiba pentandra	Bombacaceae	tree
Cenchrus brownii	Poaceae	grass
Cenchrus echinatus	Poaceae	grass
Centrosema pubescens	Fabaceae	herb
Chamaecrista nictitans	Fabaceae	shrub
Chloris barbata	Poaceae	grass
Chloris radiata	Poaceae	grass
Chromolaena odorata	Asteraceae	herb
Cinnamomum verum	Lauraceae	tree
Clerodendrum buchananii var. *fallax*	Verbenaceae	shrub
Clerodendrum paniculatum	Verbenaceae	shrub
Clerodendrum quadriloculare	Verbenaceae	shrub
Clidemia hirta	Melastomataceae	shrub
Clitoria ternatea	Fabaceae	vine
Coffea arabica	Rubiaceae	tree
Commelina diffusa	Commelinaceae	herb
Crassocephalum crepidoides	Asteraceae	herb
Cynodon dactylon	Poaceae	grass
Cyperus involucratus	Cyperaceae	sedge
Cyperus rotundus	Cyperaceae	sedge
Delonix regia	Fabaceae	tree
Derris elliptica	Fabaceae	vine
Desmanthus pernambucanus	Fabaceae	herb
Dieffenbachia seguine	Araceae	herb
Digitaria ciliaris	Poaceae	grass
Digitaria violascens	Poaceae	grass
Dissotis rotundifolia	Melastomataceae	herb
Duranta erecta	Verbenaceae	shrub
Eichhornia crassipes	Pontederiaceae	aquatic herb
Elaeis guineensis	Arecaceae	tree

Scientific name	Family	Habit
Eleusine indica	Poaceae	grass
Falcataria moluccana	Fabaceae	tree
Ficus elastica	Moraceae	tree
Ficus microcarpa	Moraceae	tree
Flemingia strobilifera	Fabaceae	shrub
Gliricidia sepium	Fabaceae	tree
Hedychium coronarium	Zingiberaceae	herb
Heliconia spp.	Heliconiaceae	herb
Hemigraphis alternata	Acanthaceae	herb
Hippobroma longiflora	Campanulaceae	herb
Hyptis capitata	Lamiaceae	herb
Hyptis pectinata	Lamiaceae	herb
Impatiens balsamina	Balsaminaceae	succulent
Impatiens walleriana	Balsaminaceae	succulent
Imperata cylindrica	Poaceae	grass
Ipomoea aquatica	Convolvulaceae	aquatic herb
Ipomoea spp.	Convolvulaceae	herb
Ischaemum rugosum	Poaceae	grass
Jatropha curcas	Euphorbiaceae	shrub
Jatropha gossypiifolia	Euphorbiaceae	shrub
Kyllinga brevifolia	Cyperaceae	sedge
Lantana camara	Verbenaceae	shrub
Leonurus japonicus	Lamiaceae	herb
Leucaena leucocephala	Fabaceae	tree
Melaleuca quinquenervia	Myrtaceae	tree
Melia azedarach	Meliaceae	tree
Melinis minutiflora	Poaceae	grass
Mikania micrantha	Asteraceae	vine
Mimosa invisa	Fabaceae	shrub
Mimosa pudica	Fabaceae	herb
Momordica charantia	Cucurbitaceae	vine
Moringa oleifera	Moringaceae	tree
Muntingia calabura	Tiliaceae	tree
Nymphaea spp.	Nymphaeaceae	herb
Ocimum gratissimum	Lamiaceae	herb
Opuntia spp.	Cactaceae	succulents
Orthosiphon aristatus	Lamiaceae	herb
Panicum maximum	Poaceae	grass

Scientific name	Family	Habit
Panicum repens	Poaceae	grass
Paspalum conjugatum	Poaceae	grass
Paspalum orbiculare	Poaceae	grass
Passiflora foetida	Passifloraceae	vine
Passiflora quadrangularis	Passifloraceae	vine
Passiflora suberosa	Passifloraceae	vine
Pennisetum polystachion	Poaceae	grass
Pennisetum purpureum	Poaceae	grass
Persea americana	Lauraceae	tree
Pithecellobium dulce	Fabaceae	tree
Pluchea carolinensis	Asteraceae	shrub
Pluchea indica	Asteraceae	shrub
Psidium cattleianum	Myrtaceae	tree
Psidium guajava	Myrtaceae	tree
Ricinus communis	Euphorbiaceae	shrub
Samanea saman	Fabaceae	tree
Sambucus mexicana	Caprifoliaceae	small tree
Sansevieria trifasciata	Agavaceae	herb
Senna alata	Fabaceae	shrub
Senna obtusifolia	Fabaceae	herb
Sesbania grandiflora	Fabaceae	small tree
Solanum torvum	Solanaceae	shrub
Solenostemon scutellarioides	Lamiaceae	herb
Sorghum halepense	Poaceae	grass
Spathodea campanulata	Bignoniaceae	tree
Sporobolus indicus	Poaceae	grass
Stachytarpheta cayennensis	Verbenaceae	herb
Stylosanthes guianensis	Fabaceae	herb
Syngonium podophyllum	Araceae	vine
Syzygium cumini	Myrtaceae	tree
Syzygium jambos	Myrtaceae	tree
Tabebuia heterophylla	Bignoniaceae	tree
Tecoma stans	Bignoniaceae	small tree
Thevetia peruviana	Apocynaceae	small tree
Thunbergia grandiflora	Acanthaceae	vine
Timonius timon	Rubiaceae	tree
Tradescantia spathacea	Commelinaceae	herb
Tradescantia zebrina	Commelinaceae	herb

Scientific name	Family	Habit
Triumfetta rhomboidea	Tiliaceae	shrub
Urena lobata	Malvaceae	shrub
Vitex parviflora	Verbenaceae	shrub/tree
Wedelia trilobata	Asteraceae	herb

Native or early introduction

Scientific name	Family	Habit
Bischofia javanica	Euphorbiaceae	tree
Caesalpinia bonduc	Fabaceae	vine
Caesalpinia major	Fabaceae	vine
Canna indica	Cannaceae	herb
Casuarina equisetifolia	Casuarinaceae	tree
Chrysopogon aciculatus	Poaceae	grass
Costus speciosus	Zingiberaceae	herb
Heterospathe elata	Arecaceae	tree (palm)
Ischaemum polystachyum	Poaceae	grass
Melochia umbellata	Sterculiaceae	tree
Merremia peltata	Convolvulaceae	vine
Miscanthus floridulus	Poaceae	grass
Pueraria montana var. lobata	Fabaceae	vine
Saccharum spontaneum	Poaceae	grass
Sacciolepis indica	Poaceae	grass
Setaria pallide-fusca	Poaceae	grass
Trema orientalis	Ulmaceae	tree

1.2 List of agricultural pests in Palau

(Source: *Survey of Insect Pests of Crops and Invasive Weeds in the Republic of Palau 1999*)

NOTE: The common names in these tables include those in use at various locations throughout the Pacific and elsewhere. Additional information, including the locations where the various names are used, can be found in the individual species summaries.

Scientific name	Common name	Host
Acrocercops sp.	Leaf blotch miner	Sweet potato
Adoretus sinicus	Chinese rose beetle	Banana, beans, rose, hibiscus, cocoa
Aleurodicus disperses	Spiraling whitefly	Banana, coconut guava, plumeria, cassava, papaya, bell pepper, eggplant, breadfruit

Scientific name	Common name	Host
Anomis flava	Okra semi-looper	Okra
Aphis craccivora	Cowpea aphid	Beans, cucurbit, citrus, mango, breadfruit
Aphis gossypii	Melon aphid	Cucurbits
Aspidiotus destructor	Coconut scale	Banana, coconut, breadfruit, papaya, plumeria, cassava, kava, betelnut
Aulacophora similes	Pumpkin beetle	Cucurbits
Bactrocera doralis	Oriental fruit fly	Guava, mango, papaya, starfruit, citrus, mountain apple
Bactrocera frauenfeldi	Mango fruit fly	Tropical almonds, avocado, mountain apple, breadfruit, soursop, tangerine, mango, oranges
Bactrocera umbrosa	Breadfruitfly	Breadfruit, jackfruit
Brontispa palauensis	Palau coconut leaf beetle	Coconut
Chaetocnema affinis	Flea beetle	Sweet potato
Chrysodeixis eriosoma	Garden looper	Cucurbits
Cosmopolites sordidus	Banana weevil	Banana
Cylas formicarius	Sweet potato weevil	Sweet potato
Diaphania indica	Cucumber moth	Cucurbits
Dysmicoccus brevipes	Pineapple mealybug	Pineapple, taro, pandanus, soursop, coconut, betelnut
Furcaspis oceanica	Red coconut scale	coconut, pandanus
Halticus tibialis	Garden fleahopper	Cabbage, cucurbits, beans, sweet potato
Hellula undalis	Cabbage webworm	Cabbage
Hippotion celerio	Hornworm	Taro
Idioscopus niveosparsus	Mango leafhopper	Mango
Leptoglossus gonagra	Coreid bug	Beans, cucumber, bitter melon, citrus guava, eggplant
Liriomyza trifolii	Leafminer	Beans
Maruca vitrata	Legume pod borer	Beans
Metriona circumdata	Green tortoise beetle	Sweet potato, kangkong
Neomaskella bergii	Sugarcane whitefly	Sugarcane
Ophiomyia phaseoli	Bean fly	Beans
Oryctes rhinoceros	Rhinoceros beetle	Coconut, betelnut, pandanus, sugarcane, pineapple
Othreis fullonia	Fruit-piercing moth	Citrus, guava, papaya, banana, mango, tomato, eggplant
Oxya japonica	Japanese grasshopper	Sugarcane, coconut, betelnut
Papilio polytes	Black citrus swallowtail butterfly	Citrus, guava, papaya, banana, mango, tomato, eggplant
Penicillaria jocosatrix	Mango shoot caterpillar	Mango
Pentalonia nigronervosa	Banana aphid	Banana, tomato, taro
Phyllocnistis citrella	Citrus leafminer	Citrus, guava, papaya, banana, mango, tomato, eggplant
Plutella xylostella	Diamond-back moth	Cabbage
Polyphagotarsonemus latus	Broad mite	Bell pepper, beans, tomato, papaya, tobacco, sweet potato

Scientific name	Common name	Host
Rhabdoscelus obscurus	New Guinea sugarcane weevil	Sugarcane, coconut, betelnut
Selenothrips rubrocinctus	Red banded thrips	Mango, guava, avocado
Spodoptera litura	Cutworm	Cabbage, tomato, sweet potato, taro, cucurbits
Tarophagus colocasiae	Taro planthopper	Taro
Tetranychus sp.	Spider mite	Beans, cassava
Trigonops sp.	Weevil	Sweet potato
Trioza vitiensis	Psyllid	Mountain apple
Valanga nigricornis	Valanga grasshopper	Sugarcane, coconut, betelnut

1.3 List of invasive animal species

This is a preliminary list put together by the National Task Force on Invasive Animal Species, created by Executive Order in April 2002 (see Annex 2**)**. This is the only IAS list to cover potential impacts.

National Task Force On Invasive Animal Species ***List of Invasive Animal Species***				
Invasive animal species definition: "Non-native animals, including insects, which have been introduced into Palau, tend to increase in population, spread and have a negative impact on health, biodiversity, farming, tourism, the environment or the economy."				
Mammals, reptiles, and amphibians				
	Location	***Threat level***	***Impact***	***Action***
Cat	All	Medium	Negative: Eats bird eggs and other local species Positive: Reduces rat population	Monitor. Consider legislation similar to dogs.
Dog	All	Medium High in Koror	Negative: May have leptospirosis, have bitten people, uncontrolled dogs are a public nuisance. Positive: Dogs can make good pets that deter criminal activity	Support legislation introduced by OEK (National Congress) and strengthen as necessary. Veterinarian now on island. Send press release and promote neutering/spaying nation-wide. Consider other mechanisms to reduce strays
Goat	Babeldaob	Low	Negative: Eats and damages native plants, especially new seedlings. Positive: Controls weeds and grasses.	Must be monitored. Consider legislation to require fences/leashes and reporting.

Macaque Monkey	Anguar/All	High	Negative: Damage crops, potential human health problem, public nuisance Positive: Limited potential as tourist attraction.	Legislation to ensure that monkeys do not spread to other islands. Strengthen enforcement. Consider neutering pets or destruction of unwanted monkeys. Assist Anguar in efforts to reduce population. Seek off-island assistance.
Musk Shrew	Anguar	High	Negative: Damages crops and eats stored food.	Seek off-island assistance.
Rats	All	High	Negative: Spread diseases, including leptospirosis, damages property and food supplies.	Seek off-island assistance. Letter drafted for the Minister of Resources and Development to sign.
Pig	Babeldaob	High	Negative: Damage crops, damage native vegetation, threat to human life.	Seek off-island assistance.
African Snail	All	Low	Negative: Possible threat to biodiversity, crop pest.	Control measures need to be determined. Seek off-island assistance.
Cane Toad	All	Low	Negative: Poisonous and threaten biodiversity, particularly native insect populations and other native species	Control measures need to be determined. Seek off-island assistance.
Brown Tree Snake	Guam and Saipan (possibly)	Medium	Eats bird eggs and is a serious potential threat to native bird populations.	Ensure snakes do not enter through enhanced enforcement. Seek off-island assistance for training and a monitoring protocol to ensure that they are not yet present. Seek assistance to conduct thorough bird survey.
Birds				
Cockatoo	Rock Islands and Southern Babeldaob	Medium	Negative: Eats the hearts of the endemic palm, reducing populations of these palms to endangered status	Monitor and research impacts. Seek off-island assistance.
Eclectus Parrot	Rock Islands	Low	Negative: Eats plant seeds.	Monitor and research impacts. Seek off-island assistance.
City Pigeon or Rock Dove	Koror and Babeldaob	Medium	Negative: Carries diseases that have the potential to impact on native birds.	Monitor and eradicate known pigeons. Screen blood samples taken from birds for any diseases they might have.
Chestnut Manakin	All	Medium	Negative: Spreads grass seeds—could potentially assist in spreading of *Imperata cylindrica.*	Monitor the spread of *Imperata cylindrica* and any other.
Fish				
Tilapia	Koror	High	Negative: Can outcompete native freshwater fishes eventually replacing them, changing the natural composition of Palau's streams.	Eradication effort underway (Jan. 2003). The Republic has spent over $60,000 for necessary supplies, equipment and manpower towards this eradication effort.

Insects				
Fruit Flies	All	High	Negative: Damage agriculture, high economic and health costs to the Republic	Ministry of Resources and Development expends $25,000 per year on control efforts. Seeking $1.6 million grant to implement full eradication plan.
Mosquito	All	High	Negative: Spreads dengue fever	$181,000 grant for Environmental Health and Sanitation ended 2002. OEK (National Congress) allocated $80,000 to cover salaries and supplies for 2003.
Rhino-ceros Coconut Beetle	All	High in Sonsorol	Negative: Destroys coconut trees	Ministry of Resources and Development, Bureau of Agriculture will assist Sonsorol State with Bio-control.

1.4 List of introduced marine species

This list is based on information provided by the Coral Reef Research Foundation (see Annex 3).

Probable introductions	**Possible introductions**
Hydroids	
Eudendrium carneum	
Tyroscyphus fructicosus	
Ascidians The following ascidians are found in Malakal Harbor. None appear to be problematic yet, but *Didemun perlucidum* is problematic in other areas of the world. For a reference on the invasion of *Didemnum perlucidum* into the Gulf of Mexico on an artificial reef, see http://www.beak.com/info/features/abstracts/CulbertsonHarper.htm.	
Didemnum perlucidum	*Ascidia aperta*
Diplosoma listerianum	*Ascidia archai*
Lissoclinum fragile	*Botryllus tyreus*
	Ecteinascidia diaphanis
	Eusynstyela hartmeyeri
	Hermania insolita
	Hermania momus
	Microcosmus helleri
	Microcosmus pupa
	Perophora multiclathrata
	Phallusia philippinensis
	Polyclinum nudum
	Pyura curvigona
	Pyura honu
	Pyura vittata

2. Existing coordination and programs on IAS

The Bureau of Agriculture is the government agency that has been the most involved in invasive species management efforts. It has recently hired an Invasive Species Officer who will be working full

time on the mapping and monitoring of priority plant species as well as eradication and control efforts, using both manual community-based and chemical control methods.

There are two main groups at the national level that focus on IAS management and awareness. Most efforts on IAS are pursued through agencies that are members of these two groups. These two groups are the Palau Natural Resources Council (PNRC) and the National Task Force on Invasive Animal Species (NTFIAS) (see further 3 below).

2.1 Invasive plant species

The Palau Natural Resources Council has established an Invasive Weed Committee ("Weedbusters") which has now conducted two Annual Invasive Weed Clean Ups. The main purpose of this activity is to increase public awareness of invasive plants and their impacts. This year's clean up and awareness campaign focuses on mile-a-minute weed (*Mikania micrantha*). *Mikania* is now found in about 20 sites on the capital island of Koror and one site in the state of Airai on the island of Babeldaob. The goal of the clean-up is to reduce the weed's potential to spread by destroying as much of it as possible before the flowering season begins late October. In 2002, the clean-up started in late September with local groups working on the weekends to clean up the 20 sites and ended on 2 November 2002.

The Weedbusters have recently prepared an invasive plants booklet which focuses on the eleven species targeted for management in Palau. The Secretariat of the Pacific Community (SPC) has kindly provided funds to print this publication for wide distribution throughout Palau.

⇒ ***Invasive Plant Survey***

The Republic of Palau requested assistance from the US Department of Agriculture Forest Service (Institute of Pacific Islands Forestry) to conduct a survey of invasive plant species of environmental concern. A less comprehensive survey was conducted as part of a general survey of the major Micronesian islands in 1998. Similar surveys have been conducted in American Samoa, the Cook Islands, Niue, Samoa and Tonga. The survey was carried out from December 2002 – January 2003. The entire team surveyed the islands of Koror, Ngerekebesang, Malakal, Babeldaob, Angaur, Peleliu and the Rock Islands while Miles and Tiobech surveyed Sonsorol and Hatohobei States the last week of December. Tiobech, Rengulbai, and Terebkul Tellei surveyed Kayangel. Places of present and former habitation and those used by visitors were surveyed in the Rock Islands (Bablomekang, Betikel, Bkul a Chesemiich, Carp Resort on Ngercheu Island, Dwight Beach, Ngchelobel, Ngchus, Ngeanges (Neco), Ngerchong, Ngeremdiu, Ngermeaus, Ngidech, and Ulong).

The objectives of the survey were to: (1) identify plant species presently causing problems to natural and semi-natural ecosystems; (2) identify species that, even though they are not presently a major problem, could spread more widely or are known to be problem species elsewhere; (3) confirm the absence of species that are a problem elsewhere and, if introduced to Palau, could be a threat there; and (4) make appropriate recommendations (see Annex 1 for the draft list from this survey). The final report on this survey is due to be published in mid-2003.

2.2 Invasive animal species

The NTFIAS is still in the initial stages of organization since its creation by Executive Order No. 207 in April 2002 (see Annex 1). It has met several times since its inception to list all invasive animal species (including insects) present in Palau and to identify their range, what level of threat each of them pose and what actions should be taken to manage them. Using a broad definition of invasive animals

("Invasive animals are non-native animals, including insects, which have been introduced to Palau, tend to increase in population, spread and have a negative impact on health, biodiversity, farming, tourism, the environment or the economy"), the NTFIAS has prepared a survey (see Annex 4) to be conducted in all 16 states to identify which animal invasives should be prioritized and be the focus of initial efforts.

⇒ ***Rat control and eradication efforts***

The two main agencies involved in rat control efforts in the Republic are the Koror State Rangers and the Division of Environmental Health. The Koror State Rangers have been using various techniques to control rats on some of the Rock Islands that are frequently visited by locals and tourists. The Division of Environmental Health has also done rat control in some of the urban areas of Palau. They have rat bait stations for the public to use if necessary, which are available upon request. Both of these agencies are interested in further training and technical assistance in rat control and eradication.

It is likely that rats are having a severe negative effect on Palau's biodiversity, especially birds. There is also interest in conducting a study to look at the population densities of birds on some of the rock islands with high populations of rats, followed by a series of eradication and monitoring efforts over time to see if bird populations increase with the absence of rats and by how much.

⇒ ***Helen Reef rat eradication project***

The only rat eradication project to date in Palau was conducted on Helen Island in 2001. In 1996, two confiscated fishing vessels from the Philippines were anchored and abandoned at Helen Island located in the Southwest Islands of Palau, approximately 200 miles southwest of the main archipelago. Inadvertently, this event introduced rats to the island, which was previously believed not to harbor alien rat species (Maragos et al. 1994). This introduction was of concern to the community, which quickly initiated a rat control program. These efforts to control rats failed, due to inappropriate rodenticide choice and incomplete bait delivery.

The Helen Reef Atoll is a priority conservation site for marine and coastal biodiversity protection in the Pacific. The Community Conservation Network worked with the community of Hatohobei State to develop a management plan for enhancing the conservation of the Helen Reef ecosystem and its resources. One of the activities identified by preliminary planning efforts was the eradication of recently introduced rats to Helen Reef Island. Rats were viewed as one of the primary threats to the continued existence to ground dwelling sea birds, as well as a serious impact on the reproduction of threatened nesting sea turtle populations. The project proposed to implement a complete eradication of rats on Helen Island, as well as to incorporate preventive measures and policies to reduce the likelihood of rat reintroduction on the island. The community participated in all aspects of planning and implementation of the project, with expert advice, as a means of furthering involvement and experiences with management efforts. The project was implemented successfully with assistance from the Division of Environmental Health and the Environmental Quality Protection Board (see Annex 5 for the original proposal and more details of the project).

⇒ ***Tilapia and city pigeons***

In October 2002, tilapia - an invasive fish - was discovered in a small landlocked body of water in Palau. Around the same time, city pigeons were discovered that had been brought into Palau illegally. Some of the pigeons were said to have been in Palau for approximately 15-20 years, most being kept in people's houses as pets. All of the pigeons kept as pets have been euthanized except for five that are being kept for disease screening. Some of the owners say that a few pigeons escaped, which means that

the potential for them to establish themselves in the wild still exists. It is still uncertain who was responsible for the import of these pigeons.

The person thought to be responsible for the tilapia introduction was questioned about where the fish came from and what it was being used for and responded that it was sold locally, and was imported from several neighboring countries. Subsequent investigations into the spread of tilapia have found the fish in several different locations in the Republic, including an old dry dock, a quarry pond, a collection of shallow pools, an old water tank, etc.. Tilapia is a hardy fish that can survive in extreme conditions and can out-compete most of the native fish of Palau. The release of this fish into open waters is very likely to be devastating to the ecology of Palau's freshwater ecosystems.

The tilapia eradication effort has been undertaken by several government agencies, including the Division of Fire Protection, Division of Fish and Wildlife Protection, the Environmental Quality Protection Board and many local volunteers. Taking account of government expenditure and very generous donations from concerned citizens, residents and commercial businesses, the Republic has spent in excess of US$60,000 for chlorine, rotenone (a fish poison), overtime expenses, gasoline and diesel fuel for generators and water pumps, dynamite, safety equipment, and other expenses in order to try and eliminate the serious threat that tilapia poses. This rough estimate does not include the countless hours of volunteer work, research and equipment donations that have also supported the effort to save Palau's freshwater ecosystems and the biological diversity they contain (see Annex 6 for the press release on Tilapia and City Pigeons published in the local newspaper in October 2002).

⇒ ***Longtailed macaque monkeys***

The longtailed macaque (*Macacca fascicularis*) occurs on the island of Angaur (Ngeaur), a small 830 ha coral atoll in the Republic of Palau, and the easternmost location for *Macacca fascicularis* in the Pacific. These animals are significantly smaller in body weight and other morphological dimensions than populations of longtailed macaques found elsewhere (Matsubayashi et al. 1989). These monkeys were introduced to the island during the German occupation, probably between 1909 and 1914 when phosphate mining began (Potrier and Smith 1974, Wheatley et al. 1997). It is likely that the monkeys have negative effects on the biodiversity of the island. The local people consider the macaques of Angaur a major agricultural pest because they raid gardens, eating oranges, bananas, coconuts and, especially taro.

In response, the State Government of Ngeaur put a bounty on monkeys. While approximately 300 monkeys were killed during this bounty, it did not seem to have much of an effect on the population. The macaques have been sighted in the wild occasionally in parts of Airai on Palau's largest island, Babeldaob and in the Rock Islands. The potential for these animals to colonize other islands is high and would result in significant environmental and agricultural damage. The NTFIAS is currently looking for assistance in conducting a feasibility study for eradication of the macaques on the island of Angaur.

⇒ ***Fruit flies***

There are three species of fruit fly that are problematic in Palau. The report by Allwood et al. (1999) contains information on the distribution and economic consequences of fruit flies in Palau. The major change in the fruit fly situation in Palau is the vastly increased losses now occurring as a result of the oriental fruit fly numbers increasing and the host range expanding. This is typical of species, like many of the '*dorsalis*' complex fruit flies, which have been recently introduced into new areas.

There are two species of fruit flies, which are attracted to methyl eugenol (oriental fruit fly and breadfruit fly) and one species attracted to cue-lure (mango fly *B. frauenfeldi*). A fourth species, *B. calophylli*, is not attracted to either lure: however, it is not an economically significant species as it only occurs in the wild fruit of a native tree, *Calophyllum inophyllum*. The distribution of oriental fruit fly in Palau is now well known, with the exception of information from Southwest Islands, where trapping still has to be done. It occurs on all islands, including the Rock Islands, Kayangel and Peleliu. The number of traps currently being serviced by DAMR has changed only marginally. Two extra traps have been placed on two Rock Islands to give better coverage than in 1999.

The Bureau of Agriculture's Fruit Fly Program is currently conducting fruit fly egg and larval thermal mortality tests on the three flies. This is being done to develop quarantine treatments for potential export of fruits and vegetables to Guam and other locations. The purpose of the thermal mortality tests is to determine the most heat-tolerant fruit fly life stage(s) by immersing early- and late-aged eggs, first instars, and feeding and non- feeding third instars larvae in a controlled- temperature water bath for selected time and temperature combinations. The thermal mortality test will determine a correct temperature required to treat fruits and fleshy vegetables against a specific fruit fly species for export.

The Fruit Fly Program also plans in the near future to conduct non-host status tests. Determination of non-host status involves the testing of fresh fruits and vegetables for their susceptibility to fruit fly infestations to a specified standard. It is an important method in quarantine treatments as it is relatively fast and simple to do, less costly than other treatments, environmentally friendly, permanently established and accepted by quarantine authorities.

An implementation plan for the eradication of the two fruit flies attracted to methyl eugenol (oriental fruit fly and breadfruit fly) was developed in 2001 with funding from the Secretariat of the Pacific Community ("Fruit Fly Management - Pest Management in the Pacific Project", see Annex 7). The Republic is currently seeking funding for the implementation of this plan. In the interim, it is working to build the capacity of quarantine officers and to increase the number of quarantine staff before implementation commences.

2.3 Marine invasive species

Currently, no organization or agency is working on marine invasives. Information gathered from the Coral Reef Research Foundation indicates that the only introduced marine species that is showing invasive behaviour is a recently introduced hydroid, *Eudendrium carneum.* The hydroid was introduced in July 1997 when a floating bridge was brought over from Guangzhou City in Southern China to be used to temporarily connect Koror and Babeldaob after the KB Bridge collapsed in September 1996. Since its introduction, the hydroid has spread rapidly (approximately 3-4 kilometers in each direction in the channel). Funding and technical assistance is needed to begin a monitoring protocol for the nation's marine invasives (see Annex 3 for more detailed information on marine invasive species in Palau, provided by Dr. Patrick L.Colin of the Coral Reef Research Foundation).

2.4 GIS and mapping

The Office of the Palau Automated Land and Resource Information System (PALARIS), Palau's national GIS system, is a key player in tackling both plant and animal IAS. The Bureau of Agriculture, the Bureau of Lands and Surveys in partnership with the Palau Community College-Agriculture Department, and PALARIS have surveyed and mapped the grass, *Imperata cylindrical,* in Airai State (see map, Annex 8). The team plans to continue to monitor and treat this grass with herbicides regularly

over the next 3 to 5 years until it is completely eradicated. The team is now able to track its progress and detect any potential spreading of this grass.

The eradication team also surveyed and mapped 18 sites of *Mikania micrantha* in Koror State for ongoing monitoring (see map, Annex 9). The team has also located and begun the eradication of the African Tulip tree (*Spathodea campanulata*) which is now found in five States. Future work will include surveying and mapping more species and new infestation sites for onging monitoring.

Work on Palau's invasive animal species is expected to start in 2003 with cooperation from the NTFIAS and PALARIS. One project involves the surveying and mapping of the invasive alien marine species, *Eudendrium carneum*, the hydroid that was brought in from the floating bridge back in 1997 (see 2.3 above).

3. Government departments/agencies and other organisations concerned with IAS

The Palau Natural Resources Council and the National Task Force on Invasive Animal Species consist of various government and semi-government agencies as well as non-government organizations.

3.1 Palau Natural Resource Council members

The Palau Natural Resources Council was established in 2000 and has been meeting regularly since its inception. The Council's mandate is broad and its main function is to provide for proper coordination and cooperation among all agencies, individuals and organizations involved in managing land-based natural resources. Its vision statement is: *"People working together to ensure the use and management of Palau's natural resources is in harmony with the environment and culture"*. Its mission statement is: "*The council shall provide leadership for the wise use and sustainable management of Palau's (land-based) natural resources using appropriate technology. To accomplish its mission the council shall cooperate and coordinate with other organizations, agencies, groups and individuals."* IAS issues are one of the main areas the Council focuses its efforts.

The Council's members and contact details are as follows:

Bureau of Agriculture (BOA), damr@palaunet.com
Environmental Quality Protection Board (EQPB), eqpb@palaunet.com
Office of Environmental Response and Coordination (OERC), ercpalau@hotmail.com
Palau Conservation Society (PCS), pcs@palaunet.com
Palau Community Action Agency (PCAA)
Office of the Palau Automated Land and Resource Information System (PALARIS), raleighkl@palaunet.com
Bureau of Lands and Surveys, bls@palaunet.com
Peace Corps Volunteers (PCV)
The Nature Conservancy (TNC), dhinchley@palaunet.com
Palau Community College-Agriculture Department (PCC-Ag), cyprot@yahoo.com
Palau Community College-Cooperative Research and Extension (PCC-CRE), asuta@palaunet.com
Natural Resources Conservation Service (NRCS), rdemeo@palaunet.com

3.2 National Task Force on Invasive Animal Species Members

As noted, the Task Force was created by Executive Order No. 207 (see Annex 1) in April 2002 and is still in the initial stages of organization. Its members and contact details are as follows:

Minister of Resources and Development, Chairman, mrd@palaunet.com
Minister of Justice, Vice-Chairman, justice@palaunet.com
Director of the Bureau of Agriculture, Member, damr@palaunet.com
Director of the Bureau of Domestic Affairs, Member, stellames@bdarop.com
The Office of Environmental Response and Coordination, Member, ercpalau@hotmail.com
The Palau Conservation Society, Member, pcs@palaunet.com
The Nature Conservancy, Member, dhinchley@palaunet.com
The USDA-Natural Resource Conservation Service, Member, rdemeo@palaunet.com

4. Priorities identified for future work

4.1 Invasive plant species

The main priorities identified by the Invasive Weed Committee are to increase public awareness, prevent new entries, control or stop spread, eradication and to support efforts of others. Ongoing public education and awareness efforts include press releases, community meetings, radio interviews, posters, booklets, leaflets and annual invasive weed clean ups.

Biological control agents have been released for *Chromolaena odorata* and *Mimosa diplotricha*. Physical control measures are being used to target *Mikania micrantha* and *Merremia peltata*. Chemical control measures are being used to target *Imperata cylindrica* and *Spathodea campanulata*. Another species that will soon be targeted for eradication is the vine *Antigonon leptopus,* chain of love. Several species on the ISSG list (Lowe et al. 2000) are not yet targeted for control or eradication due to limited resources. These are: *Clidemia hirta, Lantana camara, Leucaena leucocephola* and *Wedelia trilobata.* Future work includes the development of management plans for each invasive plant species. See **Annex 10** for more detailed information on eradication efforts for *Imperata cylindrica*.

4.2 Invasive animal species

The main priorities and target species for the NTFIAS are currently being developed. The species that have a high level of threat are most likely the ones that will be prioritized for immediate action. These are: the macaque monkey (*Macaca fascicularis*), musk shrew (believed to be *Suncus murinus*), rats and mice, pig, mosquitos, fruit flies (*Dorsalis bactrocera philipinensis and D. bactrocera occipitalis*) and rhinoceros beetle (*Oryctes rhinoceros*). The findings from the invasive animal survey conducted in all 16 states will influence which species efforts will be put towards. Many of the invasive animal species require off-island assistance. Availability of this assistance will also influence the species on which management efforts are focused.

5. List of experts working in the field of biological invasions

Dr. Joel Miles – Palau Community College, cyprot@yahoo.com
Dr. Nelson Esguerra – PCC-CRE, nmesguerra@yahoo.com
Ms. Pua Michaels – Bureau of Agriculture, damr@palaunet.com
Mr. Kashgar Rengulbai – Bureau of Agriculture, damr@palaunet.com
Mr. Trebkul Tellei – Bureau of Agriculture, damr@palaunet.com
Mr. Fred Sengebau – Bureau of Agriculture, damr@palaunet.com
Ms. Kelly Raleigh Moses – Office of PALARIS, raleighkl@palaunet.com
Ms. Robin DeMeo – USDA NRCS, rdemeo@palaunet.com
Ms. Tarita Holm – OERC, ercpalau@hotmail.com
Mr. Henson Deltang – PCS, pcs@palaunet.com
Mrs. Ann Kitalong – The Environment, Inc., kitalong@hotmail.com
Mr. Joe Tiobech – BOA, damr@palaunet.com
Mr. David Hinchley – TNC, dhinchley@palaunet.com
Mr. Alex Sumor – Division of Environmental Health, lead@palaunet.com
Mr. Godwin Siliang – Division of Environmental Health, lead@palaunet.com
Mr. Adalbert Eledui – Koror State Rangers, rorrangers@palaunet.com
Mr. Harry Blesam – Koror State Rangers, rorrangers@palaunet.com
Dr. Pat Colin – Coral Reef Research Foundation, crrf@palaunet.com

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Annexes

Annex 1

Taken from the draft "Report to the Republic of Palau
on Invasive Plant Species of Environmental Concern"

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USDA – Forest Service
January 17, 2003

Table A. Priority species for exclusion from Palau

Scientific name	Common names (abridged)	Family	Invasive in:
Acacia aulacocarpa	brown salwood	Fabaceae	Cook Islands
Acacia crassicarpa	Redwood	Fabaceae	Cook Islands
Acacia curassavica	northern wattle, Papua New Guinea red wattle	Fabaceae	Cook Islands
Albizia chinensis	Chinese albizia, silktree	Fabaceae	Samoa
Ardisia elliptica	shoebutton ardisia	Myrsinaceae	Cook Islands, French Polynesia, Hawai'i, Samoa and USA (Florida)
Cardiospermum grandiflorum	balloon vine; heart seed	Sapindaceae	Cook Islands (Rarotonga)
Carludovica palmata	Panama hat plant	Cyclanthaceae	Samoa (Upolu)
Castilla elastica	Panama rubber tree	Moraceae	Samoa
Cecropia obtusifolia	trumpet tree, guarumo	Cecropiaceae	Hawai'i, Cook Islands
Cecropia peltata	trumpet tree	Cecropiaceae	French Polynesia
Cestrum diurnum	day cestrum	Solanaceae	Cook Islands
Cestrum nocturnum	night-flowering cestrum	Solanaceae	Cook Islands, French Polynesia (Tahiti), Samoa, Tonga
Clerodendrum chinense	Honolulu rose	Lamiaceae	Samoa, Tonga and elsewhere
Coccinia grandis	ivy gourd, scarlet-fruited gourd	Cucurbitaceae	Hawai'i, Saipan
Cordia alliodora	Ecuador laurel, salmwood	Boraginaceae	Samoa, Tonga, Vanuatu
Cryptostegia grandiflora	rubber vine, India rubber vine	Asclepiadaceae	Australia (Queensland)
Eugenia uniflora	Surinam cherry	Myrtaceae	Cook Islands
Funtumia elastica	African rubber tree	Apocynaceae	Samoa
Hiptage benghalensis	hiptage	Malpighiaceae	Hawai'i, La Réunion, Mauritius
Indigofera suffruticosa	indigo	Fabaceae	Tonga and elsewhere
Macfadyena unguis-cati	cat's-claw climber	Bignoniaceae	Hawai'i, Niue, New Caledonia

Scientific name	Common names (abridged)	Family	Invasive in:
Maesopsis eminii	umbrella tree, musizi	Rhamnaceae	Fiji
Merremia tuberosa	wood rose	Convolvulaceae	Hawai‘i, Niue
Miconia calvescens	miconia, velvetleaf, purple plague, bush currant	Melastomataceae	French Polynesia, Hawai'i
Mucuna pruriens	cow itch, velvet bean	Fabaceae	Saipan
Odontonema tubaeforme	fire spike, cardinal flower	Acanthaceae	American Samoa, Samoa
Passiflora spp.	all Passifloraceae not already present	Passifloraceae	
Passiflora tarminiana	banana poka, banana passionfruit, bananadilla	Passifloraceae	Hawai’i
Phyllostachys spp.	running bamboos	Poaceae	Hawai‘i (*P. nigra*), Cook Islands (*P. bissetii*)
Pimenta dioica	pimento, allspice	Myrtaceae	Hawai‘i, Tonga
Pimenta. racemosa	bay tree	Myrtaceae	Cook Islands
Piper aduncum	spiked pepper	Piperaceae	Fiji, Papua New Guinea, Solomon Islands, Indonesia, Malaysia
Piper auritum	eared pepper, false kava	Piperaceae	Hawai‘i, Pohnpei, Tonga
Rubus spp.	raspberries, blackberries, brambles	Rosaceae	Hawai‘i, French Polynesia, etc.
Schinus terebinthifolius	Christmas-berry, Brazilian pepper	Anacardiaceae	USA (Hawai‘i, Florida)
Setaria palmifolia	palmgrass, short pitpit	Poaceae	Hawai‘i, French Polynesia (Tahiti), Samoa
Solanum capsicoides	cockroach berry, devil’s apple, soda apple	Solanaceae	Hawai‘i, Samoa, Tonga
Solanum mauritianum	bugweed, wild tobacco, tree tobacco	Solanaceae	Hawai‘i, Tonga
Tibouchina herbacea	glorybush, cane ti, tibouchina	Melastomataceae	Hawai’i
Trubulus cistoides	puncture vine	Zygophyllaceae	Hawai‘i
All grasses	all other grass species not already present	Poaceae	pan-tropical
All melastomes	all other non-native melastomes	Melastomataceae	Hawai'i, etc.

Note: Appendix 1, Table A is a complete list of IAS and potential IAS of environmental concern not yet present in Palau. Appendix 1, Table B contains a list of other IAS not reported to be present in Palau.

Table B. Cultivated species of possible threat to Palau

Scientific name	Common names (abridged)	Family	Present on:	Invasive in:
Acacia farnesiana	Ellington curse, klu	Fabaceae	Babeldaob	Fiji, French Polynesia, New Caledonia, Solomon Islands, Vanuatu
Asparagus densiflorus	asparagus fern, sprengeri fern, smilax, regal fern	Liliaceae	Koror, Ngerekebesang	Hawai‘i
Calotropis gigantea	calotrope, crown flower, madar	Ascelepiadaceae	Koror, Ngerekebesang, Babeldaob, Peleliu	Australia (Queensland), Timor
Cinnamomum verum	ochod ra ngebard, cinnamon tree	Lauraceae	reported present, no location given	American Samoa, Cook Islands, Samoa
Cyperus alternifolius	umbrella sedge	Cyperaceae	Koror	Cook Islands, Tonga
Eichhornia crassipes	bung el ralm, water hyacinth	Pontederiaceae	Koror, Ngerekebesang, Babeldaob	pantropical
Elaeocarpus angustifolius	blue fig, blue marble tree	Elaeocarpaceae	reported present, no location given	Samoa
Flemingia macrophylla		Fabaceae	Koror, Airai	Cook Islands, Samoa
Hevea brasiliensis	Brazilian rubber tree	Euphorbiaceae	Koror, Babeldaob	Christmas Island (Indian Ocean)
Murraya paniculata	orange jessamine, satin-wood, Chinese box	Rutaceae	Upolu Koror, Babeldaob	French Polynesia, Hawai‘i; host to citrus psyllid
Nymphaea spp.	Waterlily	Nymphaeaceae	Koror	pantropical
Pennisetum setaceum	fountain grass	Poaceae	Ngerekebesang, Babeldaob	USA (California, Hawai‘i), Canary Islands
Quisqualis indica	Rangoon creeper	Combretaceae	Ngerekebesang, Babeldaob	Australia (Northern Territories)
Sanchezia parvibracteata	Sanchezia	Acanthaceae	Koror, Malakal, Ngerekebesang	Hawai‘i
Sesbania grandiflora	katurai, sesbania, scarlet wisteria	Fabaceae	Koror, Malakal, Babeldaob	American Samoa, Samoa
Spathodea campanulata	African tulip tree	Bignoniaceae	Koror, Ngerekebesang, Babeldaob	Fiji, French Polynesia, Hawai'i, Samoa, Vanuatu
Syzygium cumini	Mesekerrák, Java plum	Myrtaceae	Koror, Babeldaob, Aulupse‘el	Cook Islands, Hawai‘i, French Polynesia (Raiatea)
Syzygium jambos	malabar plum, Malay apple	Myrtaceae	Koror, Babeldaob	French Polynesia, Galapagos Islands, Mauritius, La Réunion
Tabebuia heterophylla	pink tecoma, pink trumpet tree, white cedar	Bignoniaceae	Koror, Malakal, Ngerekebesang	Hawai‘i
Vitex parviflora	small-leaved vitex	Verbenaceae	reported present, no location given	Guam

Note: See Appendix 1, Tables B and C for a complete list of cultivated plants with invasive potential.

All invasive plant species are not present on all islands. As would be expected, the islands of Koror, Malakal, Ngerekebesang and Babeldaob have most of the weedy species; there are significantly fewer on the outer islands. However, a few unique species occur on Peleliu and Angaur. Kayangel, Sonsorol

and Hatohobei have the fewest invasive plants. Thus, there is the opportunity to prevent the movement and establishment of invasive plants on new islands, either through quarantine procedures or by surveying for and rapidly responding to new infestations. Table C shows critical species that should be subject to restrictions on inter-island movement or promptly eradicated if found. Appendix 5 shows, for each island, all the invasive species that are not present there but are present elsewhere in Palau. Because they have few invasive plants, exclusion of new species is especially important for the southwest islands. Appendix 5, Tables 7 and 8 show species present elsewhere in Palau that are not yet present in these islands.

Table C. Critical species that should be subject to inter-island quarantine

Scientific name	Common name	Present on:
Acacia farnesiana	Ellington curse, klu, sweet acacia	Babeldaob
Adenanthera pavonina	telengtúngd, telentundalel, coral bean tree	Koror, Malakal, Ngerekebesang, Babeldaob
Allamanda cathartica	shimizu , allamanda, yellow trumpet vine	Koror, Malakal, Ngerekebesang, Babeldaob
Alternanthera brasiliana	Brazilian joyweed, Joseph's coat	Koror, Malakal, Carp
Antigonon leptopus	dilngau, chain of love	Koror, Babeldaob
Arundo donax	giant reed	Koror, Babeldaob
Asparagus densiflorus	asparagus fern, sprengeri fern	Koror, Ngerekebesang
Calotropis gigantea	calotrope, crown flower, madar	Koror, Ngerekebesang, Babeldaob, Peleliu
Chromolaena odorata	ngesngesil, Siam weed	Koror, Malakal, Ngerekebesang, Babeldaob, Angaur, Peleliu, Ngidech
Cinnamomum verum	ochod ra ngebard, cinnamon tree	Not known
Clerodendrum quadriloculare	kleuang, bronze-leaved clerodendrum	Koror, Malakal, Ngerekebesang, Babeldaob, Angaur, Kayangel, Peleliu, Carp
Clidemia hirta	kúi, Koster's curse	Malakal, Babeldaob
Cyperus alternifolius	deus, umbrella sedge	Koror
Dieffenbachia seguine	spotted dieffenbachia, dumb cane	Koror, Malakal, Ngerekebesang, Babeldaob, Peleliu
Dissotis rotundifolia	dissotis, pink lady	Koror, Babeldaob
Eichhornia crassipes	bung el ralm, water hyacinth	Koror, Ngerekebesang, Babeldaob
Elaeocarpus angustifolius	blue fig, blue marble tree	Not known
Falcataria moluccana	ukall ra ngebard, Moluccca albizia	Koror, Babeldaob
Flemingia macrophylla		Koror, Babeldaob
Hedychium coronarium	white ginger	Koror, Ngerekebesang
Hevea brasiliensis	Brazilian rubber tree, Para rubber tree	Koror, Babeldaob
Hyptis pectinata	mint weed	Babeldaob, Angaur?
Imperata cylindrica	kasoring, blady grass, cogon grass	Babeldaob
Ipomoea hederifolia	ivy-leaf morning glory, star ipomoea	Babeldaob
Lantana camara	lantana	Koror, Malakal, Ngerekebesang, Babeldaob, Angaur, Peleliu, Carp

Scientific name	Common name	Present on:
Leucaena leucocephala	telengtungd, leucaena	Koror, Malakal, Ngerekebesang, Babeldaob, Angaur, Peleliu, Carp, Ngerchong, Sonsorol
Macroptilium lathyroides	cow pea, phasey bean	Babeldaob
Melaleuca quinquenervia	cajeput, paper bark tree	Babeldaob
Melia azedarach	Chinaberry, pride-of-India, Indian lilac	Koror, Babeldaob
Melinis minutiflora	molasses grass	Babeldaob
Merremia peltata	kebeas, merremia	Koror, Malakal, Ngerekebesang, Babeldaob, Kayangel
Mikania micrantha	teb el yas, mile-a-minute weed	Peleliu, Koror, Ngerkebesang, Babeldaob, Malakal
Mimosa diplotricha	mechiuaiuu, giant sensitive plant	Koror, Malakal, Ngerekebesang, Babeldaob, Angaur
Mimosa pudica	mechiuaiuu, sensitive plant	Koror, Malakal, Ngerekebesang, Babeldaob, Angaur
Panicum maximum	Guinea grass	Koror, Babeldaob
Pennisetum polystachion	desum, mission grass	Koror, Malakal, Ngerekebesang, Babeldaob, Peleliu
Pennisetum setaceum	fountain grass	Ngerekebesang, Babeldaob
Pluchea carolinensis	sour bush	Peleliu
Psidium cattleianum	strawberry guava	Koror?
Psidium guajava	guabang, kuabang, guava	Koror, Malakal, Ngerekebesang, Babeldaob, Angaur, Peleliu, Bkul a Chesemiich, Ngerchong
Scindapsus aureus	pothos, money plant	Koror, Malakal, Ngerekebesang, Babeldaob
Sesbania grandiflora	katurai, hummingbird tree, scarlet wisteria tree	Koror, Malakal, Babeldaob
Solanum torvum	prickly solanum, devil's fig	Babeldaob
Stachytarpheta cayennensis	louch beluu, blue rat's tail, dark blue snakeweed	Koror, Malakal, , Babeldaob, Angaur, Kayangel, Peleliu, Ngidech, Urukthapel
Syngonium angustatum	arrowhead plant, goosefoot plant	Koror, Malakal, Ngerekebesang, Babeldaob, Angaur, Peleliu
Tephrosia candida	white tephrosia	Babeldaob
Thunbergia grandiflora	bungel 'l etiu, blue trumpet vine, Bengal trumpet	Koror, Babeldaob, Kayangel
Timonius timon	liberal	Ngerekebesang, Angaur, Peleliu, Kayangel, Bkul a Chesemiich, Carp, Ngerchong, Ngchelobel, Ngeanges
Turnera ulmifolia/subulata	yellow alder, sage rose/white alder	Koror, Malakal, Ngerekebesang, Babeldaob, Angaur, Peleliu
Vitex parviflora	small-leaved vitex	not known
Wedelia trilobata	ngesil ra ngebard, Singapore daisy	Koror, Malakal, Ngerekebesang, Babeldaob, Angaur, Peleliu

Note: This table lists only the most serious invasive plants of environmental concern. See Appendix 5 for complete lists of species not yet present on each island or island group.

Table D shows the most serious invasive plant species in Palau and summarizes recommendations for their management. In a number of cases, more detailed information and recommendations follow the table.

Table D. Summary of major IAS present in Palau with recommendations for their management

Scientific name	Common names (abridged)	Family	Comments and recommendations
*† *Acacia farnesiana*	Ellington curse, klu, sweet acacia	Fabaceae	Eradicate
Adenanthera pavonina	telengtúngd, telentundalel, coral bean tree	Fabaceae	Control as needed in sensitive and natural areas
Allamanda cathartica	shimizu, allamanda, yellow trumpet vine	Apocynaceae	Discourage planting; remove when a problem
Alternanthera brasiliana	Brazilian joyweed, Joseph's coat	Amaranthaceae	Discontinue planting; be alert to escapes from cultivation; eradicate single plant on Carp island and other isolated plantings
Antigonon leptopus	dilngau, chain of love	Polygonaceae	Discourage further planting; work to eradicate over time
Arundo donax	giant reed	Poaceae	Limit burning; control as needed in sensitive and natural areas
*† *Asparagus densiflorus*	asparagus fern, sprengeri fern	Liliaceae	Eradicate
† *Barleria lupulina*	hophead, Philippine violet	Acanthaceae	Eradicate if of limited extent
Bryophyllum pinnatum	life plant	Crassulaceae	Control outside of cultivation
Calotropis gigantea	calotrope, crown flower, madar	Ascelepiadaceae	Monitor for spread
Casuarina equisetifolia	ngas, casuarina, ironwood, Australian pine	Casuarinaceae	Eradicate on Tobi and Helen's Reef; exclude from Sonsorol and other islands of Sonsorol State consider removal from beaches in Rock Islands
Chromolaena odorata	ngesngesil, Siam weed	Asteraceae	Introduce and maintain biological control agents
Chrysopogon aciculatus	iul, Mackie's pest, lovegrass	Poaceae	Provide advice on control to Sonsorol and Tobi; promptly eradicate if found on new islands
Cinnamomum verum	ochod ra ngebard, cinnamon tree	Lauraceae	Eradicate if found and of limited extent
Clerodendrum quadriloculare	kleuang, bronze-leaved clerodendrum	Lamiaceae	Discourage planting and dumping of cuttings; control outside of cultivation; evaluate for possible eradication on Peleliu and Angaur
* *Clidemia hirta*	kúi, Koster's curse	Melastomataceae	Evaluate extent and the possibility of eradication; request technical assistance for evaluation if needed
*† *Cyperus alternifolius* subsp. *flabelliformis*	deus, umbrella sedge	Cyperaceae	Eradicate if of limited extent
Dieffenbachia seguine	spotted dieffenbachia, dumb cane	Araceae	Remove outside of cultivation
Dissotis rotundifolia	dissotis, pink lady	Melastomataceae	Discourage planting and dumping of garden waste; control escaped populations as needed
Eichhornia crassipes	bung el ralm, water hyacinth	Pontederiaceae	Eradicate if of limited extent

	Scientific name	Common names (abridged)	Family	Comments and recommendations
	Elaeocarpus angustifolius	blue fig, blue marble tree	Elaeocarpaceae	Evaluate for invasiveness or eradicate if found and of limited extent
	Falcataria moluccana	ukall ra ngebard, Moluccca albizia	Fabaceae	Evaluate reproduction and spread (low priority); discourage further planting; control in sensitive and natural areas as needed
	Flemingia macrophylla		Fabaceae	Discontinue planting, control outside of cultivation; eradicate if possible
	Gmelina elliptica	kalngebard ra belau	Lamiaceae	Do not introduce to new islands
	Hedychium coronarium	white ginger	Zingiberaceae	Control outside of cultivation
	Hemigraphis alternata	metal leaf, red ivy	Acanthaceae	Control outside of cultivation
	Hevea brasiliensis	Brazilian rubber tree, Para rubber tree	Euphorbiaceae	Evaluate for invasiveness or eradicate if of limited extent
*	*Hyptis pectinata*	mint weed	Verbenaceae	Evaluate extent and eradicate if possible
*	*Imperata cylindrica*	kasoring, blady grass, cogon grass	Poaceae	Continue eradication program
*†	*Inga edulis*	ice cream bean	Fabaceae	Investigate source and extent, eradicate
*†	*Ipomoea hederifolia*	ivy-leaf morning glory, star ipomoea	Convolvulaceae	Eliminate at the locations where found; survey for it in the road seeding; trace source of contamination
	Lantana camara	lantana	Verbenaceae	Check status of previously introduced biocontrol agents, reintroduce or introduce new ones as appropriate
*†	*Macroptilium lathyroides*	cow pea, phasey bean	Fabaceae	Eliminate at the locations where found; survey for it in the road seeding; trace source of contamination
	Melaleuca quinquenervia	cajeput, paper bark tree	Myrtaceae	Monitor for invasiveness
*†	*Melia azedarach*	Chinaberry, pride-of-India, Indian lilac	Meliaceae	Trace source and distribution, eradicate
	Melinis minutiflora	molasses grass	Poaceae	Monitor for spread, especially if burned; limit burning
	Merremia peltata	kebeas, merremia	Convolvulaceae	Exclude from islands where not present; provide advice to landowners on control
*	*Mikania micrantha*	teb el yas, mile-a-minute weed	Asteraceae	Continue eradication program
	Mimosa diplotricha	mechiuaiuu, giant sensitive plant	Fabaceae	Check status of previously introduced biocontrol agents, reintroduce or introduce new ones as appropriate; exclude from islands where not present.; eradicate on islands with small populations

	Scientific name	Common names (abridged)	Family	Comments and recommendations
	Mimosa pudica	mechiuaiuu, sensitive plant	Fabaceae	Exclude from Peleliu and other islands where not present, eradicate promptly if found
	Murraya paniculata	orange jessamine, satin-wood, Chinese box	Rutaceae	Reduce the number of plants to prevent spread of the citrus psyllid if it should be introduced
	Panicum maximum	Guinea grass	Poaceae	Limit burning
	Pennisetum polystachion	desum, mission grass	Poaceae	Work to decrease burning and other disturbance
*†	*Pennisetum setaceum*	fountain grass	Poaceae	Trace source and distribution, eradicate
	Pithecellobium dulce	kamatsíri, opiuma, Madras thorn	Fabaceae	Locate and monitor for invasiveness
†	*Pluchea carolinensis*	sour bush	Asteraceae	Consider for eradication (low priority)
†	*Pluchea indica*	Indian fleabane, Indian pluchea, Indian camphorweed	Asteraceae	Consider for eradication (low priority)
	Pseuderanthemum carruthersii		Acanthaceae	Control outside of cultivation; eradicate on Sonsorol
*†	*Psidium cattleianum*	strawberry guava	Myrtaceae	Attempt to locate and eradicate
	Psidium guajava	guabang, kuabang, guava	Myrtaceae	Control as needed in sensitive and natural areas
†	*Quisqualis indica*	Rangoon creeper	Combretaceae	Monitor for invasiveness
	Ricinus communis	gelug, maskerekur, uluchula skoki, castor bean	Euphorbiaceae	Monitor spread
*†	*Schefflera actinophylla*	octopus tree	Araliaceae	Confirm eradication
	Scindapsus aureus	pothos, money plant	Araceae	Control outside of cultivation, especially when growing in forested area
	Sesbania grandiflora	katurai, hummingbird tree, scarlet wisteria tree	Fabaceae	Discourage further planting; monitor closely for any spread; eradicate if it begins to spread
	Solanum torvum	prickly solanum, devil's fig	Solanaceae	Evaluate for extent and possible control measures; encourage landowners to control plants on their land
*	*Spathodea campanulata*	orsachel kui, African tulip tree	Bignoniaceae	Continue eradication program
	Stachytarpheta cayennensis	louch beluu, blue rat's tail, dark blue snakeweed	Verbenaceae	Control as needed in sensitive and natural areas
	Stachytarpheta jamaicensis	louch beluu, blue porterweed, light blue snakeweed	Verbenaceae	Control as needed in sensitive and natural areas
	Syngonium angustatum	arrowhead plant, goosefoot plant	Araceae	Control outside of cultivation, especially when growing in forested area
	Syzygium cumini	mesekerrák, Java plum	Myrtaceae	Locate, monitor for invasiveness

	Scientific name	Common names (abridged)	Family	Comments and recommendations
	Tecoma stans	yellow bells, yellow-elder, yellow trumpetbush	Bignoniaceae	Monitor for spread, eradicate on Sonsorol
	Tephrosia candida	white tephrosia	Fabaceae	Monitor for spread
*	*Thunbergia grandiflora*	bungel ‘l etiu, blue trumpet vine, Bengal trumpet	Acanthaceae	Discourage planting; control as needed; eliminate plants outside of cultivation; eradicate in Melekeok and Aimeliik/ Ngatpan; evaluate for eventual eradication in Koror
	Timonius timon	Liberal	Rubiaceae	Eradicate infestations on the Rock Islands; discourage planting; remove individual specimen(s) planted in Koror and Kayangel
	Tradescantia spathacea	kobesos, oyster plant, boat plant, boat lily, Moses in a boat	Commelinaceae	Discourage further planting and dumping; control outside of cultivation
	Tradescantia zebrina	wandering jew	Commelinaceae	Discourage further planting and dumping; control outside of cultivation
	Turnera subulata	white alder	Turneraceae	Discourage further planting; control outside of cultivation
	Turnera ulmifolia	yellow alder, sage rose	Turneraceae	Discourage further planting; control outside of cultivation
*†	*Vitex parviflora*	small-leaved vitex	Verbenaceae	Eradicate if found
	Wedelia trilobata	ngesil ra ngebard, Singapore daisy	Asteraceae	Discourage further planting; local control as needed; exclude from islands where not present

**High priority for eradication*

† Eradication can probably be accomplished at low cost

Annex 2

Executive Order No. 207

Establishing a National Task Force on Invasive Animal Species

Republic of Palau
Office of the President

RECEIVED MAY 2 1 2002

Tommy E. Remengesau, Jr.
President

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EXECUTIVE ORDER NO. 207

Establishing a National Task Force on Invasive Animal Species

WHEREAS, invasive animal species compete with and at the expense of the unique animal species indigenous to Palau; and

WHEREAS, invasive animal species represent a threat to both the unique animal species and the unique plant life found in Palau; and

WHEREAS, invasive animal species have a negative impact on agricultural production, bio-diversity, the health of the inhabitants of Palau and the environmental integrity of Palau; and

WHEREAS, several invasive animal species, including the Long-Tailed Macaque Monkey, the Musk Shrew, and feral pigs, now exist in Palau; and

WHEREAS, the populations of the invasive animal species now existing in Palau are thriving; and

WHEREAS, the threat of additional, new invasions by animal species not indigenous to Palau is real and will increase as more visitors arrive in Palau from more destinations; and

WHEREAS, the Republic of Palau must establish a comprehensive, workable plan to reduce or eliminate the existing populations of invasive animal species in Palau and to prevent additional, new invasions in order to protect and preserve the unique animal and plant species of Palau, maintain and restore bio-diversity, and reduce the negative impact invasive animal species have on agricultural production, the health of the inhabitants of Palau and the environmental integrity of Palau,

NOW, THEREFORE, by the authority vested in me pursuant to the Constitution and laws of the Republic of Palau, I hereby order that a National Task Force on Invasive Animal Species (hereinafter "NTFIAS") be, and hereby is, established with the following characteristics, functions, and responsibilities:

1. Composition. The NTFIAS shall be comprised of the following:

Minister of Resources and Development, who shall be chairman;

Minister of Justice, who shall be vice-chairman;

Director of the Bureau of Agriculture or his designee;

Director of the Bureau of Domestic Affairs or his designee;

a member appointed by the Office of Environmental Response and Coordination; and

two members appointed by the Association of Governors.

In addition, at its organizational meeting, the NTFIAS may choose to invite the Palau Conservation Society and the Nature Conservancy to each appoint one individual to the NTFIAS, which individual(s) shall have full membership status and all rights and duties appurtenant thereto. In the event that any member of the NTFIAS is removed or resigns, the entity which nominated the removed or resigned member shall appoint a replacement.

2. Organizational Meeting. The NTFIAS shall hold an organizational meeting no later than fifteen (15) days after the entry of this Order. At such meeting, the NTFIAS shall set procedures for scheduling and holding meetings, allocate responsibilities among the membership, determine whether or not to invite the participation of the Palau Conservation Society, the Nature Conservancy, or both, and take such other action as appropriate to organize itself and carry out its functions.

3. Inventory of Invasive Animal Species. The NTFIAS shall conduct an inventory of the invasive animal species present in Palau. The inventory shall identify each invasive animal species and, for each, estimate the scope (either in terms of estimated populations or in terms of estimated area of the territory invaded) of the invasion. To the extent practicable, the inventory shall also specify how each species was introduced to Palau.

4. Evaluation of Responses to Invasive Animal Species. The NTFIAS shall investigate methods to reduce and contain or eradicate each invasive animal species existing in Palau. In doing so, the NTFIAS shall consult with knowledgeable individuals in the private sector and officials of the State and National Governments. The NTFIAS may also consult appropriate representatives of foreign governments or international organizations. The NTFIAS will evaluate the various responses to invasive animal species in terms of effectiveness, cost,

potential collateral impacts on plant and animal species indigenous to Palau, and potential impacts on the environmental integrity of Palau.

5. Evaluation of Barriers to Invasive Animal Species. The NTFIAS shall investigate methods to prevent the introduction of invasive animal species to Palau. In doing so, the NTFIAS shall consult with knowledgeable individuals in the private sector and officials of the State and National Governments. The NTFIAS may also consult appropriate representatives of foreign governments or international organizations. The NTFIAS will evaluate the various barriers to invasive animal species in terms of effectiveness, cost, potential collateral impacts on plant and animal species indigenous to Palau, and potential impacts on the environmental integrity of Palau.

6. Development of Comprehensive Strategic Response to Invasive Animal Species. Based on the evaluations described in paragraphs 4 and 5, *supra*, the NTFIAS shall develop a comprehensive strategic plan to reduce and contain or eradicate invasive animal species existing in Palau and to establish barriers to the introduction of invasive animal species to Palau. In developing the plan, the NTFIAS shall explore sources of funding and technical assistance for the implementation of the plan. In doing so, the NTFIAS may consult appropriate representatives of foreign governments or international organizations. Options for funding the implementation of the plan shall be described in the plan.

7. Compensation/Support from the National Government. No member of the NTFIAS shall be compensated for participating as a member of the NTFIAS. However, all Ministries, offices, and agencies of the Executive Branch are hereby ordered to fully cooperate with and, as appropriate, lend assistance to, the NTFIAS. Such assistance may include providing the NTFIAS with space for its offices or meetings, detailing support staff to the NTFIAS, and providing access to supplies and equipment, as appropriate, for NTFIAS functions.

8. Reporting. The NTFIAS shall report to the President on a quarterly basis, fully describing the status of its efforts and its conclusions as of the date of the given report. The final report shall consist of the comprehensive strategic plan described in paragraph 6, *supra*.

9. Term. Unless terminated earlier by Executive Order, the NTFIAS shall terminate forty-five (45) days after delivery to the President of the comprehensive strategic plan described in paragraph 6, *supra*.

SO ORDERED THIS 30th DAY OF APRIL, 2002,

Tommy E. Remengesau, Jr.
President of the Republic of Palau

Annex 3

Status of Marine Invasive Species in the Republic of Palau

Mr. Patrick L. Colin
Coral Reef Research Foundation
P.O. Box 1765
Koror, Palau 96940

Marine invasive alien species (IAS) have the potential to become a problem in Palau. Fortunately at present it appears there are no marine invasive species that are having a quantifiable effect on fisheries, marine tourism or other activity in the ocean. Marine IAS typically come from a small group of marine invertebrates typically introduced as fouling on ship's hulls or other objects in the ocean. Potentially, some could come from ballast water, pumped out in harbors, but less is known about this possibility. The major animal groups with invasives are the ascidians or tunicates (Phylum Chordata, Subphylum Urochordata), hydroids and other cnidarians (Phylum Cnidaria), molluscs (Phylum Mollusca), sponges (Phylum Porifera), bryozoans (Phylum Ectoprocta) and other small groups. Algae also have the potential to become invasives, such as the introduction of *Caulerpa taxifolia* into areas of the Mediterranean Sea, but there is better baseline information on algae of Palau than comparable invertebrate groups.

There is relatively little baseline information for the groups of marine invertebrates that are typical IAS in Palau. Knowledge of marine IAS is largely a result of the work of the Coral Reef Research Foundation for the U.S. National Cancer Institute (NCI), one of the "spin-off" benefits resulting from such activity. CRRF is tasked with providing marine invertebrate and marine plant (algae) samples to the NCI for screening tests for anti-cancer compounds and has to identify each sample to species level. The final identifications are done by specialist taxonomists all over the world.

Work in Palau commenced in 1993 and we have endeavored to find as many different species of organisms as possible for the NCI, hence have generally tried to leave “no stone unturned.” One benefit of this work is that we now have a good idea for many groups what are the common species in Palau, plus have biological reference collections and data to support this information. Due to familiarity with the fauna and flora of Palau, we are able to determine when something "different" is seen. Often that "different" organism is an IS.

Usually, the species dealt with in Palau are identified by taxonomists at their home institutions. The taxonomists do not come to Palau to do this work. However, in early 2000 Ms. Gretchen Lambert and Dr. Charles Lambert came to Palau to examine ascidians growing in Malakal Harbor, and other potential introduced ascidians. They had been working on a similar project with Dr. Gustav Pauley at the University of Guam, so their presence in the western Pacific was an opportunity to bring them to Palau. Gretchen Lambert is one of the few authorities on ascidian taxonomy, and had done similar work identifying introduced ascidians in Hawai'i and Guam. She was able to identify nearly 40 species of ascidians collected by CRRF from the buoys, with their mooring chains and anchor blocks, in Malakal Harbor. It is believed as many as 16 of these are introductions, but generally they seem limited to the harbor area on artificial substrates. Such ascidians are found in fouling communities in harbors worldwide in the tropics and appear to pose no threat to Palau's marine life. This has provided important baseline information on fouling ascidians in Palau. At the time they were visiting Palau, there was a barge in the harbor which had come from the Philippines. We were able to collect specifimens and they

identified 9 species of ascidians from it, some of which were previously unknown from Palau. Overall, they identified 68 species of ascidians from human-made surfaces in Palau. CRRF has voucher specimens and photographs of all these species in our reference collection.

The status of *Eudendrium carneum*

At present only one marine IAS, a hydroid (*Eudendrium carneum*), has the potential for becoming a "pest" organism. It is believed that the organism was introduced with the floating Palau Pontoon Bridge which was brought to Palau in August 1997. CRRF did not examine the floating bridge until April 1998, at which time it was found to have a wide variety of invertebrates growing on it. *E. carneum* was found growing both on the bridge structure and the rocky bottom around the Airai end of the bridge. This hydroid was identified by Dr. Dale Calder of the Royal Ontario Museum, Toronto, Canada.

Subsequent work in the KB channel area has found *E. carneum* growing on rocky bottoms at least 3-4 km from the bridge site. It lives on rocky bottoms, where it forms a tangle of branches that tend to accumulate sediment, making it a fairly unattractive "weed" species. These masses of hydroid tend to make the rocky surfaces of the reef less visible, and tend to make the reef look “dirty.” Fortunately, it does not seem to grow on or kill corals, and does not appear to colonize other living organisms. It does not grow on sediment bottoms.

Another hydroid, *Tyroscyphus furticosus*, was also found growing on the Airai end of the bridge, covering the mooring chains in a layer about 30-40 cm thick. This is probably also an introduced species, but seems to have died back, or at least not expanded its range like *E. carneum*. For *T. furticosus*, it appears to be a situation where the presence of a new, uncolonized substratum (the mooring chains) caused it to "bloom," but it has replaced after a time by a more persistent species.

E. carneum has the potential to spread throughout the rocky bottoms of Palau. At this point there is no conceivable way the species could be eliminated or controlled. It is now part of the local fauna until it dies out by some natural cause. It would be very useful to survey the extent of its distribution at regular intervals. Fortunately the hydroid does not seem to have a strong sting, but is, perhaps, mildly irritating. It could potentially interfere with feeding of bottom grazers, such as parrotfishes and surgeonfishes, which scrape algae from rock surfaces. If it started growing at the popular dive sites, it would potentially make these sites less attractive.

Future considerations

There is always the potential for introductions of marine organisms from fouling communities. Most of the vessels that come to Palau have their bottoms relatively clean, since a heavily fouled bottom makes for poor fuel economy. However, there are cases, such as the barge mentioned above, where thickly encrusted vessels have come to Palau. The barge in question had ascidians, hydroids, and sponges covering every bit of its bottom. CRRF collected about 20 samples of 1 kg weight of each species from this barge for testing. There were jellyfish polyps growing on the bottom, which could have resulted in the introduction of a new species of jellyfish to Palau. We do not know what species the polyps represented, but most likely it was a species that already occurs locally.

In the future, when vessels, barges, and other floating structures are brought into Palau, it will be important to do a survey of the bottoms of such structures upon arrival to see what they might be transporting. If there could be some law or regulation requiring vessels coming permanently to Palau to be scrapped and anti-fouled at their home location prior to coming to Palau, that would be beneficial. Also vessel that become grounded on the reefs of Palau, like the recent aggregate barge off Ngeremlengui, should have a survey done as soon as possible after grounding, to see what species are

on the hull as fouling. Fortunately the Ngeremlengui barge had a very clean hull, but the potential is there for such accidents to introduce undesirable species.

List of marine introduced species	
Probable introductions	**Possible introductions**
Hydroids	
Eudendrium carneum	
Tyroscyphus fructicosus	
Ascidians	
Didemnum perlucidum	*Ascidia aperta*
Diplosoma listerianum	*Ascidia archai*
Lissoclinum fragile	*Botryllus tyreus*
	Ecteinascidia diaphanis
	Eusynstyela hartmeyeri
	Hermania insolita
	Hermania momus
	Microcosmus helleri
	Microcosmus pupa
	Perophora multiclathrata
	Phallusia philippinensis
	Polyclinum nudum
	Pyura curvigona
	Pyura honu
	Pyura vittata

Annex 4

INVASIVE ANIMAL SURVEY

The National Task Force on Invasive Animal Species is collecting information to determine the degree to which invasive animals cause problems in Palau. The answers you provide in this survey will assist in deciding the problem and determining the best solutions. Please fill out each question completely. Use Question 3 if necessary to provide additional responses to answer questions. Thank you for your help.

Definition: Invasive animals are non-native species that have been introduced to Palau, and which tend to increase their population and spread, and have a negative impact on biodiversity, farming, tourism or the human population.

1. **Where do you live**? State _____ Hamlet _____

2. **Types of problem animals**?

Type of animal	Is this type of animal a problem in your State?		What types of problems do these animals cause? (e.g. damage to crops, damage to natural resources, health, public nuisance etc)	If possible, estimate the cost of these problems to you or your family	
	Yes	No		Economic ($ per year)	Other - describe (health, property damage)
Pig					
Macaque Monkey					
Rat					
Dog					
Cat					
Shrew					
Cockatoo					
Eclectus Parrot					
Fruit Fly					
Mosquito					
Rhinoceros beetle					
African Snail					
Cane Toad					

Other (list)					

3. **Solutions to problems?** For each type of animal you feel is a problem, please answer the following

Type of animal (list below)	What, if anything, should be done about these animals?						
	Nothing	New Laws	Trapping	Shooting	Poison	Rewards	Other (please explain)

3. **Additional Comments**: Please provide additional comments or suggestions on controlling invasive animals in Palau.

Annex 5

Project for the Eradication of Alien Rats on Helen Island, Helen Reef, Hatohobei State, Republic of Palau, Micronesia 1 June 2000

PROPOSED BY:
The Hatohobei State Government,
Republic of Palau
&
The Community Conservation Network
Honolulu, Hawai'i

CONTACT:
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Summary

The Helen Reef Atoll is a priority conservation site for marine and coastal biodiversity protection in Pacific Ocean. The Community Conservation Network is working with the historical resource owning community, the people of Hatohobei, to develop a management plan for enhancing the conservation of the Helen Reef ecosystem and its resources. One of the activities identified by preliminary planning efforts is the eradication of recently introduced rats to Helen Reef Island. Rats are viewed as one of the primary threats to the continued existence to ground dwelling sea birds, as well as a serious impact on the reproduction of threatened nesting sea turtle populations. This project proposes to implement a complete eradication of rats on Helen Islands, as well as to incorporate preventative measures and policies to reduce the likelihood of rat reintroduction on the island.

Helen Reef background

Helen Reef is a 162 km^2 coral reef atoll situated between the Palau archipelago in Micronesia and insular Southeast Asia. This large remote coral reef atoll is unparalleled in all of Palau and Micronesia in terms of its ecological integrity, abundance, and biological diversity, and provides habitat for – or otherwise supports – many renowned and critical wildlife populations. Located just north of the equator in the far Western Pacific, Helen Reef is remote from large human settlement, being over 600 km from the main islands of Palau, with Eastern Indonesia 200 km to the south and the Southern Islands of the Philippines more than 400 km to the west. As the largest geologic formation in the Southwest Islands of Palau, Helen Reef, its lagoon and near-shore waters, and associated vegetated low coral islet support a vast diversity of marine habitats and abundance of tropical coastal biota.

Problem context and opportunity

In 1996, two confiscated fishing vessels from the Philippines were anchored and abandoned at Helen Island. Unwittingly, this event introduced rats to the island, which had been previously believed not to harbor alien rat species (Maragos et al. 1994). This introduction was of concern to the community, which quickly initiated a rat control program. These efforts to control rats failed, due to inappropriate rodenticide choice and incomplete bait delivery. While this attempt to eradicate rats demonstrates the community's motivation to undertake conservation activities, it illustrates that technical assistance is necessary to completely and effectively eradicate rats on Helen Island.

This project will plan for an effective rat eradication so that further damage by rats to sensitive sea bird and sea turtle populations is avoided. Effective rat eradication approaches have been developed in recent years with the improvement of delivery systems and rodenticide formulas, namely Brodifacoum (Morrell et al. 1991). An opportunity to conduct rat eradication activities will occur during a resource monitoring expedition to Helen Reef scheduled for July 2000. The community will participate in all aspects of planning and implementation of this project, with expert advice, as a means of furthering involvement and experiences with management efforts. This project will also include the planning of preventative measures to lessen the chance of re-introduction once rats are eliminated (Moors et al. 1992).

Biodiversity features of concern

Many biologists and resource managers have verified the rat as a significant factor in the degradation of island ecosystems, especially island avifaunas (Atkinson 1985). Helen Reef Island (3 ha) and surrounding waters historically supports some of the largest known nesting sea bird colonies in Micronesia (Enbring 1983), all of which are threatened, to a greater or lesser extent, by alien rats. These colonies include brown footed boobies (*Sula Leucogaster*), red footed boobies (*Sula sula*), the great and lesser frigatebirds (*Fregata minor* and *Fregata ariel)*, great crested terns (*Sterna bergii*), black-naped terns (*Sterna sumatrana*), sooty terns (*Sterna Fuscata*), black noddys (*Anous stolidus*), and white terns (*Gygis alba*)(Keppler 1993). The rare coastal nesting population of the great crested tern at Helen is thought to be one of the largest colony remaining in the entire Pacific Ocean (King et al. 1980, in Keppler 1993). In addition, regionally important foraging and nesting populations of green (*chelonia mydas)* and hawksbill (*Eretmochelys imbricata*) sea turtles may be impacted, as rats have been witnessed attaching hatchling turtles (Morrell et al. 1991). The eradication of rats will reduce an important threat to existing nesting sea birds (and sea turtles), and with further management and protection create the conditions necessary for Helen Reef to regain important avifuna components typical of undisturbed Pacific islands though successful re-colonization (Flint 1999).

Objectives

1. To enhance the survivorship of nesting sea birds and sea turtles on Helen Island by eradicating rats recently introduced to and preventing their reintroduction.
2. To catalyze community involvement and participation in site management activities through this important and measurable conservation action.

Activities

1. Design rat eradication plan with community based participation.
2. Community implement and monitoring rat eradication plan
3. Monitor effectiveness of eradication activities
4. Follow-up eradication treatments as needed

Rat eradication design and implantation

Complete eradication of the rat population on Helen Island is the desired outcome of this project. To reach this goal of complete eradication, the island (area = 3 ha) will be gridded with bait stations at 3m apart. Bait station will be composed of PVC piping material constructed in such a way that the bait is available to targets that can fit through a hole the diameter of 6cm. The bait (0.002% Brodifacoum) placed in bait stations will be made available to rats and stations monitored and replenished as necessary for 4 to 5 days. Possible non-target effects (eg: small sand crabs, sea birds) will be monitored for impact. Live traps will also be placed on the island during the final days of the first application of the bait to monitor for rat survivorship. If necessary a second application of bait will be implemented to attempt the complete eradication of any surviving rats. Special safety procedures and handling precautions will be explained and demonstrated to project assistants. Palau EQPB and the Sanitation Division will be contacted and notified of intended activities and invited to participate. All appropriate procedures and practices will followed and adhered to by State and participating agency staff. To minimize the potential for future reintroduction, a rat prevention and education program will be developed for the State.

Deployment strategy:

Assuming 7 days at Helen Reef:
Day 1: Arrive Helen Reef; prepare deployment supplies; lay out 40 kg bait.
Day 2-6: Monitor uptake by crabs, rats.
Day 7: Lay out another 40 kg, depart Helen.

Helen Reef Rat Eradication Project -
July – December 2000
Item description

I. Personnel costs
Project Staff State Staff and Local Assistants (for eradication and follow up over one year) Expert Technical Assistance Rat Eradication Expert.

II. Travel
Round trip travel from Koror, Palau to Helen Reef, JUNE 2000 Cost include travel for Implementation Team.

III. Supplies

Rodenticide: Talon-G WeatherBlok Sufficient supply for the treatment of 3 ha (40 kg) and followup, plus shipping from New Zealand Rodeniticide Bait stations Agricultural pipe Safety Equipment Gloves for handling rats and rodenticide Rodent Live Traps For follow-up monitoring.

IV. Other

Community Planning Meeting Design and Coordinate Community Participation Community Honorarium For participation in eradication and follow-up monitoring

Project Administration For administration costs Miscellaneous Hospitality costs, contingencies, communications, etc.

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Annex 6

PRESS RELEASE
25 October 2002

Quarantine Emergency: NEPC seeks public's assistance to eradicate Tilapia and City Pigeon recently found in Palau

The National Environmental Protection Council is asking for the public's cooperation and assistance to exterminate tilapia and city pigeon recently found in Palau. These species are highly invasive and may have extreme negative impacts on our natural environment if they establish themselves in the wild.

Tilapia breed 3 or 4 times per year, live in both fresh and salt water, and are known for their ability to displace and destroy many other fresh and salt water species. Although tilapia are successfully farmed in some areas, such as Guam, where they have already escaped into the wild, they are a low value fish and are generally considered a pest species that can interfere with aquaculture efforts for other species such as milkfish or bonefish. Aquaculture of tilapia in areas where they are not already present in the wild can result in the loss of native biodiversity as they have the ability to out-compete native species. Tilapia are very difficult to kill; they are resistant to chemicals such as chorine, can withstand prolonged periods out of the water, and have been known to make their way between ponds over land, much like catfish. Individuals seeking to kill Tilapia are encouraged to contact the Division of Fish and Wildlife Enforcement for assistance at 488-2487. If Tilapia ponds or tanks are drained, measures such as screening of drain water through a mosquito net must be taken to prevent escape of juveniles and eggs, and the pond or tank should be kept dry for at least one week. All adult Tilapia should be captured and killed before or during draining to prevent their escape over land.

"City pigeon" or "rock doves" are not native or endemic to Palau and are a potentially invasive pest species. "City pigeon" live for up to 15 years, and pairs produce an average of 15 surviving young per year, so they spread very rapidly if they enter the wild and may displace native species such as the Micronesian Pigeon. "City Pigeon" also carry many diseases that could infect and impact wild and domestic birds and domestic animals, and they can also carry diseases and mites that can infect and impact humans. "City pigeon" are often referred to as "rats with feathers" or "flying rats," and are the subject of pest control efforts in most places in the world. City pigeon are particularly a nuisance and threat to human health because of their habit of nesting over air conditioners and dropping feces into the air conditioner causing the spread of disease to humans.

Efforts are underway to locate and exterminate the invasive city pigeons and on Thursday, October 3, 2002, the Bureau of Agriculture issued a Declaration of National Quarantine Emergency for Eradication of Tilapia.

Importation of any exotic species to Palau without a permit from the Minister of Resources and Development is prohibited under the Endangered Species Act and is potentially subject to a penalty of up to a year in jail and a fine of up to $10,000 per violation. Importation of live animals or plants without a permit is also prohibited under the Plant and Animal Quarantine Regulations of the Bureau of Agriculture. Movement within Palau as well as movement to Palau is considered importation under the quarantine regulations.

The public is urged to cooperate with efforts to eradicate tilapia and city pigeon. No criminal charges are being filed against individuals who voluntarily contact the Division of Fish and Wildlife Protection to assist with efforts to locate and eradicate city pigeon or tilapia.

Anyone with information about tilapia or pigeon in Palau should contact the Division of Fish and Wildlife Protection at 488-2487. Anyone with information about other invasive species should contact Joe Tiobech, at the Bureau of Agriculture 488-2504, the Division of Fish and Wildlife Protection may also be able to assist with other species.

Annex 7

PALAU FRUIT FLY ERADICATION PROGRAM

IMPLEMENTATION PLAN

ERADICATION OF FRUIT FLIES

ATTRACTED TO METHYL EUGENOL

ORIENTAL FRUIT FLY (*Bactrocera dorsalis*)

AND

BREADFRUIT FLY (*Bactrocera umbrosa*)

(January 2001)

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Contents

INTRODUCTION

Under the charter of the FAO/AusAID/UNDP/SPC Project on Regional Management of Fruit Flies in the Pacific and following a request for assistance from the Government of the Republic of Palau, studies on the technical feasibility and economic viability of the eradication of oriental fruit fly (*Bactrocera dorsalis*) and breadfruit fly (*B. umbrosa*) were undertaken by Allwood et al. (1999) and McGregor (2000). The reports from these studies showed clearly that it was technically feasible and economically beneficial to eradicate oriental fruit fly. The eradication of breadfruit fly at the same time and at no extra effort or cost would be a bonus. Not only would agriculture and the people of Palau benefit considerably from the eradication program, but also the quarantine risk of oriental fruit fly's spreading to other Pacific Island countries and territories in the region would be greatly reduced.

Predictably, during the short time since these studies were completed, oriental fruit fly has expanded its host range and is now causing very high levels of damage and losses to a wide range of fruits and vegetables in Palau. Some fruits such as mountain apple (*Syzygium malaccense*) and carambola (*Averrhoa carambolae*) are sustaining such high levels of damage (up to 100%) that people no longer bother harvesting or eating them. Fruits fall to the ground, are not collected and destroyed, and, as major breeding sites for oriental fruit fly, add to the already sizeable fruit fly population. Other commodities such as guava and 'Cavendish' and 'Maad' type bananas are suffering losses of 80%, if left on the tree to colour, a normal practice in Palauan culture. Bananas are now being harvested at mature green stage to avoid damage. Guava and mango continue to be harvested green and eaten with soy sauce to avoid damage by fruit flies. It is expected that vegetables such as tomatoes, eggplant, capsicum and chillies will suffer damage by oriental fruit fly in the near future. The situation is likely to worsen unless urgent action is taken.

The Committee of Transition, set up by the new Government in December 2000, identified several initiatives, which will focus on agricultural development, diversification, and expansion. Three of the initiatives are to develop separate strategic plans for implementing the recommendations of the National Task Force on Agriculture Development, for diversifying and increasing the level of agricultural production, and for supporting subsistence agriculture. Other initiatives recommended that the viability of establishing a central Farmers' Market in Koror be reviewed and determined and that technical support for the development of agricultural products and markets be improved.

Essential to the prospects of achieving positive results from these initiatives is the eradication of oriental fruit fly from Palau. The Transition Committee recognized that this was essential and included in its Report an initiative to develop and implement a fruit fly eradication program. This initiative has to be activated within the first 100days of the new Government's term. The development of the Implementation Plan for the eradication of oriental fruit fly was a recommendation of the feasibility report by Allwood et al. (1999) and is now formalized as part of the activities under the Government's initiatives.

The Implementation Plan is sub-divided into broad activities, namely, Management, Regulatory, Public Awareness, Field and Laboratory, Training, and Contingencies. A Schedule for the Implementation of the Palau Fruit Fly Eradication Program is provided as Attachment A. It was considered necessary to update the report by Allwood et al. (1999) and this was done in the attached Addendum (Attachment B). The Implementation Plan should be read in conjunction with the reports by Allwood et al. (1999) and McGregor (2000) and Attachments A and B.

INFORMATION ON FRUIT FLIES IN PALAU

The report by Allwood et al. (1999) contains information on the distributions and economic importance of fruit flies in Palau. In summary, there are two species of fruit flies, which are attracted to methyl eugenol (oriental fruit fly and breadfruit fly) and one species attracted to cue-lure (mango fly (*B. frauenfeldi*)). A fourth species, *B. calophylli*, is not attracted to either lure. It is not an economically important species, occurring only in the wild fruit of *Calophyllum inophyllum*. The distribution of oriental fruit fly in Palau is now well known, with the exception of information from Southwest Islands, where trapping still has to be done. It occurs on all islands, including the Rock Islands, Kayangel and Peleliu. The number of traps currently being serviced by DAMR has changed only marginally. Two extra traps have been placed on two Rock Islands to give better coverage than that in 1999.

The major change in the fruit fly situation in Palau is, as stated earlier, the vastly increased losses that are now occurring as a result of oriental fruit fly numbers increasing and the host range expanding. This is typical of species, like many of the '*dorsalis*' complex fruit flies, which have been recently introduced into new areas.

ERADICATION OPTIONS AND PRINCIPLES OF THE TECHNIQUES

The options for eradication in Palau include the Male Annihilation Technique, commonly referred to as MAT, and protein bait spray technique, sometimes referred to as BAT. Other methods of fruit fly management or control will be used to supplement these techniques. For example, sound crop sanitation by destroying fallen or damaged, unwanted fruits and the release of parasitoids such as *Fopius arisanus* and *Diacasmimorpha longicaudata,* will be encouraged as an integrated approach to reducing fruit fly populations.

Male Annihilation Technique (MAT)

The most appropriate technique of eradication of species of fruit flies attracted to methyl eugenol is MAT. Methyl eugenol is a very powerful attractant for male fruit flies. The technique consists of combining the attractant with an insecticide, impregnating bait stations made of paper mâché with the mixture, and distributing them over large areas either by ground teams or from a helicopter. The principle of the technique is that the male flies are attracted to the bait stations and, providing they are distributed at 400-600 per km², the male population will be reduced to the point where no mating occurs. The population eventually will crash and the species attracted to methyl eugenol will be eradicated.

It has been successfully used for eradication of oriental fruit fly in Okinawa (Japan) and Rota Island (Commonwealth of the Northern Mariana Islands). MAT, using the toxicant malathion, was one of the techniques used for the eradication of Asian papaya fruit fly (B. papayae) and Philippine fruit fly (B. philippinensis) in northern Queensland and Northern Territory of Australia, respectively. MAT was successfully used for eradication of oriental fruit fly and Pacific fruit fly (B. xanthodes) in Nauru and for the eradication program for oriental fruit fly in French Polynesia currently being run. In Nauru, for the first time, the insecticide Fipronil was incorporated with methyl eugenol, replacing malathion as the toxicant. Melon fly (B. cucurbitae) was also eradicated from Nauru, but by using fibreboard blocks impregnated with cue-lure and Fipronil.

Protein Bait Spray Technique

All female fruit flies require a feed of protein before they are able to lay viable eggs. This requirement by female flies is used in rearing fruit flies in the laboratory and is also used to control fruit flies in fruit and vegetable crops or in eradication programs. Small amounts of a bait made of protein autolysate or hydrolysate plus an insecticide are applied to the leaf surface. The female fruit flies are attracted to the protein and are killed by the insecticide as they feed. The bait attracts particularly the sexually immature females, but will attract sexually mature females and also male flies.

In the eradication program in Palau, protein bait spraying will be used in situations where populations of oriental fruit fly and breadfruit fly persist and are difficult to bring under control with the blocking program. These areas are referred to as 'hot spots'. Protein bait will applied using ground teams with small hand held single-action sprayers ('Rega' sprayers), so that the application is controlled. Aerial application of protein bait sprays will not be used.

The preferred source of protein is from Mauri Yeast Australia. It is called Mauri Pinnacle Protein Insect Lure (MPPIL) - Low Salt (420g of protein per litre). The recommended rate of use in Australia is 30-60 ml of the MPPIL, made up to one litre with water. For Palau, the rate of use will be 30 ml of MPPIL made up to one litre with water.

The insecticide is available as Fipronil powder gel containing 1% Fipronil weight by weight. The powder gel is sprinkled slowly on the surface of a protein/water solution and stirred vigorously. It is mixed with the protein/water solution at the rate of 5g Fipronil powder gel per litre, resulting in a 0.005% solution. The resultant liquid bait is as the name suggests a gel. The thickened mixture sticks to the underside of the leaves of fruit trees and is tolerant to being washed off the leaves by rain, a distinct advantage under weather conditions in Palau. The deposits on the leaves will re-hydrate after it has dried, making it attractive for a relatively long period. The protein bait mixture may be applied to the underside of leaves in spots of 10-15ml at the rate of 25 spots per hectare or 10 spots per acre. In an eradication programme, this mixture is applied to leaves of fruit trees in hot spot areas on a weekly schedule for about 4-6 weeks or until the population is managed.

MANAGEMENT ACTIVITIES

Development and Submission of Implementation Plan

The development of the Implementation Plan has taken place in consultation with staff of Department of Agriculture and Mineral Resources (DAMR) and the Environment Quality and Protection Board (EQPB). The prospective activities, budget, and timeframes were presented for discussion to a seminar attended by 29 representatives of the Government, institutions, and interested groups in Palau Pacific Resort on 31 January. A representative from Aventis CropScience Pty Ltd presented, for discussion, information on the new technologies, namely BactroMAT M-E and Bactrogel. The Implementation Plan has taken into account the initiatives of the Government of the Republic of Palau identified in the Report of the Transition Committee. Attached to the Implementation Plan is an Addendum to the Feasibility Study on the Eradication of Fruit Flies Attracted to Methyl Eugenol (*Bactrocera dorsalis* and *Bactrocera umbrosa* in Palau, 10-23 August 1999 by Allwood et al. The Addendum updates the study report.

The report by Allwood et al. (1999) and the subsequent Addendum enunciated the Management Structure that is needed to run the PFFEP. The Management Structure has not changed, but is a minimum requirement. However, it is important to stress that, unless the full-time staff recruited to perform the respective functions are dedicated solely to the activities of the PFFEP for two years, there

will be inefficiencies that are likely to adversely affect the achievement of objectives of the PFFEP. Also, it is imperative that the staff used in the PFFEP are high achievers, are fully committed to the activities, and are able to become an integral part of a very proactive team.

Appropriation of Funds

The commencement of the Palau Fruit Fly Eradication Program (PFFEP) is dependent on the availability of funds from the Government. The Implementation Plan has been developed assuming that funds would be made available almost immediately after the Implementation Plan is submitted and accepted. On this basis, the activities are due to commence in March 2001. If funds are not made available almost immediately, then activities will need to be re-scheduled accordingly.

It is important that the commitment of funds be for a minimum of two years rather than on an annual basis, so that activities later in 2001 or in 2002 are not curtailed in any way due to deficiencies or lateness in funding. It is imperative that, subject to satisfactory delivery and progress, funds are not reduced before the proposed PFFEP is completed. Before any reduction in funding is contemplated, the progress of the PFFEP needs to be technically assessed to determine if final eradication is feasible or not within the timeframe and budget.

Because the PFFEP is dealing with a complex biological system, it is important to maintain a high degree of flexibility and the capacity to respond quickly to particular situations that may arise during the running of the program.

Technical Audit and Advisory Committee

To assist in maintaining quality of the technical delivery of the PFFEP, a Technical Audit and Advisory Committee (TAAC) should be formed at the start of the program. The TAAC should comprise the members of the ex-Sub-Committee on Fruit Fly Eradication plus the Fruit Fly Coordinator of the Fruit Fly Management Project in SPC, and an external consultant with considerable expertise in project management, fruit fly management and eradication programs. The TAAC should liaise closely with the EQPB and the Office of Environmental Response and Coordination (OERC).

The TAAC should be responsible for monitoring the progress of the PFFEP, for facilitating the technical inputs and management of the program, for keeping the Government informed of the achievements and needs of the program, and providing technical backstopping for the PFFEP Manager and the Government. The TAAC should meet as necessary, but at least quarterly.

Recruitment of Full-Time and Part-Time Staff

The Schedule for Implementation of the PFFEP and the budget identifies the full-time and minimum number of part-time staff needed to run the program. It is imperative to recognize that staff currently occupying a position within the Government cannot undertake the duties of their current position and perform the duties of a position with the PFFEP concurrently. Staff working on activities of the PFFEP need to be dedicated to these activities and these activities alone. This is particularly so for the positions of PFFEP Manager, Plant Protection Officer, Coordinator Field Operations, and Public Awareness Officer.

The position of the PFFEP Manager is critical to the success of the whole program. This position needs to be filled urgently once the funding has been secured. The appointee needs qualifications and experience in entomology and running fruit fly eradication programs and wide experience in people and project management. It may be an advantage to appoint someone from outside of Palau, but the

appointee must be sensitive to the ways of Pacific Islanders. It should be the PFFEP Manager's role to arrange the recruitment of the other positions, focussing on the need to create very effective teamwork.

Laboratory, Office, and Storage Facilities

The existing laboratories are adequate, except that there is insufficient space for processing and holding the very large number and volume of fruit samples, which will be necessary in a program such as thIslands It must be remembered that fruit sampling becomes the major method of assessing the effectiveness of the MAT and BAT. Once MAT has been implemented, the usefulness of the trapping system to monitor methyl eugenol attracted fruit flies becomes less, because of the direct competition between the traps and the bait stations.

The storage space in the existing laboratory is inadequate. Extra storage will need to be provided for BactroMAT M-E bait stations, MPPIL, Bactrogel, and containers for fruit rearing. Securing two shipping containers and setting these up near the existing laboratory/office would overcome this shortage. One could be used for storage and one, with internal shelving, could be used for holding fruit samples. Both need to be weatherproofed with a simple roof and silicon sealing of vertical walls if necessary. Both must be air-conditioned.

The office space is not adequate for all of the PFFEP staff, who require office space. More effective use of other areas adjacent to the existing Fruit Fly Laboratory is necessary.

Procurement of Supplies and Equipment

The essential issue relating to procurement is to ensure that orders are placed early and that arrangements for early payment are made. For example, the supply of BactroMAT M-E is essential to the program and must be ordered well in advance to ensure that the 192,000 bait stations needed for each campaign are in Palau in good time. It would be sensible to purchase enough for two or three campaigns to ensure that there is no shortage and that freight rates are the best available. Aventis CropScience Pty Ltd has indicated that BactroMAT M-E can be supplied in lots sufficient for six months, providing adequate air-conditioned storage space is available. Providing storage is air-conditioned, no problem with effectiveness of the bait stations should occur. As far as possible, supplies should be brought in by ship, rather than by air to save on the cost of freight.

Access to GIS, Maps and Aerial Photographs

Access to a Geographic Information System (GIS) will make reporting on trapping, fruit surveys, bait station application, and protein bait spray application easier and clearer. The Department of Lands and Survey has the capacity and has indicated willingness to assist the PFFEP in using this technology and setting up a model that could be used for eradication programs in other PICTs. This needs to be in place very early in the program.

Contracts for Helicopter and Consultants

At this stage, a quotation to provide a H500 helicopter from Americopter of Guam has been received. The details are with DAMR. It is necessary to arrange a contract for the PFFEP work well in advance of the proposed start date in July 2001, so that arrangements can be made to ship the helicopter to Palau for a period of 12 months and perform the necessary modifications and calibrations. Should the US Military become involved in the provision of the helicopter services, then a formal arrangement or memorandum of understanding may be required.

It is important to understand that, by using a private company, there is a greater chance of having the same helicopter crew throughout the program. This represents a tremendous advantage in getting the job done as efficiently and effectively as possible. Using the same crew will result in time- savings as each campaign is done and there will not be the need to provide training for a new pilot before each campaign.

The helicopter and crew must have the capacity to fly accurate 100 metre transects at about 30 metres above the tree canopy and to fly at around 50-70 kph. To ensure that this is possible, the helicopter must be equipped with a continuous display Geographic Positioning System (GPS) that is normally used for ground tracking for crop spraying. In this type of program, precision is imperative for a number of reasons. The distribution of bait stations needs to be thorough and precise. Areas that are missed may become small pockets for breeding fruit flies, which reinfest treated areas. The observer in the helicopter must carefully record treated areas on maps sub-divided into clearly defined sectors. Also, precision will ensure that sensitive areas are avoided during helicopter drops.

Assuming that a consultant is to be used for the TAAC, a contract for his/her inputs is necessary. SPC may be able to assist with a identifying an appropriate consultant, if necessary.

Reporting on Progress and Delivery

Regular reporting on the progress of the PFFEP and the delivery of services needs to be made to Government. The PFFEP Manager should report on a regular basis (probably quarterly) on the technical and management issues related to the program. The format for the report needs to be negotiated between the PFFEP Manager and DAMR, but it needs to simple and not time consuming.

Insurance for Helicopter Workers

Special insurance for the Government workers involved in the helicopter dropping of BactroMAT M-E bait stations may be necessary. DAMR needs to investigate the best options for this insurance coverage. The coverage of government insurance may be adequate.

REGULATORY ACTIVITIES

Initiation of PFFEP

The PFFEP will commence as soon as funding is available. It is necessary to provide a legislative basis for the program. This could be done by either declaring the PFFEP a National Emergency under Sections 2.27 and 2.28 of the Plant and Animal Quarantine Regulations or by Executive Order of the President or Presidential Directive. Whichever method is chosen, DAMR needs to put in place the necessary action and documentation as soon as possible.

Fruit Movement Controls and Inter-Island Quarantine

Preparation needs to be made to impose movement controls on fresh fruits and vegetables both from overseas to prevent the incursion of new species of fruit flies and, when appropriate, between islands, as they become free of oriental fruit fly and breadfruit fly. Quarantine in DAMR needs to consider and develop the mechanisms involved well in advance so that the timing of the imposition of movement restrictions is precise and not delayed because of uncertainty. Discussion on this issue with the SPC Plant Protection (Micronesia) Project may be beneficial.

Final Clearance for the PFFEP from EQPB

Because the PFFEP will use the insecticide Fipronil in both BactroMAT M-E and Bactrogel, EQPB requested that the Implementation Plan be submitted so that the use of Fipronil can be approved. The Implementation Plan must be submitted urgently to EQPB.

As a flow-on from this action, DAMR should document the technical information of the use of BactroMAT M-E and C-L and Bactrogel, with the view of applying for formal registration and approval for use of all three formulations for fruit fly management in general. A combination of BactroMAT C-L and Bactrogel will reduce the losses caused by mango fly, a fly attracted to cue-lure and the fly that will remain after the PFFEP is successful.

The use of other formulations of Fipronil, e.g. for use for termite control, ant control, and cockroach control may be appropriate at the same time.

Increased Quarantine Vigilance

The Budget contained in the Addendum includes salary provision for two additional Quarantine Officers, with the aim of increasing quarantine inspections for fresh fruits and vegetable, being brought into Palau with or without permits. The objective is to reduce the risk of new introductions of exotic fruit fly species, which would jeopardize the expected achievements of the PFFEP. These officers would also assist with the imposition and policing of inter-island quarantine, when it is required, and permanent quarantine surveillance to identify new incursions of exotic fruit flies.

Quarantine signage and quarantine bins at the Palau International Airport make the traveller aware of the dangers of carrying fruits and vegetables without permits and the importance of fruit flies as a pest and requests travellers to dispose of fruits in the bins or declare them to Quarantine. Maintaining at least this level of quarantine awareness is imperative. There may be some Rock Islands visited by tourists and Palauans, which are not infested with oriental fruit fly and it is important to keep these islands free. As the PFFEP takes effect, oriental fruit fly and breadfruit fly will be progressively eradicated from the Rock Islands and other islands. Quarantine signs warning of the dangers of taking fruits and vegetables from infested areas into areas that have undergone eradication and warning of the penalties of moving these commodities into uninfested areas must be developed by Quarantine, in liaison with the PFFEP Manager and the PPM.

One way of improving this quarantine vigilance is to enlist the help of school children by running awareness programs in schools. Children may remind parents of the importance of quarantine, fruit flies and moving fruits and vegetables. This awareness needs not be restricted to the importance of fruit flies, but should cover other quarantinable pests and diseases.

Declaration of Successful Eradication

Criteria for the declaring Palau free from oriental fruit fly and breadfruit fly need to be developed early in the life of the PFFEP. A minimum requirement would that Palau or areas of Palau are free from one or both of these species, indicated by intensive trapping and fruit sampling, for at least two generations of the fly species. This would amount to a freedom period of about 2-3 months. However, under the conditions that exist in Palau, it may be appropriate to be a little more conservative and suggest a period of freedom of at least six months before a declaration of eradication should be made.

It is important to recognize that the density of traps may need to be increased as the numbers and distribution of flies decrease as the MAT and BAT programs take effect. Also, the reliance on methyl eugenol trapping as a sole indicator of fruit fly numbers will be reduced due to the competition between the traps and the bait stations. More reliance has to be placed on fruit sampling.

PUBLIC AWARENESS ACTIVITIES

Recruitment of Public Awareness Officer

Recruitment of the Public Awareness Officer needs to be done as soon as the PFFEP Manager is in place. The public awareness activities must be commenced in March and continue for the duration of the PFFEP. This person is the first point of contact for enquiries from the public and must be dedicated completely to the task rather than being shared with another government department.

Official Launch of PFFEP

The official launch of the PFFEP should take place in March 2001 and be used as a promotion and public awareness exercise to get the message of how serious the problem of losses caused by fruit flies is and what is involved in the proposed PFFEP. Television and other media coverage is necessary.

Establishment of Public Awareness Working Group

Public awareness is extremely important in a campaign as complex as thIslands To be effective, it must involve the whole community. Setting up a Public Awareness working Group, which has representation from community groups, NGOs, and appropriate government departments, will assist the Public Awareness Officer in getting a coordinated message out to the public. Representation may come from DAMR, EQPB, Health, Education, National Informal Education and Sustainable Livelihoods Project, OERC, Bureau of Women's International, Palau Conservation Society, and the Palau Community College. The working group should be established as soon as the Public Awareness Officer is appointed in March 2001 and should met as necessary.

Development of Public Awareness Program

All forms of media and as many avenues as possible should be used for public awareness. Programs that involve radio, television, and newspapers need to be developed urgently. A short video on fruit flies, the damage they cause to fruits, and the eradication techniques to be used in Palau, should be produced for regular airing on local television and distribution to schools and other education institutions.

A monthly newsletter can be produced very cheaply and distributed through schools, government offices, supermarkets, and shops. The purpose of the newsletter is to keep everyone informed of the achievements of the PFFEP, the proposed activities such as the bait station distribution program and the protein bait spray program, the assistance that the public can provide, and any inter-island quarantines that are imposed as a result of successful eradication in some areas.

Workers involved in the PFFEP should be supplied with readily identifiable caps and T-shirts. Aventis CropScience Pty Ltd of Australia has indicated that it may be prepared to donate caps and T-shirts with an appropriate design depicting the PFFEP and for advertising the importance of the program. The Public Awareness Officer needs to liaise with Mr Richard Bull of Aventis CropScience Pty Ltd, Brisbane.

The Public Awareness Officer must liaise closely with community and women's groups and NGOs. It is expected that, if the public awareness working group or committee works effectively, then this contact will occur regularly.

Notification of Public and Farmers of Schedule of Campaigns

It is the responsibility of the Public Awareness Officer to notify the public and farmers of the schedule for the aerial and ground distribution of BactroMAT M-E bait stations and the ground application of protein bait spray in urban and village areas. This must be done one week before the campaign begins. Reminder notices to householders to tie up their dogs need to be put over the local radio station on a daily basis during the distribution of BactroMAT M-E bait stations and the application of Bactrogel protein bait sprays.

FIELD AND LABORATORY ACTIVITIES

Review and Modify Current Trapping and Host Surveys and Data

Currently, DAMR is servicing monthly 112 permanent trap sites on Rock Islands (30 traps), Peleliu (6), Angaur (6), Babeldaob (51), Koror (13), and Kayangel (6). The raw data accumulated from these traps need to be placed on one file and the data entered into an EXCEL spreadsheet that has been set up by the SPC Fruit Fly Management-Pest Management in the Pacific Project (FFM) in January 2001. These data will provide valuable baseline information on seasonal trends in fruit fly populations. Combined with data from host surveys, the trapping data give an indication of the areas where high populations of oriental fruit fly and breadfruit fly occur and where the eradication program may have to focus its activities.

It is recommended that the trap sites on Koror and Babeldaob be rationalized. For example, on Babeldaob, the number of trap sites may be reduced from 51 to 20, but still maintain a reasonable geographic distribution of the whole island. This will reduce the time spent on sorting flies. It is recommended also that the traps be cleared every two weeks instead of monthly as is done now. The number of traps on Koror could be reduced to ten and cleared every two weeks.

Although there are difficulties in regular transport, trapping on the Southwest Islands is essential to determine if oriental fruit fly and breadfruit fly are present or not. Also, it is important to determine if there are other exotic fruit flies on these islands, which are close to Indonesia and Papua New Guinea. Both countries have Asian papaya fruit fly and a number of other economically important fruit fly species. This survey should be done in February or March 2001. Arrangements should be made for people living on the islands to regularly service traps that are permanently located there.

As the numbers of flies decrease as a result of the PFFEP, it is likely that the numbers of traps will have to increased and they will have to be cleared weekly on Koror and Babeldaob and every two weeks elsewhere. This is necessary to provide guidance to the PFFEP Manager and the eradication teams.

The level of host surveys currently being carried out is inadequate. Compiling from fruit surveys a comprehensive list of edible/commercial fruits and wild/forest fruits, which are hosts to oriental fruit fly and breadfruit fly, provides essential information that will be used during the PFFEP. It is important to remember that once BactroMAT M-E bait stations are distributed, the traps using methyl eugenol are less effective due to the competition between the traps and the bait stations. Greater reliance on the results of host surveys will be necessary.

It is recommended that the common host fruits such as guava, carambola, mountain apple, and *Terminalia catappa* be collected and the fruits held in individual containers to determine the percentage of the fruits that are infested. This baseline information will be valuable in assessing the effectiveness of the PFFEP once BactroMAT M-E bait stations are applied.

Trapping and Host Survey Program During PFFEP

Results from trapping and host surveys form the basis of the weekly reports from the Plant Protection Officer to the PFFEP Manager and the decisions on the activities of the PFFEP by the PFFEP Manager. The weekly reports will identify the locations of 'hot spots', i.e., areas where persistent breeding populations of fruit flies occur or where extra BactroMAT M-E bait stations need to be distributed or Bactrogel protein bait sprays need to be applied. To do this effectively, records need to be kept up-to-date and computerized so that graphical reports for each trap site may be produced as necessary. Comments on the number of traps and the frequency of clearing the traps are provided in the previous section.

Package of Fruit Fly Management Practices

While the PFFEP is taking effect, field control of fruit flies should be implemented to reduce the very high levels of loss currently occurring. The PFFEP Manager should develop, in liaison with the Coordinator of the SPC FFM, a package of fruit fly control practices, which may be implemented by backyard or commercial growers. The package should include physical control (bagging of fruits), cultural control (harvesting fruits early and crop sanitation by destroying fallen fruits), biological control (use of parasitoids), and behavioural control (BactroMAT M-E and C-L bait stations and Bactrogel protein bait sprays).

The package should also address the issue of increased quarantine vigilance for inter-island movements of fruits and vegetables and the likely illegal movements of fruits by international passengers entering Palau and nationals returning to Palau.

Confirmation of the Status of Biological Control Agents

Although parasitoids are unlikely to control fruit flies on their own, they should be included into any integrated approach to controlling or eradicating fruit flies. It is believed that *Fopius arisanus* was introduced into Palau in about 1969, based on two specimens in the Belau National Museum. Parasitoids, which were *Fopius* like, have been recently recovered from carambola fruit samples. Its presence needs to be confirmed before any further efforts are made to re-introduce or introduce the parasitoids from Hawai'i for laboratory multiplication and release.

Documentation of Safe Practices

In consultation with Palau EQPB, OERC, and possibly Health, documentation of safe practices for the use of BactroMAT M-E bait stations and Bactrogel protein bait sprays should be completed well before the PFFEP field operations commence. All staff of the PFFEP must be trained in these practices.

Documentation of Monitoring Systems for BactroMAT M-E and Bactrogel Application

In consultation with Aventis CropScience Pty Ltd and SPC FFM, a system of monitoring the application of BactroMAT M-E and Bactrogel needs to be developed. Ground teams and the helicopter team must record, on detailed maps, the areas that have been treated. This must be done on a daily basis, with the maps being returned to the PFFEP Manager so that the next day's treatment can be

planned. The information on each map must include date, number of people in team (for ground teams only), number of bait stations distributed/litres of protein bait spray applied, estimate of area covered, actual area covered marked on the map provided, any problems such as difficulty in gaining access to areas or compounds, and areas where there are particularly large concentrations of fruit trees or fallen fruits.

The information identified above, together with trapping and host fruit data, should be incorporated into the GIS system under Lands and Survey. The framework for this needs to developed prior to the application of MAT or protein bait sprays. Using GIS will provide the capacity for regular and detailed reporting needed to make decisions on the PFFEP.

Supplies of BactroMAT M-E and Bactrogel

Early ordering and supply of BactroMAT M-E and Bactrogel is essential to the effective operation of the PFFEP. Early ordering will also ensure that supplies can be sent from Australia by sea-freight, thus saving the very large costs of air-freight. To guarantee timely supply, orders must be placed at least four months prior to the time the materials are needed, i.e., ordered in early March to guarantee supply for the July campaign. Ordering sufficient materials for six months operation will ensure the materials are available and the freight costs are kept to a minimum.

GPS Capacity for Helicopter and Other Activities

The helicopter must be equipped with a GPS system that has the capacity to fly very accurately transects 100 metres apart for long distances, with ground tracking with continuous digital display, similar to the technology used by aerial operators for crop pest control.

The PFFEP should purchase two GPS units that may be used for locating traps and host trees with latitude and longitude readings so that these data can be included into the GIS system.

Mapping of Ground/Aerial Application Areas and Environmentally Sensitive Areas

Prior to the ground and aerial application activities, areas that will be treated with BactroMAT M-E and Bactrogel must be identified on reference maps. At the same time, sensitive areas, such as the major watersheds used for supply of drinking water should be identified on reference maps (e.g. a stand-off area of 50 metres on either side of the Ngerimel and Ngrikil Rivers and the dam areas)

It is highly unlikely that mangrove areas will have host plants for oriental fruit fly or breadfruit fly, so there is no need to treat these areas by helicopter or from the ground. However, it will be necessary to treat the vegetation adjacent to the mangroves. To facilitate the identification of mangrove areas, mangrove areas should be clearly identified on the reference maps. As well as reducing the time and costs of aerial application of BactroMAT M-E, it will ensure that the bait stations are not dropped into this sensitive marine environment.

PFFEP and Lands and Survey should be responsible for the exercise of identifying these areas by the end of May 2001. Close liaison and collaboration with EQPB, OERC, and the Palau Conservation Society must be maintained at all times.

A map dividing Palau into treatment sectors should be produced so that the helicopter team and the ground teams have achievable daily targets. Lands and Survey may be able to assist with this exercise and may be able to produce the maps with sufficient details.

Adoption of Fruit Sanitation and Destruction Methods

All communities should adopt immediately sound crop sanitation by daily collection and destruction of unwanted fallen, damaged, or over-ripe fruits. Putting the collected fruits into garbags or plastic bags without any holes, securely sealing the bags, and placing them in the sun will kill the maggots or larvae. Heating fruits in this way to about 48-50°C will kill the maggots. If this practice is done over large areas, the impact on fruit fly populations may be significant and will certainly assist the overall PFFEP. To convince everyone to cooperate, a proactive public awareness campaign, identifying the benefits of this practice, is necessary and needs to start as soon as possible.

Calibration of Helicopter Drops

The calibration of the dropping of BactroMAT M-E by the helicopter team must be done in June as soon as the helicopter is operational. This should involve identifying the combination of ground speed, height above the canopy, and the time interval between drops of the BactroMAT M-E bait stations to achieve a interval between bait stations of 25 metres. Ground speeds of 50 and 60 kph should be tested. The time interval between the drops of BactroMAT M-E should be about two seconds. The height above the canopy should be 30 metres. The pattern of BactroMAT M-E on the ground should be about 350-400 bait stations per km² for the combination of 50 kph, two-second drop interval and 30 metres above the canopy. At 60kph, the number of bait stations per km² would be reduced to about 300, which is probably too few.

Distribution of BactroMAT M-E

The method of distribution of BactroMAT M-E bait stations to be used in Palau will include:

. Paper mâché bait stations soaked in mixture of methyl eugenol and Fipronil will be distributed every 8 weeks for up to eight campaigns at a bait station density of 350-400 per km² by helicopter over Palau, with the exception of urban areas on Koror and Babeldaob, small villages elsewhere, and in the specified watersheds. In urban areas of Koror and Babeldaob and in small villages, the bait stations will be distributed, at a density of 400-500 per km², by ground teams. The higher numbers of bait stations to be used in urban and village areas are advisable because the incidence of fruit flies is higher in these areas, compared to that in rainforest or native vegetation areas. Teams in Koror will comprise six teams of four people for two days and for other areas four teams of four people for two days will be used. This distribution pattern equates to a bait station every 40-50 metres.

. Special attention will be paid to application of bait stations to watersheds. These areas will be identified on maps. Bait stations will not be dropped closer than 50 metres to the edges of specified watersheds. Where necessary, ground applications will have to be done.

. Helicopter drops will be done on the basis of runs at 100 metre intervals, probably in east-west and west-east directions. The height and air-speed will be decided after calibration by carrying out passes at different combinations of height and air-speed at the local airport. However, it is expected that the bait stations will be dropped from about 30 metres above the canopy, at a speed of about 50 kph, and a drop interval of about two seconds. This combination should give accurate control of where the bait stations are positioned.

. The insecticide of choice for the eradication program in Palau is Fipronil. It is registered in Australia for numerous uses, including control of banana weevil borer, rice seedling pests in an aquatic environment, plague locusts, and turf pests, and for integrated pest management of pests of crucifers, brassicas, and cotton. The formulation of Fipronil used to impregnate the fibreboard blocks in virtually

insoluble in water and, consequently, poses little risk environmentally. It is also used in very small quantities - 5mg per bait station. The Palau EQPB will approve the usage of Fipronil upon acceptance of this Implementation Plan.

The bait stations will be prepared under contract by Aventis CropScience Pty Ltd based in Brisbane, Australia. They will be supplied already treated with plant ties for attaching to trees. This means that there will be no need to store or mix either methyl eugenol or Fipronil on Palau. This approach ensures that there will be no spillages or other environmental problems.

Identification of Fruit Fly Population 'Hot Spots'

Records of oriental fruit fly and breadfruit fly from traps and regular fruit surveys will assist in identifying 'hot spots' of persistently high fruit fly populations. The Plant Protection Officer has the responsibility of collating data and reporting on the incidence and location of 'hot spots'. Though identification of these areas may be possible after the first BactroMAT M-E application, realistically these areas may not be clearly identifiable until after the second bait station application.

When 'hot spots' are identified, it is necessary to confirm this by intensified trapping over an area of about 200 metres radius and sampling of host fruits to determine if there is a breeding population in the area. If this is the case, then application of Bactrogel commences and probably additional distribution of BactroMAT M-E bait stations.

Application of Bactrogel Protein Bait Sprays

The method of application of Bactrogel protein bait sprays is covered in the section of this plan on the Eradication Options and the Principles of the Techniques – Protein Bait Spray Technique.
The great advantage of using Bactrogel is that the protein attracts female flies before they are sexually mature and ready to lay eggs, sexually mature female flies, and male flies. Applied correctly in 'hot spots', it will reduce fly numbers markedly.

Organizationally, it is important that each team nominates a team supervisor, who has the responsibility of monitoring the effectiveness of the application, ensuring that the bait is applied to the undersides of leaves at the recommended rate, and not wasted on fence posts or elsewhere. Also, the team supervisor must keep detailed records of the areas covered and the amount of bait spray applied. At the end of each day, the supervisor must provide a map showing the area treated, the amount of bait used, and any problems that arose, particularly if householders would not permit entry to carry out the treatment of a backyard or compound. The application must be done inside of compounds as well as along streets. Most of the fruit trees are inside housing blocks or compounds, rather than on the street.

Monitoring the Effectiveness of PFFEP and Reporting Progress

The Plant Protection Officer must collate the data from fruit fly trapping and host surveys and report on these on a weekly basis to the PFFEP Manager. These assessments and reports form the basis of the decisions by the PFFEP Manager with respect to the following week's program of activities. The reports should contain:

Graphs of the numbers of flies per week for each trap site;

Graphs of the percentage of traps that have produced oriental fruit fly and breadfruit fly for Koror, Babeldaob, Rock Islands, Peleliu, Angaur, and Kayangel, as well as overall;

Host records and estimates of percentage fruit infested with oriental fruit fly, breadfruit fly, and mango fly;

List of 'hot spots.'

Debriefing and Reports after Each Campaign

Immediately following the completion of each full campaign, a debriefing must be held. The purpose of the debriefing is to identify the deficiencies in, or problems encountered during, the completed campaign, to identify the positive aspects of the campaign that can be built on, and to develop improvements to the operations. This debriefing should involve all staff working on the PFFEP. All activity leaders and supervisors should provide a verbal report on the activities and problems encountered. Everyone should be allowed an opportunity to air grievances and make suggestions on improvements to the program. The aim of this session is to engender teamwork and collaboration.

TRAINING

All staff employed on the PFFEP will require training in the numerous facets of fruit flies, their biology, and control, and the eradication techniques to be used over the next two years. The training should cover the following topics:

. Fruit flies and their biology, ecology, quarantine importance, and control;

. The principles of MAT and protein bait sprays as eradication technology;

. The use of helicopters and GPS for applying BactroMAT M-E;

. Applying BactroMAT M-E and Bactrogel protein bait sprays for eradication by ground teams;

. Safe usage of BactroMAT M-E, Bactrogel protein bait sprays and safety procedures in helicopter use;

. The use of GIS for data collation and reporting, to be provided by Lands and Survey.

As well as training of PFFEP staff, groups such as the schools, community/women's groups, NGOs, farmers, backyard growers, and interested members of the public should be exposed to the activities of the PFFEP. Also, it is the intention of the PFFEP to demonstrate to government people from EQPB, OERC, Health, and Education and others such as the Palau Conservation Society, the techniques to be used. For example, a demonstration of the aerial dropping of BactroMAT M-E bait stations will be arranged so that staff of these departments and groups will be able to actually fly in the helicopter to witness the accuracy of the dropping process or see the results from the ground. This approach may dispel any doubts on the efficiency of this technology that may still persist.

All of the proposed training must be completed before the end of June, but the timing will be dependent upon exactly when the helicopter is positioned and operational. A consultant should be hired to provide this training.

The opportunity should be taken to train representatives from those PICTs, which may require the technology related to aerial treatment, using BactroMAT M-E. The responsibility for this will rest

primarily with SPC FFM. It should not occur prior to November 2001, to allow the Palau authorities to concentrate on the PFFEP initially.

CONTINGENCIES

The prospects for running a successful eradication program is very good, especially as there is a high level of support from most areas of government and the private sector. The local knowledge and appreciation of the losses to fruit production being caused by oriental fruit fly is nation-wide. This situation lends itself to excellent community cooperation and support, both of which are prerequisites for conducting a successful eradication program.

However, the PFFEP is dealing with a complex biological system and, consequently, even with the best technology and predictions and a high level of commitment at all levels, achievements may not go to plan. Not completing the eradication program of at least oriental fruit fly would be economically unsound and a waste of funds already expended, particularly if a relatively small amount of additional funding would be required to run a further one or two campaigns of aerial application of BactroMAT M-E bait stations and limited Bactrogel protein bait sprays.

A review of the progress and future needs of the PFFEP should be done in about July-August 2002 to assess the needs for additional resources past the eighth campaign. Between the commencement of the PFFEP and July 2002, it should be possible to develop an actual cost of further inputs from historical expenditure, calculated on a per square kilometre basis or on a per campaign basIslands As a preliminary guide, the estimated cost of one further campaign based on application of BactroMAT M-E over the whole of Palau plus limited application of Bactrogel would be about USD128,300 per campaign. Realistically, a campaign involving the whole country is unlikely after eight campaigns, so this cost would be reduced significantly.

The PFFEP and DAMR should develop a package of fruit fly control practices, which may have to be implemented if the PFFEP for oriental fruit fly and breadfruit fly were unsuccessful. These control practices may have to be adopted anyhow, as mango fly will still be present and will cause damage to a range of fruits after oriental fruit fly is eliminated. The package should include area-wide control or suppression using BactroMAT C-L bait stations, application of Bactrogel protein bait sprays, bagging of fruits, and enhancing the use of parasitoids.

If the PFFEP were not entirely successful, the implementation of inter-island quarantine between islands on which eradication was successful and other islands still infested would be advisable. Policing this would be very difficult but needs to be addressed by Quarantine and possibly PPM.

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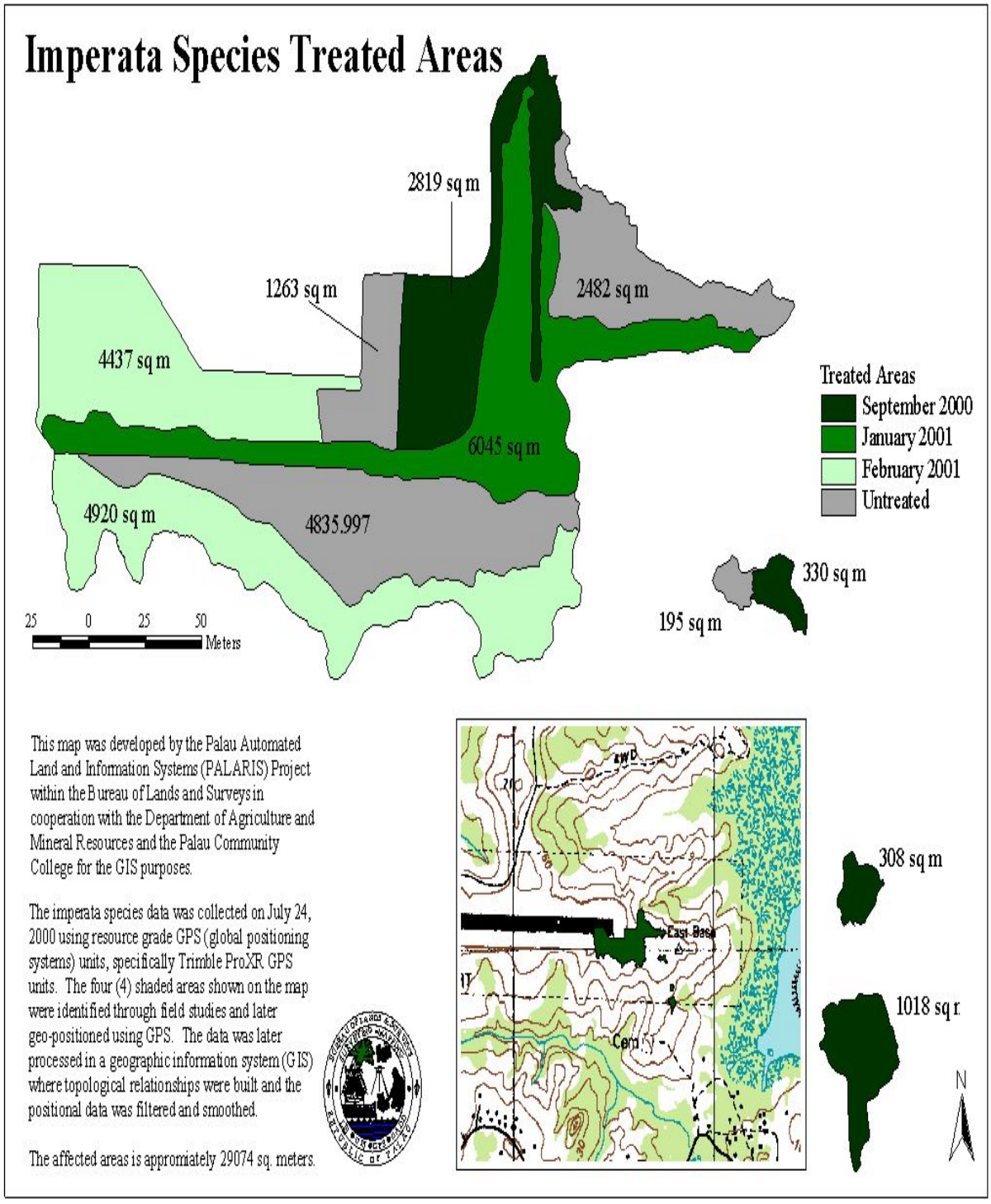
Allwood, A.J., Armstrong, J.W., Englberger, K. and Sengebau, F (1999). Feasibility study on eradication of fruit flies attracted to methyl eugenol (*Bactrocera dorsalis* and *Bactrocera umbrosa*) in Palau. Report for the Project on Regional Management of Fruit Flies in the Pacific (SPC). 26pp. + Attachments.

McGregor, A. (2000). A feasibility study of the eradication of oriental fruit fly (*Bactrocera dorsalis*) and breadfruit fly (*B. umbrosa*) from the republic of Palau.44pp + Annex.

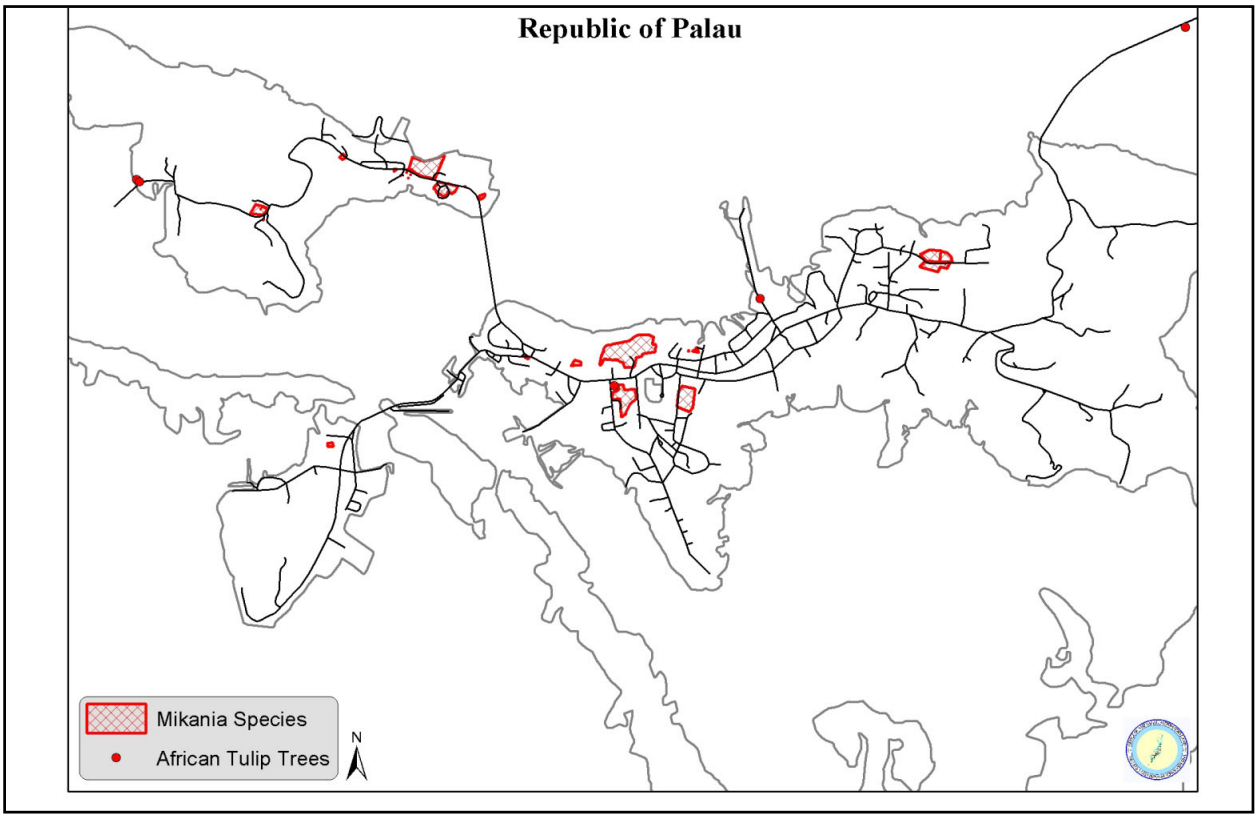
Annex 8

Imperata cylindrica
Treated areas



Annex 9

Mikania micrantha infestations in Koror



Annex 10

Case Study: Imperata cylindrica in Palau

***Imperata cylindrica* eradication site in July 2000 & July 2002 after two years of spraying herbicide.**

The grass *Imperata cylindrica* is a serious weed that was discovered by the main airstrip of the Palau International Airport located in Airai, on the main island of Babeldaob. There was a large infestation of approximately 60 acres of this grass in the vicinity of the airport in Yap State, Federated States of Micronesia. An eradication project is well underway in Yap, with funding from the State government and support from the US Forest Service and the Secretariat of the South Pacific (SPC). It has been estimated that this project will take 5 to 10 years to complete. A similiar amount of time will be required to eradicate *Imperata cylindrica* in Palau.

In the summer of 2000, Palau began an eradication project on *Imperata cylindrica*. The team working on this project included the Division of Agriculture and Palau Community College. The grass was only found within a 5 acre area in Airai by the main airport. After trials to determine the best, most effective means to eradicate the weed, the team began treating the grass with the herbicide, Round-up. The initial activities have been very successful and the size of the area of *I. cylindrica* has decreased significantly over the past 2 years. The invasive weed team will continue to spray this area over the next few years. The team plans to eradicate other highly invasive plants found in Koror and Babeldaob, Peleliu and Angaur. These plants include *Mikania micrantha*, considered the second worst weed problem in the Pacific islands (Waterhouse and Norris 1997), chain of love (*Antigonon leptopus*) and the African tulip tree (*Spathodea campanulata*).

Samoa

No report has been submitted.

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Introduction

Terrestrial and aquatic invasive alien species (IAS) of, flora, fauna and microorganisms in the Solomon Islands have not been properly documented. Some have caused catastrophic impacts to the environment becoming dominant invaders or serious pests (agricultural term) in the ecosystem. Some of these invasive species have significant economic impacts and are a deterrent to farming, some kinds of transport and potential future markets.

There is no information currently available on the potential economic, social, and biological impacts of IAS on the Islands' ecosystems. No one has seriously looked into documenting or researching the impact of IAS on the Solomon Islands' flora and fauna or its economy and society.

1. Main IAS in the Solomon Islands

IAS in the Solomon Islands can be categorized as intentional introductions or as unintentional introductions. Plants have been intentionally introduced for three main reasons

⇒ agricultural purposes;
⇒ forestry purposes; and
⇒ ornamentals.

Table 1 lists species that have been introduced and have become invasive or are likely to be highly invasive. The list contains some of the IAS of Solomon Island but is not exhaustive. The categorisation is not based on standard criteria but mainly on the views of the authors.

Table 1:List of IAS

Dominant plant invaders

Scientific name	**Common name**	**Habit/ habitat**	**Purpose of introduction**
Acacia fanersiana	Ellinton's curse	Thorny scrub	Agriculture
Eichhornia crassipes	Water hyacinth	Aquatic herb on wetlands	Ornamental
Morus sp.	Mulberry tree	Tree	Forestry
Lantana camara	Lantana	Thorny shrub on dry land	Ornamentals
Makania Macrantha	Mile-a-minute	Vine	Accidental
Mimosa invasa	Giant sensitive grass	Thorny spiny shrub	Accidental

Scientific name	Common name	Habit/ habitat	Purpose of introduction
Mimosa pudica	Sensitive grass	Spiny shrub	Accidental
Psidium guajava	Guava	Tree	Agriculture
Solanum torvum	Prickly solanum	Shrub	Accidental
Solanun mauritianum	Tobacco Weed	Shrub	Accidental
Stachytarpheta jamaiccencis	Blue rats tail	Shrub up to 1m pasture	Accident
Sida rhombifolia	Narrow leaf sida	Shrub weed at roadside & pasture	Accident
Sida acuta	Broom weed	Shrub weed at roadside & pasture	Accident

Moderate plant invaders

Scientific Name	Common Name	Habit/Habitat	Remarks
Cyperus rotundus	Nat grass	Sedge	Accidental
Ipmoea aquatica	Kangkong	Succulent vine, waterways	Agriculture
Luecaena leucocephala	Luecaena	Small tree	Agriculture
Nymphia giagantia	Water lilies	Succulent plant, waterways	Ornamentals
Bracharia spp.	Para grass	Grass on dry and wetlands	Agriculture
Sorghum halepense	Johnson grass	Grass	Accident
Pueraria Phaseloides	Puero	Leguminous vine	Agriculture
Pennistum purpurem	Elephant grass	Grass	Agriculture
Trema aspera	Poison peach	Shrub up to 4 m height	Accident

Other potential plant invaders

Scientific Name	Common Name	Habit/Habitat	Remarks
Acacia spp.	Acacia	Tree	Forestry
Araucaria heterophyla	Norfork Island pine	Tree	Forestry
Annona glabara	Bullocks heart	Tree	Agriculture
Annona muricata	Sour sop	Tree	Agriculture
Annona squamosa	Sweet sop	Tree	Agriculture
Calliandra haematocephala	Calliandra	Shrub	Agriculture
Ficus altissima	Banayan tree	Tree	Ornamental
Durio zibethinus	Durian	Tree	Agriculture
Eliaes guinneensis	Oil palm	Palm	Agriculture
Royastonia venezuelana	Royal palm	Palm	Ornamentals

Dominant micro-organism invaders

Scientific Name	Common Name	Habit/ Habitat	Remarks
Phytopthora colocasiae	Taro leaf blight	Fungus attacks taro	Accidental from PNG

Dominant insect invaders

Scientific Name	Common Name	Habit/Habitat	Remarks
Bactrocera cucubitae	Melon fruit fly	Tephritidae - pest of the cucurbit family	Accidental

Aquatic vertebrate and invertebrate invasive species

Scientific Name	Common Name	Habit/Habitat	Remarks
Tilapia spp	Tilapia	Fish- fresh water fish	Introduced
Bufo marinus	Common toad	Toad- water	Introduced to control mosquito
	Minorbird	Bird	Introduced
Kappaphycus alverezii	Seaweed	Seaweed	Introduced

2. Existing programs on IAS

While the problems associated with IAS exist, there are no formal programs, management efforts or awareness campaigns in existence in the country.

In terms of legislation, there are no legal instruments to try and stop the introduction of invasive species. The only instrument that is presently available is the Agriculture Quarantine Act 1982 which is itself in need of amendment. The Environment Act 1998 tried to cover some aspects of IAS issues, but this is also inadequate as implementing regulations have not yet been promulgated under the Act.

3. Government agencies/departments and other organizations concerned with IAS

The various functions on IAS are fragmented between various government ministries. The Ministry of Forestry, Environment and Conservation is the focal point for IAS. However, the ministry does not have a management strategy in place to address IAS issues and lacks technical manpower and capacity to implement programs. The Environment and Conservation Division is a very small division with only four officers. Its capacity to effectively implement such a program is very limited: moreover, lack of funds from government makes it even more difficult to carry out any work.

The Quarantine and Plant Protection Division of the Ministry of Agriculture and Livestock conducts surveillance against pests and diseases at all international entry points. The division is under-staffed and lacks equipment to conduct effective surveillance work. The Division comes across pecies that are regarded as invasive in the course of its surveillance work and does collect information on IAS that are of importance to the country's ecology and economy. However, the term "invasive alien species" has never been used because the function of this section is mainly on surveillance for pest and diseases.

Customs and Excise Division staff are trained in surveillance for materials like drugs and do regular checks on all incoming vessels and flights at the same time as Quarantine officers. This combined effort is very useful in terms of sharing the scarce manpower resources in the respective divisions.

4. Priorities identified for future work

The Solomon Islands do not have a national strategy on IAS but are covered by the Regional Strategy produced by the South Pacific Regional Environmental Programme (SPREP) under its Regional Invasive Species Programme. The aim of the Regional Strategy is to promote the efforts of the Pacific Island Countries in protecting and maintaining the rich and fragile natural heritage of the Pacific Islands from the impact of invasive species through cooperative efforts to:

⇒ develop and maintain an effective, coordinated network of information and technical expertise;
⇒ prevent the introduction of new IAS;
⇒ reduce the impact of existing IAS;
⇒ raise awareness; and
⇒ build the capacity required to manage the threats posed by IAS.

Although this Strategy is in place, it has not been implemented nationally in the Solomon Islands. SPREP will need to seek assistance from donors to initiate and support implementation of the strategy in member countries, especially the Solomon Islands.

5. List of experts working in the field of biological invasions

There are no experts in the country.

Tokelau

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Introduction

Tokelau, a non-self-governing territory under New Zealand's administration, is the smallest administrative unit in the South Pacific, consisting of three small atolls with a total land area of about 12 km^2, sea area covering 300,000 km^2 and a population of about 1,700.

The three small coral atolls of Tokelau - Atafu, Nukunonu and Fakaofo - lie between latitudes 8 and 10 degrees south and 171 and 173 degrees west. The central atoll, Nukunonu, is 92 kilometres from Atafu and 64 kilometres from Fakaofo. Swains Island (Olohega), 200km south of Fakaofo, traditionally belonged to Tokelau but is now part of American Samoa. Samoa, the nearest sizeable neighbour, is 480 kilometres to the south.

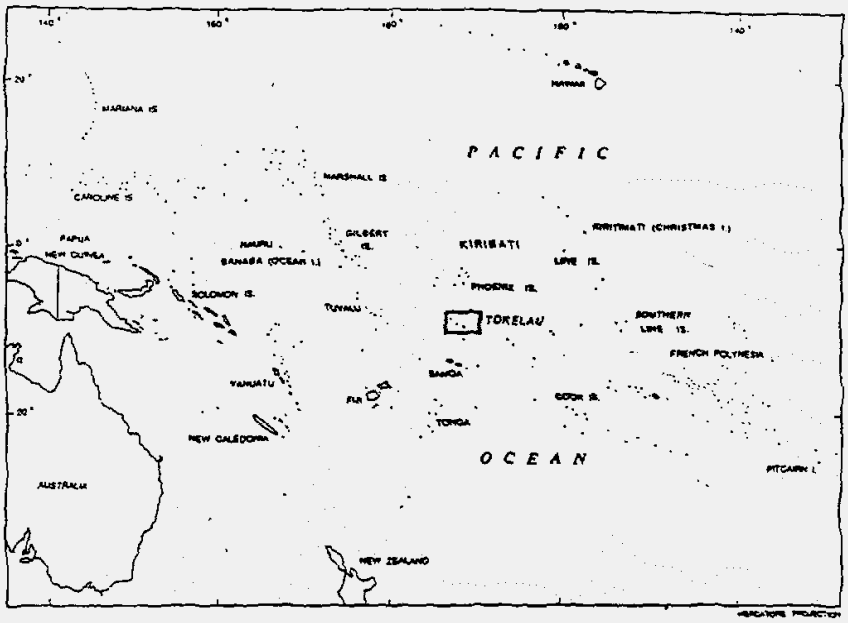
Each atoll consists of a ribbon of coral *motu* (islets) which vary in length from 90 metres to 6 kilometres, and in width from a few metres to 200 metres. They cover a total land area of 12.7sq km and at no point do they rise higher than five metres above sea level. This means that the physical features in Tokelau are very limited indeed, making the territory vulnerable to sea level rising caused by the greenhouse effect. The three atolls also includes 165 km^2 of enclosed lagoons and 290,000 km^2 of territorial sea that make up Tokelau's Exclusive Economic Zone.

The atolls are composed of calcium carbonate reef, sands and rock. Generally the soils are highly porous and nutrient poor: they have a low humus content and high surface salinity and are of very high alkalinity. These porous soils have prevented agricultural development beyond a subsistence economy. Only a few food crops are supported by this infertile land and these are confined to the supply of domestic needs: coconut (*Cocos nucifera*), breadfruit (*Artocarpus altilis*), pandanus (*Pandanus* spp.), giant swamp taro (*Cytosperma chamissonis*), taamu (*Zanthosoma sagitifolum*), taro (*Colocasia esculanta*) and banana (*Musa* spp.). The forest vegetation is made up of coconut palms, kanava (*Cordia subcordata*), pukakakai (*Pisonia grandis*), and pandanus. *Tiumfetta procumbens, Solanum virdee,* and a number of fern species make up the lower levels of forest cover.

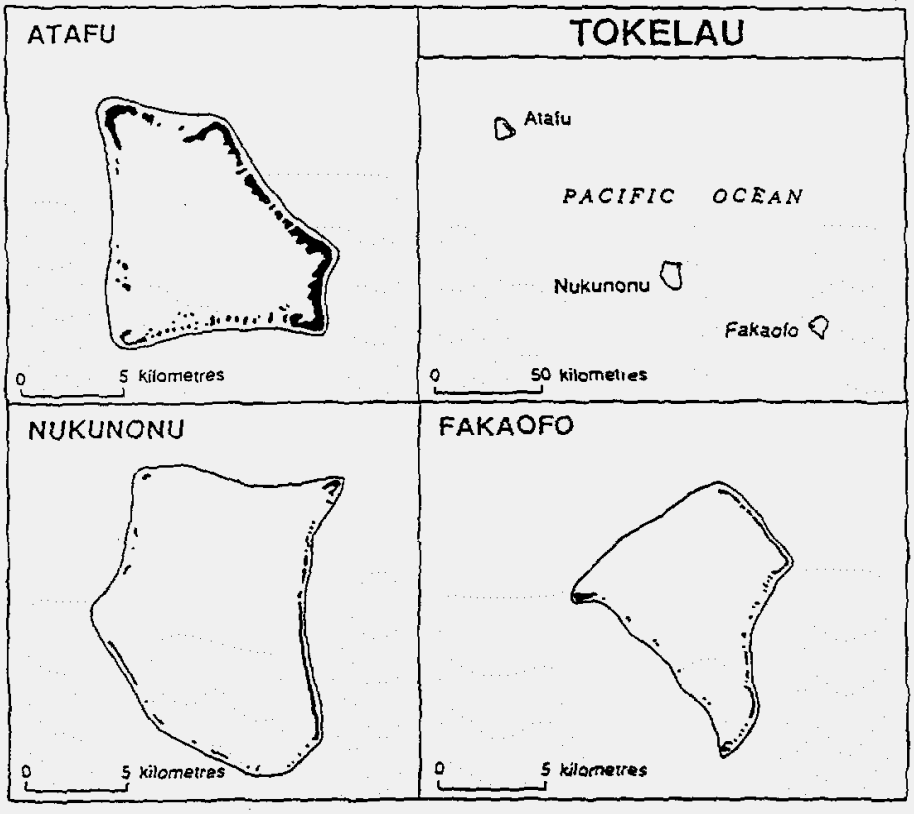
The average mean temperature is 28^oC. Rainfall is heavy but irregular, and a fall of eight centimetres or more in a single day is possible at any time of the year. Tokelau is at the north edge of the main hurricane belt, but tropical storms sometimes sweep through between November and February. Severe tropical cyclones have become more frequent with the last two in 1990 and 1991 (Ioane 1994). Hurricane Ofa (February 1990) broke across the atolls, washing topsoil away and contaminating the freshwater lens. Residual salt prevented new plant growth for months. The recent increase in such storms seems to be related to global warming.

The purpose of this report is to provide information on the programmes and resources regarding the issue of IAS in Tokelau.

Geographic Map



Location of Tokelau in the wider Pacific



Location and general outline of three atolls in Tokelau

1. Main IAS in Tokelau

⇒ **Polynesian rats (*Rattus exulan*)**

Considered a primary pest, it is estimated that the destruction caused by this pest accounts for about 40% of the total coconut production in the country. For the past 2-3 decades, bromodialone wax rat bait, with warfarin as the active ingredient, has been used. This practice is now in need of new alternatives as it is considered ineffective, costly and environmentally unfriendly (it is not target specific about tends to destroy other animals).

Due to Tokelau's isolation, limited financial resources and lack of technical knowledge, it is difficult to identify and utilize other effective and cheaper means of controlling or totally eradicating the rats.

⇒ **Rhinoceros beetle (*Oryctes rhinoceros*)**

This is another very serious pest of coconut and has a record damage rate. In 1997, a biological control programme was launched by the Secretariat of the Pacific Community (SPC) with assistance from Samoa. This involved the use of pathogens including the green muscardine fungus *Metarrhizium anispoliae* and the *Baculovirus.* In December 2002, SPC again released biocontrol agents.

⇒ **Yellow crazy ant (*Anoplolepis gracilipes*)**

This species arrived relatively recently – probably in 1999 - but emerged in significant numbers in 2001 and its population is still rapidly increasing. It is concentrated mainly on Nukunonu but recently in Fakaofo certain sites have become infected with the ants and there is a fear that they will spread rapidly to other areas.

⇒ **Soft brown scale (*Coccus hesperidium*)**

At present, the scale insect is confined only to Nukunonu within the immediate surroundings of the village. Plants infested are pawpaws, bananas, gardenia and lily.

⇒ **Spiralling whitefly (*Aleurodicus disperses*)**

Fakaofo first became infested in 1989. In 1991, SPC released laboratory-reared pupae of the parasite *Encarsia haitiensIslands* The problem has since decreased and is now under control. Infested plants include papaya, banana, and frangipani.

2. Existing coordination and programs on IAS

Tokelau is no exception to other countries in recognizing the seriousness of the IAS problem. However, the shortage of technically trained personnel and the inadequate quarantine risk assessment facilities continues to be a problem.

Tokelau is currently developing an IAS plan and programme with the SPC Plant Protection Service (for contact information, see 5 below).

It is also developing public awareness campaigns at local level amongst the three communities.

3. Government departments/agencies and other organisations concerned with IAS

⇒ **Natural Resources & Environment Unit (Office of the Council of Faipule)**

This Unit, which comes under the umbrella of the Office of the Council of Faipule, is the government agency that is responsible for the protection, preservation and the conservation overall of Tokelau's land and also marine resources.

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⇒ **Office of the Council of Elders (one for each island: Fakaofo/Nukunonu/Atafu)**

⇒ **Department of Health**
Nukunonu
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⇒ **Transport Tokelau**
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4. Priorities identified for future work

4.1 Control measures

The incursion of the soft brown scale (*Coccus hesperidum*) and the yellow crazy ant (*Anonplolepis gracilipes*) on Nukunonu and Fakaofo are new pest records for Tokelau. These areas have thus been prioritized and identified as needing immediate action to control the spread of these pests. Tokelau is working very closely with SPC to bring the problem under control. Assistance from interested individuals from other institutions has also been welcomed.

4.2 Legislation

Tokelau is currently reviewing the Animal Regulations 1991 and the Plant Regulations 1999. Extensive work has been done by Tokelau and SPC in this area in recent months.

Working closely with SPC, Tokelau is considering a regional move to harmonize all quarantine laws, with a focus on trade relations between Tokelau and other countries, especially Samoa as the port of entry into Tokelau. There appears to be a need in the region to strengthen capacity to meet the standards for quarantine services established by regional and international organizations.

Draft Tokelau Biosecurity Rules 2003 have therefore been developed. It is hoped that these Rules will be tabled at the June/July 2003 General Fono (equivalent of Parliament) for endorsement.

5. List of experts working in the field of biological invasions

⇒ Experts working for the Secretariat of the Pacific Community who have experience of IAS issues in Tokelau include:

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⇒ Other experts include:

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Kingdom of Tonga

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Introduction

The Kingdom of Tonga is situated just west of the International Dateline, east of Fiji, north of New Zealand, and southwest of Hawai'i. It is the only Polynesian country never to have been colonized and the only monarchy in the Pacific, with rich cultural history and traditions. Tonga has many sought-after attributes including a pristine natural environment, warm tropical climate, and beautiful reefs and beaches.

Tonga's economy is based on agriculture (70%), fisheries, remittances from people living overseas, and tourism. Examples of important economic activities include:

⇒ the export of squash-pumpkin to Japan (US$15 m/yr);
⇒ vanilla export to U.S., European Union, Japan, New Zealand, Australia (US$5 m/yr);
⇒ root crops export (taro, yam, cassava) (>US$5 m/yr);
⇒ fresh fish exports (tuna, snapper, etc.) to Japan, U.S., New Zealand (>US$10 m/yr); and
⇒ tourism and ecotourism, such as whale watching (now a major activity with an estimated value >US$10 m/yr).

Traditional food crops need to be maintained in Tonga because the residents cannot afford to import food crops. Tonga grows food crops for consumption and export, and has fresh fruit and vegetable markets open to the general public.

1. Status of IAS in Tonga

Tonga is highly vulnerable to new IAS and has considerable trouble managing existing invasives. Pathways and vectors for introduction of non-native species to Tonga include:

⇒ direct flights to Hawai'i, Fiji, New Zealand, and Australia (e.g. tourists bringing in non-native plant specimens). Tonga has no X-ray machines or dogs so it would be necessary to do a full search to detect material. The aircraft themselves also provide vectors for introductions.;

⇒ ships and yachts;

[2] Adapted from an oral presentation given at the workshop entitled, Prevention and Management of Invasive Alien Species: Forging Cooperation throughout the Austral-Pacific, 15-17 October 2003, Honolulu, Hawai'i.

⇒ the import of personal effects, mainly from Australia and Hawai'i. Even if inspections are carried out, it is impossible to ensure that these effects are free of IAS;

⇒ risk goods (e.g. used machinery, used cars from Japan, construction materials);

⇒ natural disaster relief and assistance (including bulldozers, chainsaws, foods and seeds); and

⇒ forestry.

The marine environment is particularly vulnerable off the main island of Tonga, which has implications for fish exports and traditional fishing practices (e.g. foraging for shellfish). Ballast water is a significant pathway for IAS.

Species information in Tonga is very limited. Baseline surveys for animals and plants are needed as well as surveys to update the list of pests and IAS. Marine surveys are needed to identify species already present in Tongan waters, and which of these species may be invasive.

2. Government departments/agencies and other organizations concerned with IAS

Stakeholders currently involved with the management of IAS include:

⇒ **Ministry of Agriculture and Forestry (MAF).**

The MAF Quarantine and Quality Management Division oversees: compliance with international standards set by International Plant Protection Convention (IPPC), International Organization for Epizotics (OIE), or Codex Alimentarius and recognized under the World Trade Organization Agreement on the Application of Sanitary and Phytosanitary Measures (WTO-SPS Agreement); import risk analysis; import standards; import and export inspection certification; surveillance; and emergency response plans. These powers are exercised in consultation with the Secretariat of the Pacific Community (SPC), especially the SPC Plant Protection Service and the Pacific Plant Protection Organization.

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⇒ **Department of Environment**

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⇒ **Ministry of Fisheries**

This deals with marine import and export requirements and marine conservation and research.

⇒ **Ministry of Health**

This deals with IAS of public health concern, based on standards set by Codex Alimentarius. It works in close consultation with the Ministry of Agriculture and Forestry.

3. Priorities identified for future work

Tonga needs to address a series of constraints on prevention and management of IAS. These include:

⇒ technical deficiencies in national and regional quarantine services (lack of capacity to meet the requirements of the WTO-SPS Agreement), border protection and trade facilitation functions;

⇒ lack of trained staff and necessary capacity;

⇒ poor facilities and infrastructure;

⇒ diminishing access to methyl bromide for use as a pesticide as a result of its impacts on the environment (this puts a constraint on international and regional trade);

⇒ shortage and/or inaccessibility of scientific and technical information and expertise required for pest risk analysis and import risk analysis and for the management of IAS and living modified organisms/genetically modified organisms;

⇒ cost of accessing and updating technical information (e.g. web, electronic information sources).

⇒ the lack of up-to-date surveys on pests and IAS;

⇒ outdated and/or inconsistent legislation to address agricultural-environment-marine-public health concerns;

⇒ poor coordination and collaboration of work programs between government agencies concerned with IAS (e.g. agriculture, fisheries, environment, public health) and with other stakeholders (e.g. shipping and airline agents, non-governmental organizations);

⇒ duplication of international/regional work programs, leading to a waste of resources and efforts (e.g. the International Plant Protection Convention and the Convention on Biological Diversity, SPC and SPREP);

⇒ lack of funding or budget allocations for IAS work from the government, regional or international organizations; and

⇒ lack of awareness among the general public, politicians, decision-makers, and the private sector.

Tuvalu

No report was submitted. The delegates invited to the workshop could not attend due to travel difficulties. Their contact details, and comments on Tuvalu from the report of the island assessment consultation, which they attended in lieu of the regional workshop, are included below.

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Tuvalu is a small island nation in the Pacific made up of nine islands totaling 25 square kilometers. Forest covers approximately 67% of the land. Three of the major IAS in Tuvalu are the coconut scale insect (*Aspidiotus destructor*) which damages food crops (e.g. breadfruit [*Artocarpus altilis*], sweet potatoes [*Ipomoea batatas*]), and impacts both social and economic systems; the termite (*Neotermes rainbowi*), which topples coconut palms, and the pink mealy bug (*Macinellicocus hirsutus*), a pest of the food staple breadfruit. A biological control program exists for coconut scale. The Secretariat of the South Pacific (SPC) provides the control agents and they are released at the site of infestation. The agricultural department provides advice on how to treat pests and planting of resistant trees. The South Pacific Regional Environmental Programme (SPREP) also works closely with environment and the local government. Tuvalu's primary needs include (1) identification of non-native and native species, (2) IAS survey results from other countries, and (3) expert technical advice and facilities for IAS identification.

Vanuatu

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Introduction

Vanuatu, formerly known as New Hebrides, comprises some 80 islands and islets extending in a Y shape over 800 km from north to south. The land area is 11,880 km^2 with the largest island being Espiritu Santo (3947 km^2). Other large islands include Malekula, Efate, Ambrym, Pentecost, Epi, Erromango, Malo, Tanna and Aneityum. The Torres and Banks islands are the most northerly and are one of the major gateways for introduction of certain species that have become invasive to native species of Vanuatu.

The ethnic composition of the population of 197,000 is 98% Melanesian Ni-Vanuatu: the remaining two percent are European, Micronesian, Polynesian, Asian and other Melanesians. Eighty percent of the population live in rural areas where subsistence farming is the major activity.

Cocoa, coconut, coffee and beef production forms the basis of agriculture. Copra, cocoa and beef make up over 70% of the country's export earnings. The export of fresh fruits and root crops is becoming increasingly, important. Because Vanuatu is dependent on agricultural exports, it is crucial that there is proper control and management of alien species that have already become or have potential to become invasive pests and weeds affecting production levels.

A report on the Vanuatu National Biodiversity Strategy and Action Plan (NBSAP) Project compiled by a team in the Environment Unit noted that biodiversity in Vanuatu is much richer than previously estimated. This assertion was based on other works previously carried out. One of the threats pointed out by the report as a threat to biodiversity is introduced alien species that either prey on or out-compete native flora and fauna. Unfortunately, not many scientific studies have been carried out on specific species, assessing the extent of their impacts and displacement of native species.

For the purposes of this report, invasive alien species (IAS) are defined as organisms (insects, fungal and viral micro-organisms, animal, plants and other aquatic life forms) introduced intentionally or unintentionally into an area. Due to lack of predators in its new habitat, the introduced species quickly multiply and spread and in most instances out-compete the native species.

1. Main alien species introduced into Vanuatu

The table below lists the various alien species of aquatic and non-aquatic flora and fauna introduced into Vanuatu. This list is not exhaustive since more work still needs to be done on identifying the existing alien species in the country. An area in which little work has been done so far is assessing the extent of the ecological, economic and health impacts of the introduced invasive species.

The NBSAP project mentioned earlier has worked on the identification of terrestrial, marine and freshwater species including introduced invasive species. The NBSAP project also works with government departments and communities to identify key issues in terms of biodiversity that need to be addressed. One of these issues is introduced IAS.

Common name	**Scientific name**	**Current/potential impacts**
Invasive alien terrestrial species: plants		
Cordia	*Cordia allidora*	Introduced in 1970s by Dept of Forestry for lumber. Lack of management and failure to establish market in the region has now lead to cordia being invasive. Very fast growing and out competes native species thus compromising biodiversity wherever it is established.
Elephant grass	*Panicum maximum*	Introduced as pasture but cattle cannot eat matured grass. Out-competes native grasses wherever establishes it itself.
Agriculture rope	*Cycling* sp.	
Aquatic plant	*Salvania* sp.	
Water lettuce	*Pistia stratiotes*	Very fast growing and can cover slow moving water surface in very short time. Can infill shallow water with decomposing plant matter, deoxygenate and taint water, leading to destruction of natural aquatic ecosystems. Takes up swimming/recreational areas
Parthenium weed	*Parthenium hysterophorus*	Grows aggressively/spreads very quickly. Poisonous for livestock (Beef industry is one of the major export industries in Vanuatu). Causes skin irritation in humans.
Giant Mimosa Big gras nil	*Mimosa invisa*	Introduced for cattle feed. Cattle feed on younger plants but matured ones are woody and has thorns. Very fast growing and grows very thick completely killing out any vegetation wherever it establishes itself.
Mile-a-minute American rope	*Mikania micrantha*	Very fast growing. Beneficial in one respect because it keeps moisture in ground, but not beneficial in that growth can result from overgrazing and can completely overtake areas retarding pasture growth.
Big leaf rope	*Merremia peltata?*	Introduced by Americans during WW2 to be used in camouflaging. Very aggressive in growth completely covers occupied areas.
Water hyacinth	*Eichhornia crassipes*	
Lantana	*Lanta camara*	
Kasis	*Leucaena leucocephalia*	Very fast growing, cattle feed on young plants and improves soil quality. Crowds out other plant species.
Spiny amaranth	*Amaranthus spinosus*	
Soursop	*Annona muricata*	
Wild peanut	*Cassia tora*	
Nasasa	*Codiaeum variegatum*	
Thick head	*Crassocephalum crepidioides*	
Streaked rattlepod	*Crotalaria pallida*	
Nutgrass	*Cyperus rotundus*	
Nettle tree	*Dendrocnide sp.*	
Crow's foot grass	*Eleusine indica*	

Common name	Scientific name	Current/potential impacts
Invasive alien terrestrial species: plants		
Asthma plant	*Euphorbia hirta*	
Giant mimosa	*Mimosa invisa*	
Sensitive plant	*Mimosa pudica*	
Balsam pear	*Mormordica charantia*	
Big bol tree	*Pangium edule*	
T-grass	*Paspalum conjugatum*	
Foetid passion fruit	*Passiflora foetida*	
Guava	*Psidium guava*	
Broom weed	*Sida acuta*	
Broom	*Sida rhombifolia*	
Wild aubergine	*Solanum torvum*	
Blue rats tail	*Stachytarpheta urticifolia*	
Invasive alien terrestrial species: animals		
Mynah Bird	*Acridothere tristis*	Eats fruits from gardens. Preys on other bird species, particularly their eggs. Preys on certain insect species that prey on other harmful insects
Predatory Snail	*Euglandina rosea*	
Giant African Snail	*Achatina fulica*	Early maturation
Fire Ant	*Wasmannia auropunctata*	Deters people from gardening and other economic productive activities. Stings people in private parts of the body, making it difficult to deal with in public. Affects organisms that enhance growth in some plants/crops, in the long run affecting crop production
Fruit Fly	*Bactrocera trilineola, B. minuta, B. umbrosa,, B. paraxanthodes,*	Species that are currently damaging fruits
Coconut scale Insect	*Aspidiotus destructor*	Insert their proboscius into the leaves and suck the sap
Coconut Hispine Beetle	*Brontispa longissima*	Larvae feeds on the surface of the unopened fronds, retarding growth of young coconuts
Elephant Beetle	*Xylotrupes gideon*	Damage the midribs of coconut leaves- minimal damage so far in Vanuatu
Green Scale	*Coccus celatus/ Coccus hesperidum*	Sucks the sap out of tree tissue (coffee tree) and become attached to the stem and branches
Kava Borer Weevil/Ginger Weevil	*Elytroteinus subtruncatus*	Larva and adult complete their life cycle in kava plant *(Piper methysticum)* boring down into the rhizome
Taro Beetle	*Papuan* sp.	Attack many crops but more serious on taro. It bores into tuber, making tunnels permitting entry of other organisms causing decay. Four species found in Vanuatu

Invasive alien terrestrial species: animals		
Rose Beetle	*Adoratus versutus*	Eats cocoa, yam and other plants leaves affecting biological functions through effect on the photosynthesis process. This affects the crops ability to grow thus affecting their crop production.
Rat		Damage cocoa and coconut fruits reducing production
Fruit Piercing Moth	*Othreis fullonia*	Damages lots of fruits affecting production both for home consumption as well as for markets
Taro Planthopper	*Tarophagus proserpina*	Heavy infestation causes taro plants to wilt and die
Mango Seed Weevil	*Sternochetus mangiferae*	Attacks mango fruits
Banana Weevil Borer	*Cosmopolites sordidus*	Grubs of the weevil bore down into the corm of the basal part of the plant creating tunnels up to a entimeter wide, severely weakening the plant
Banana Scab Moth	*Nacoleia octasema*	Lays its eggs on unopened inflorescence of young leaves and when hatched, caterpillars feed on banana flowers and skin of young developing fruit, causing rough, gray scabby scars
Brown Pod	*Botryodiplodia theobromae*	Dieback disease associated with death of the cocoa tree if left untereated after attack
	Phellinus noxius	Fungal disease causing cocoa tree to wilt when fungus destroys the roots or girdles the trunk
	Helminthosporium sp.	Debilitates young coconuts, causing extensive leaf spotting and stunting growth
	Cucumber mosaic cucumovirus	Kava virus
Foliar Decay	*Myndus taffini*	Affects mostly the higher yielding introduced varieties of coconuts
Coffee Leaf Rust	*Hemileia vastatrix*	
Coconut Flat Moth	*Agonoxena argaula*	
Sweet Potato Hawkmoth	*Agrius convolvuli*	
Pumpkin Beetle	*Aulacophora similes*	
Coconut Shield Bug	*Axiagastus campbelli*	
Breadfruit Fly	*Bactrocera umbrosa*	
Green Scale	*Coccus viridis 295*	
Spotted Plant Eating Weevil	*Epilachna* spp. *230*	
28-spotted Ladybird	*Epitachna vigintioctopuntata*	
Sweet Potato Weevil	*Euscepes postfasciatus*	
Mirid Bug	*Halticus* sp.	
Ant	*Neotermes* spp. *209*	
Citrus Leaf Miner	*Phyllocnistis citrella 220*	
Mealy Bug	*Pseudococcus* spp.*295*	
Stem Bleeding		

Invasive marine/freshwater species		
Tilapia	*Oreochromis* sp./*Poecilia* sp.	Introduced by Dept of Health to combat mosquitoes thus is deemed beneficial from their point of view. Has become invasive in some lakes but also food source for some people
Mosquitofish	*Gambusia affinis*	Introduced to combat malaria through eating of mosquito larvae. Predates on native fish and prawn larvae. Attack larger fish by nipping off their fins causing paralysis and eventual death
Carps	*Cyprinus* sp.	Contributes to high turbidity of lake water due to sucking mode of feeding. Breeds very rapidly. Competes with native species for food resources.
Guppies	*Poecillia reticulata*	Introduced in Vanuatu to help control malaria by feeding on mosquito larvae. Considered pest to native freshwater fauna because of its rapid breeding habits and ability to dominate, crowding out native species.

2. Summary of existing strategy and programs on IAS

2.1 Preventive measures

⇒ requirement of permits from appropriate authorities before importation of any live species;
⇒ integration of quarantine activities and procedures into the high school curriculum for awareness among students;
⇒ public awareness programs through use of various mediums; and
⇒ continuous monitoring of high risk areas by Department of Quarantine.

2.2 Control measures

⇒ **Fire ants**

Spraying of all flights and boats from Banks and Torres islands with insecticides; restriction of moving plants and other materials from Banks and Torres to all other islands; laying baits in high risk areas every quarter to assess area of spread of fruit flies and fire ants; where it is too expensive to eradicate, containment and control of spread measures are employed; continuous community education on importance and ways of limiting spread of ants; posters and pamphlets distributed. The Wan Smol Bag Theatre is preparing a play on the management of fire ants and other invasive species.

⇒ **Fruit piercing moth**

Funding has been secured and research on the different species and the extent of their impacts started in September 2002.

⇒ **Fruit fly**

Laying of traps in high-risk areas (especially around urban areas, airports, wharves, and the University of the South Pacific Campus where students from all over the Pacific are concentrated). Fruit flies are collected on a weekly basis, identified and sent to Fruit Fly Office for analysis. Public education and awareness programs an ongoing activity by the Department of Quarantine through community outreach, radio programs, posters and pamphlets.

⇒ **Cordia forests**

Forest plantations were returned to landowners and encouraged to manage and use forests for domestic needs. Department of Forestry and Environment Unit are collaborating on looking for potential market for cordia.

3. Government departments/agencies and other organisations concerned with IAS

⇒ **Environment Unit/National Biodiversity Conservation Strategy Project**

⇒ **Department of Quarantine**

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⇒ **Department of Agriculture & Animal Production**

⇒ **Department of Forestry**

⇒ **Department of Fisheries**

⇒ **Non-government agencies**

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4. Priorities identified for future work

4.1 Policy review and development

⇒ enact new legislation on Environmental Management and Conservation that gives the Director of Environment Unit the right to draft regulations pertaining to biodiversity, including IAS;

⇒ review all existing laws to ensure they are coherent and consistent with respect to IAS;

⇒ identify an organisation with an overall coordinating responsibility and with authority to define that a species, regardless of benefits, has the potential to be invasive.

4.2 Management of new introductions and of existing IAS

⇒ more collaboration between all agencies involved in management of IAS;

⇒ identify, share, record results of successful and unsuccessful trials for future reference. SPC to maintain a regional net-based list of experience;

⇒ research and documentation of IAS and their economic and ecological impacts, leading to setting up of database;

⇒ house all reports at the national library for everybody's access;

⇒ inter-island controls on moving dirty machinery;

⇒ now that the Department of Quarantine identified fire ants as one of the current major concerns, enable Provinces to take up the responsibility of managing the spread of fire ants; and

⇒ establish demonstration projects with landholder communities as trials to control or find alternative uses for introduced species that have become problems.

5. List of experts working in the field of biological invasions

No information supplied.

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