ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

FOR THE ERADICATION OF PACIFIC RATS (*Rattus exulans*) AND THE CONTROL OF YELLOW CRAZY ANTS *(Anoplolepis gracilipes)* ON NU'TELE AND NU'ULUA ISLANDS, SAMOA

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Location: Nu'utele and Nu'ulua Islands, Aleipata Island Group, Samoa

Abstract

This EIA assesses the environmental impacts of aerial helicopter baiting using brodifacoum pellets to eradicate Pacific rats from Nu'utele and Nu'ulua Islands and indoxacarb granules to control yellow crazy ants on Nu'ulua Island. The pesticides pose some risks to non-target species including birds, lizards, crabs and insects. The indoxacarb baits may pose some risk to the marine environment. Mitigation measures are outlined to prevent or reduce these impacts. The benefits of eradicating rats and controlling ants will outweigh losses that may occur. Human health risks are low and comprehensive mitigation measures are proposed. The operations will be beneficial to the local communities, are consistent with the legislation, and relevant strategies and plans. The assessment concludes that the proposed operations will be beneficial to the native species and ecosystems of Nu'utele and Nu'ulua Islands and that the mitigation measures proposed will prevent, mitigate or remedy all significant adverse environmental effects.

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Contents

Chapter 1 Summary

1. This Environmental Impact Assessment (EIA) considers the impacts on the environment of aerial baiting to eradicate (completely remove) rats from Nu'utele and Nu'ulua Islands and to control yellow crazy ants to low numbers on Nu'ulua Island.
2. Baits will be loaded into a spreader bucket at a site on the main island of Upolu and flown to the islands where they will be spread by helicopter. This method is widely and successfully used to remove animal pests from islands.
3. Rat baits will be cereal pellets containing the rat poison *brodifacoum*. They will be spread over both islands twice, approximately 10 days apart and at a rate of 12 kg/ha.
4. Ant baits are small granules containing the ant poison *indoxacarb*. They will be sown over Nu'ulua Island. Ant baits will only be sown once at a rate of between 4-8 kg/ha.
5. The helicopter will use GPS navigation equipment (global positioning system) to make sure the bait is spread accurately and consistently.
6. The proposed timing of the operations is October or November. Each bait application will take several hours.
7. The rat and ant operations are being carried out to: restore more natural processes to the islands; allow insects, lizards, turtles and birds that are affected by the rats and ants to recover; and to allow other Samoan birds and animals threatened on the main islands to be moved there. The benefits to the native wildlife of removing rats and ants are expected to be significant.
8. The aerial baiting may pose risks to the environment on Nu'utele and Nu'ulua and the surrounding area. These have been assessed and are summarised below, along with the measures proposed to prevent or reduce these risks.
9. Impacts on the friendly ground dove may be significant. To make sure the population is safe, as many ground doves as possible will be captured and held in an aviary on Nu'utele until there is no longer a risk to them.
10. Vea (banded rail) are likely to eat bait, and both vea and lulu (barn owls) are at risk from eating other insects, lizards and rats that have eaten baits. Both birds are common and widespread. If necessary, vea can be moved back to the islands and lulu will re-establish themselves.
11. Possible impacts on other birds are less significant. A few birds of some types, especially those that eat insects, may be killed, but in the long-term, the benefits of removing rats and ants will mean they will be much better off. Several measures are proposed to reduce the risk to birds.
12. There is a low risk to lizards that may eat baits or poisoned insects. In the long-term, the benefits of removing rats and ants will mean they will be better off.
13. The ant bait may pose a risk to a wide range of insects. However, monitoring of similar operations has shown that the impacts are generally not significant because yellow crazy ants eat most of the bait. Yellow crazy ants have a catastrophic impact on other insects. The benefit of controlling them will outweigh any negative impact of the ant baits.
14. Rat baits will be eaten by crabs but it will not have any significant impact on them. Land crabs, including coconut crabs may be at risk from the ant baits, but recent work suggests they will have little impact. Lures may be used to attract crabs away from the baits and they will be sown in the afternoon to avoid the peak land crab feeding time.

15. Rat baits are not expected to have a significant impact on the marine environment. Ant baits are poisonous to fish and other marine animals but dilution in the sea means the risks are probably low. A range of measures are suggested to increase the accuracy of the baiting and limit the number of baits that fall into the sea. Sowing baits at high tide will reduce the risk to intertidal marine animals. Monitoring is suggested to measure any impacts.

16. Pigs should have been removed from Nu'utele before the rat and ant baiting. No measures are suggested to prevent impacts on introduced animals and birds including pigs and chickens. For conservation purposes their removal is beneficial.

17. Removing rats and ants may have other indirect impacts on the islands' ecosystems. These are difficult to predict. No measures are available to prevent potential impacts, but monitoring will be carried out to identify these so they can be managed.

18. Neither the rat or ant operations pose significant risks to humans. The highest risks are through worker exposure, accidental poisoning and people eating contaminated animals (pigs, chickens, and coconut crabs) from the islands. Comprehensive measures are suggested and should prevent any impacts on human health. Animals from the islands should not be eaten for 18 months after the operations.

19. The rat and ant operations will be beneficial to the local communities. They offer an opportunity for education and training, and in the long-term ecotourism ventures.

20. Neither the ant or the rat operations will have any significant impacts on:

    - air, water or soil quality
    - plants and vegetation cover
    - seabirds
    - snakes and turtles
    - bats
    - cultural or spiritual values.

21. Noise impacts will be limited to helicopter noise during the operations.

22. Contaminated waste will be disposed of overseas in an approved disposal facility.

23. The operations will increase the risk of invasive species reaching the islands. Visits will be more regular before and after the operations and stores and equipment will need to be taken to the islands. Quarantine procedures will be implemented to reduce this risk.

24. Cumulative impacts are unlikely, especially because the rat operation is a one-off. If ant baiting is continued in the future monitoring of insects and crabs is suggested.

25. Consultation has been undertaken with several interest groups. Most were fully supportive of the proposed operations and did not express any concerns. More detailed consultation will be undertaken with local communities.

26. Many aspects of the operation will be monitored including: bait quality, coverage, take and breakdown; effectiveness of the operations on rats and yellow crazy ants; non-target animals; the marine environment; birds; lizards; insects and vegetation.

27. The rat and ant operations are consistent with the legislation, and relevant strategies and plans.

28. This EIA concludes that overall, the rat and ant operations will be beneficial to the species and ecosystems of Nu'utele and Nu'ulua Islands and that the measures proposed should be sufficient to prevent, mitigate or remedy all significant adverse environmental effects.

Chapter 2 Description and Purpose of the Activity

Section 2.1 Description of the proposed operations

The Division of Conservation and Environment, Ministry of Natural Resources, Environment and Meteorology (MNREM), its Aleipata Islands Restoration Plan Partners, and the Secretariat for the Pacific Regional Environment Programme (SPREP) are proposing to carry out aerial baiting on Nu'utele and Nu'ulua Islands, Samoa (Appendix 1) for the purpose of eradicating Pacific rats and controlling yellow crazy ants. While the eradication of yellow crazy ants is preferable to control, eradication would be very costly with no guarantee of success.

Nu'utele Island (108 ha) and Nu'ulua Island (25 ha) are 1.3 and 3.3 km respectively, off the coast of Upolu. The total area to be sown with baits is 133 ha. Both islands are steep, uninhabited and covered in thick, largely unmodified native coastal forest and lowland rainforest. They hold populations of native species currently found nowhere else in the country including threatened land-birds, seabirds and nesting turtles.

Baits will by sown by helicopter and an underslung spreader bucket, a standard technique used to successfully eradicate rats from much larger islands in New Zealand and other countries. A helicopter will be imported into the country for the duration of the operations. An experienced pilot and an aerial drop adviser from New Zealand will fly the helicopter and advise on the operations. Baits will be loaded into a spreader bucket at a loading area on the adjacent coast of Upolu (Appendix 1). The helicopter pilot will apply the baits by flying consistent, regularly spaced swaths across each island. The helicopter will use GPS navigation ensuring complete, accurate and consistent coverage of the islands. Each bait application will be completed within several hours.

The Pacific rat eradication will involve the aerial application of baits containing brodifacoum. Two applications of brodifacoum cereal pellets will be sown onto on each island at a rate of 12 kg/ha during the rat eradication operation (i.e. a total of 24 kg/ha for both applications). Additional bait may be hand sown in coconut plantations at Nu'utele and Vini beaches (Nu'utele Island) where rat and crab densities are high.

The bait specifications are:

Trade name:	Pestoff Rodent Bait 20R
Bait formulation:	Wanganui No.7 cereal pellets (without bitrex)
Size:	12 mm.
Toxin concentration:	20 ppm = 0.02 g brodifacoum/kg carrier
Lure:	Coconut
Colour:	Green

The yellow crazy ant control operation will involve the aerial application of commercially produced corn granules containing the insecticide indoxacarb. One application of granules will be sown onto Nu'ulua island at a rate of 4-8 kg/ha. Additional bait may be sown by hand.

The bait specifications are:

Trade name: not yet registered
Bait formulation: Soil bean oil coated corn granules

Toxin concentration: 0.045% = 0.45 g indoxacarb/kg carrier

The operations will be carried out in October or November. This will maximise the opportunity for a significant period of dry weather during which baits will remain attractive to rats and ants. In New Zealand aerial baiting operations are usually carried in winter when food sources are limited and baits are most attractive. Weather is considered a more important factor to determining the timing of the operations in Samoa, rather than possible seasonal changes in natural food supply. There is no equivalent season in Samoa, however the wet season is generally the time of greatest productivity and some birds breed then, another reason to avoid this period. Winds will generally be steady and predictable during the months chosen.

Section 2.2 Adverse impacts of Pacific rats and yellow crazy ants and reasons for control

Pacific rats

Commensal rodents are the most widespread and damaging of the introduced animals and are directly responsible for an estimated 40% of all global bird extinctions and the extirpation of many seabird populations (King 1985). Many studies detail the benefits of rat removal (e.g. Towns and Broome 2003).

Numerous studies have clearly illustrated that Pacific rats have adverse impacts on island ecosystems. They eat, and compete with invertebrates (particularly large ground dwelling invertebrates), skinks and geckos (King 2005). They eat bird's eggs and nestlings, particularly those that nest on or near the ground, low in holes in trees (Towns *et al.* 1997) or in burrows (Pierce 2002). Pacific rats eat a wide range of plant material including flowers, leaves, buds, fruits and seedlings (King 2005). On offshore islands in northern New Zealand Pacific rat studies have shown that they eat the seeds of a range of trees and shrub species significantly reducing seedling recruitment which has major effects on forest composition (Campbell and Atkinson 1999, 2002).

Yellow crazy ants

Yellow crazy ants have the ability to form multi-queened 'super-colonies', in which ants occur at extremely high densities (1000s of worker ants m^{-2}) over large areas (O'Dowd *et al.* 2003). They have a range of devastating impacts on the ecosystems they invade. They out compete and kill invertebrates, crabs, reptiles and birds and can have serious indirect impacts on natural ecosystem processes and forest composition and structure.

The most significant direct impacts of yellow crazy ants are on the other invertebrates that form the bulk of their diet. Research has shown that in areas infested with yellow crazy ants the composition of the ground invertebrate fauna is altered, the diversity of invertebrate species is reduced, there are fewer invertebrates and other ant species are displaced (Hill *et al.* 2003).

Species including the coconut crab (*Birgus latro*), other land crab species and lizards are also severely impacted by yellow crazy ants. They can be a threat to birds, either through disrupting nesting or killing young. On Christmas Island (Indian Ocean), yellow crazy ants caused sooty terns to abandon 1.5 ha of their colony, the abundance of emerald doves (*Chalcophaps indica*) is significantly lower where there are yellow crazy ant supercolonies, and nesting success of the island thrush (*Turdus poliocephalus*) may also be negatively affected (Davis 2002, *in:* Green *et al.* 2002).

The most dramatic impact of yellow crazy ants has been on Christmas Island where they have killed an estimated 20 million red crabs (*Gecarcoidea natalis*), a keystone species and the dominant endemic consumer on the forest floor. By extirpating red crabs yellow crazy ants have indirectly released seedling recruitment, enhanced species richness of seedlings, and slowed litter breakdown. In the forest canopy associations between yellow crazy ants and scale insects have lead to high densities of scale insects encouraging the growth of sooty moulds. This has led to extensive canopy dieback and deaths of some canopy trees (O'Dowd *et al.* 2003). Reduced canopy cover increases the amount of light reaching the forest floor and can provide ideal conditions for the establishment of weeds (Green *et al.* 2001, *in:* Green *et al.* 2002).

Section 2.3 Justification for the proposed operation

The islands of Nu'utele and Nu'ulua have long been identified as key sites for conservation (Holloway and Floyd 1975; Pearsall and Whistler 1991; *in*: Butler 2005a, Park *et al.* 1992). The restoration of the Aleipata Islands has been identified in conservation strategies in Samoa since 1991. It features as a priority within Samoa's National Biodiversity Strategy and Action Plan (NBSAP) prepared as a commitment to the Convention on Biological Diversity within an action recorded as "Develop a programme for the eradication of rodents from small islands which can be used for conservation of rare species such as the tuaimeo (friendly ground dove)".

The islands are listed as a Key Biodiversity Area in the Critical Ecosystem Partnership Fund's (CEPF) ecosystem profile for the Polynesia/Micronesia Hotspot. Restoration of these islands ties closely into Strategic Directions 1, 2 and 4 in the ecosystem profile for the Micronesia-Polynesia Hotspot.

The islands hold populations of internationally threatened land-birds (IUCN) (e.g. tooth-billed pigeon (*Didunculus strigirostris*) (endemic, endangered), friendly ground dove (*Gallicolumba stairi*) (regional endemic, vulnerable), Samoan broadbill (*Myiagra albiventris*) (endemic, vulnerable)), and other threatened species, coconut crab (vulnerable) and Samoan fruit bat (*Pteropus samoensis*) (endemic, endangered). Nu'utele and Nu'ulua are probably the most important breeding sites in Samoa for the red-footed and brown boobies (*Sula sula and S. leucogaster*), blue-grey noddies (*Procesterna cerulea*), and the greater frigatebird (*Fregata minor)* (Park *et al.* 1992) and are the most significant remaining hawksbill turtle (*Eretmochelys unbricata*) (critically endangered) nesting sites in Samoa (MPA 2002).

Nu'utele and Nu'ulua are Samoa's only uninhabited offshore islands large enough and far enough offshore to be considered for refuges for the conservation of species threatened by introduced pests and human activities on the main islands, including birds, reptiles and invertebrates. These island refuges have assumed greater importance as recent severe cyclones have reduced bird and bat numbers on the main islands (Butler 2005a). They have the potential to play a key role in sustaining the future of Samoa's biodiversity.

The local people who own and use the islands have given their support to the rat eradication as part of a larger, successful marine protected areas (MPA) project along the Aleipata coast. The Aleipata MPA has ongoing support from SPREP/ICRAN as a demonstration site, the SPREP Invasive Species Programme, and new support for marine work from France's CRISP (Coral Reef Initiative in the South Pacific) coordinated by

Conservation International. The Management Plan for the Aleipata Marine Protected Area for 2002 - 2006 lists island restoration, and particularly rat eradication as one of its priority working goals:

> "by the end of 2006 our offshore islands (Nu'utele and Nu'ulua) will have had a restoration programme designed, and begun implementation focusing on rat eradication, and endangered bird life (land and sea bird) and other native wildlife conservation and overall security of these islands for heritage conservation (natural and cultural)".

A final justification for the project and one reason it has the support of regional conservation agencies like SPREP is its potential role as a demonstration project for the South Pacific. It will illustrate that rat eradication and ant control can be conducted successfully and safely, bring about positive changes in island biodiversity and strengthen the region's ability to make similar projects happen (Butler 2005a).

Section 2.4 Objectives and purpose of the proposed operation

Operational objectives

- To eradicate Pacific rats from Nu'utele and Nu'ulua Islands by the end of 2006.
- To control yellow crazy ants to low numbers on Nu'ulua Island by the end of 2006.

Purpose for eradicating Pacific rats

The purpose of Pacific rat eradication on Nu'utele and Nu'ulua is to:

prevent:

- egg and nestling predation on vulnerable forest bird species such as the friendly ground dove
- egg and nestling predation on nesting seabirds
- predation on, and competition with invertebrates and lizards
- predation on seeds, fruits and seedlings thereby improving regeneration
- potential predation on hawksbill turtle eggs and hatchlings,

and to:

- restore more natural ecosystem processes to the islands
- allow for the recovery of existing invertebrate, lizard, turtle and bird populations
- allow the re-introduction of species (i.e. burrowing seabirds) that may have been extirpated by Pacific rats
- increase the islands potential as offshore refuges to which other Samoan species threatened with extinction on the main islands can be introduced.

Purpose for controlling or eradicating yellow crazy ants

The purpose of controlling or eradicating yellow crazy ants on Nu'ulua is to:

reduce or prevent:

- changes in the composition and abundance of the invertebrate fauna
- increases in sap-sucking insects and sooty moulds which reduce tree health and cause tree death

- changes in forest structure and composition due to losses of land crabs
- changes in forest litter and nutrient cycles
- declines in lizards populations
- declines in some bird populations, particularly ground birds, resulting from nest losses or competition for food
- reduced nesting success of some seabirds, and
- losses of hatchling turtles.

Other objectives of the operations

Other objectives are to:

- demonstrate best practice for rat and ant management that can be applied elsewhere in the region.
- develop the skills and understanding of local staff and the community so that they can be applied to the future management of the islands.
- strengthen partnerships for biodiversity conservation, both within Samoa and between the different countries and agencies involved with this issue in the Pacific Islands.
- establish a framework to prevent the re-introduction of Pacific rats and other invasive species with the potential to have a detrimental impact on the islands' ecosystems.

Chapter 3 Description of the Receiving Environment

Section 3.1 Introduction

This section describes the treatment area, including:

- the location and physical characteristics of the area
- the ecology of the area including the wildlife
- significance to local communities, and
- recreational and commercial values.

Section 3.2 Description of the receiving environment

Size

Nu'utele Island is 108 ha and Nu'ulua Island is 25 ha. The total area to be baited is 133 ha.

General Location

Nu'utele and Nu'ulua Islands are part of the Aleipata Island Group, and are 1.3 and 3.3 km respectively, off Cape Tapaga at the southeast corner of Upolu, Samoa (14° 06.3' S 171° 42.4' W (Nu'utele) and 14° 07.3' S 171° 41.1' W (Nu'ulua)). Nu'ulua, the outermost of the two islands is 500 m east of Nu'utele. The villages of Lalomanu, Vailoa, Ulutogia, Satitoa and Malaela are on the adjacent eastern coast of Upolu between Nu'utele and Nu'ulua Islands and Namu'a Island. Matautu is located below Cape Tapaga on the southern coast of Upolu.

The proposed helicopter loading area is on the reclaimed spit extending into the lagoon inside the reef between Malaela and Satitoa (Appendix 1). The site of the helicopter loading area will not be confirmed until a New Zealand expert has visited the site.

Climate

The islands have a tropical oceanic climate tempered by the prevalent south-east trade winds. There is a distinct wet and dry season. The climate is wetter and hotter between November and April and drier and cooler between May and October. The mean temperature is 26.5 °C.

Topography and geology

Nu'utele is the highly eroded remains of a tuff cone that was originally circular in shape, but due to erosion various portions of the rim are now gone hence the outside of the cone's rim is steep to vertical and broken by a series of bluffs. On the north and west sides of the island are steep marine cliffs up to 180m high (Whistler 1983 *in* Butler 2005a). The highest point of the island is 209 m above sea level. Most of the soil on the island is derived directly from the volcanic tuff. Soils were classified by Wright (1963 *in* Park *et al.* 1992) as "Nu'utele steepland soils" which comprise the rim of the cone, and "Vini clay, stony in part" which comprises the centre of the tuff cone. The soil on the sandy shelf above Vini beach is classified as "Fusi sands" and the soils in the bay on the eastern side are "Fusi sands" and "Muutiatele sand, peaty sandy loam etc."

The geology of Nu'ulua is similar to that of Nu'utele. It is the remains of a tuff cone breached on the eastern side by the sea. The island is 108 m high at its highest point. In general its topography is less steep. The soils are similar to Nu'utele with the ridge of the island covered with "Nu'utele steepland soils", the inner eastern slope inside the crater with "Vini hill soils" and the sandy beach of the bay with "Fusi sands" (Wright 1963 *in* Park *et al.* 1992).

Significant water bodies

There is no permanent fresh water on either island. All streams are ephemeral and only contain water after rainfall.

Section 3.3 Flora and fauna

The description of the vegetation on Nu'utele and Nu'ulua is from Park *et al.* (1992). See Whistler (1983) and Park *et al.* (1992) for a more detailed account of the vegetation on Nu'utele and Nu'ulua Islands.

Vegetation types and their extent

The vegetation covering Nu'utele is native or only partially disturbed, with a relatively open understorey, only a few vine tangles and limited ground cover (Bell, 2000 *in*: Butler 2005a). Park *et al.* (1992) recognise four plant communities: littoral forest; coastal forest; lowland forest; and managed (modified) land. The littoral forest is dominated by the canopy species talie (T*erminalia catapppa*) with futu (*Barringtonia asiatica*) and pu'a (*Hernandia nymphaeifolia*) also common. The exposed ridges of the island are covered in a unique coastal forest composed largely of asi vai (*Syzgium clusiifolium*), 'anume (*Diospyros elliptica*) and 'au'auli

(*Diospyros samoensis*). The interior of the island on the east and west facing slopes are covered with lowland forest which reaches 20 m in height in favourable places. Mamala (*Dysoxylum samoense*) is the dominant canopy species. The modified land consists mostly of the small coconut plantations at Vini and Nuutele beaches. A number of native forest tree species grow within this.

The vegetation of Nu'utele Island was considered by Park *et al.* (1992) to be of conservation significance because:

- coastal and lowland forests are rare and uncommon in Samoa, respectively
- Species diversity is high with over 160 species of plants recorded
- Several species are rare, the most significant being *Chionanthus vitiensis*, polo (*Solanum viride*) and pani (*Manilkara dissecta*)
- The vegetation is very important for the seabirds present.

Nu'ulua contains the most intact lowland coastal forest assemblage in Samoa and is of high conservation significance. The vegetation is practically unmodified and there are few coconut palms. It has some unique vegetation and species diversity is relatively high. One plant species is present that is found nowhere else in the country (*Suriana maritima*, a coastal shrub known from a single specimen on the beach (Park *et al.* 1992)) and another, *Boerhavia alba* is rare in Polynesia and has only been recorded from Nu'ulua and Fanuatapu in Samoa. The vegetation is very similar to that of Nu'utele (Park *et al.* 1992). Four vegetation types are recognised: herbaceous strand, littoral forest, coastal forest and lowland forest. The herbaceous vegetation is comprised predominantly of *Lepturus repens*, *Paspalum vaginatum*, and *Fimbristylis cymosa*. Instead of being dominated by talie, as on Nu'utele the littoral forest of Nu'ulua is dominated by pu'a (*Pisonia grandis*) which extends 100 m inland from the shore of the beach. Talie, pu'a and gatae (*Erythrina variegate*) are common in the canopy and fao (*Neisosperma oppositifolium*) is a common understorey species. The coastal and *Dysoxylum* lowland forest have not been surveyed but are probably very similar to those on Nu'utele.

Native bird species

A number of endemic and internationally threatened bird species are present on Nu'utele and Nu'ulua. These include the tooth-billed pigeon (endemic; endangered), friendly ground dove (regionally endemic, vulnerable) and the Samoan broadbill (endemic, vulnerable) (Stringer *et al.* 2003a). The islands provide habitat for a number of other locally and regionally endemic birds. Nu'utele and Nu'ulua are the most important breeding sites in Samoa for the red-footed and brown boobies, blue-grey noddies and the greater frigatebird (Park *et al.* 1992). Other seabirds also nest on the islands which are considered to be the last significant remaining seabird colonies in Samoa (MPA 2002).

Most of the bird species on these islands could be expected to benefit from the rat eradication and yellow crazy ant control operations through reduced competition for food and reduced egg and nestling predation. The native birds recorded on the islands include:

Common name	Scientific name	Status*	Island†
Land birds			
Tooth-billed pigeon	(*Didunculus strigirostris*)	EN (EN)	
Friendly ground dove	(*Gallicolumba stairi*)	VU (AR)	
Many coloured fruit dove	(*Ptilinopus perousii*)	LC (CC)	
White throated pigeon	(*Columba vitiensis*)	LC (CC)	Nu'utele
Pacific pigeon	(*Ducula pacifica*)	LC	
Crimson crowned fruit dove	(*Ptilinopus poriphyraceus*)		
Samoan broadbill	(*Mylagra albiventris*)	VU (VU)	Nu'utele
Flat-billed kingfisher	(*Todirhamphus recurvirostris*)		
White-rumped swiftlet	(*Aeroramphus spodiopygius*)		
Samoan whistler	(*Pachycephala flavifrons*)		Nu'utele
Polynesian triller	(*Lalaga maculosa*)		
Samoan triller	(*Lalage sharpei*)	NT (NT)	
Wattled honeyeater	(*Foulehalo carunculata*)		
Polynesian starling	(*Aplonis tabuensis*)		
Samoan starling	(*Aplonis atrifusca*)		
Scarlet robin	(*Petroica multicolor*)		Nu'utele
Samoan fantail	(*Rhipidura nebulosa*)		
Blue-crowned lory	(*Vini australis*)	LC	
Banded rail	(*Rallus phillippensis*)		
Barn owl	(*Tyto alba*)		
Seabirds			
White-tailed tropicbird	(*Phaethon lepturus*)	LC	
Red-footed booby	(*Sula sula*)	LC	
Brown booby	(*Sula leucogaster*)	LC (CC)	
Greater frigatebird	(*Fregata minor*)	LC	
Lesser frigatebird	(*Fregata ariel*)	LC	
Reef heron	(*Egretta sacra*)		
Golden plover	(*Pluvialis fulva*)		
Wandering tattler	(*Tringa incana*)		
Turnstone	(*Arenaria interpres*)		
Common noddy	(*Anous stolidus*)		
Black noddy	(*Anous minutus*)		
Blue-grey noddy	(*Procesterna cerulea*)		
White tern	(*Gygis alba*)		

List compiled from: Park *et al.* (1992), Stringer *et al.* (2003a, 2003b), Parrish *et al.* (2004).

* Threat status (see below).

Global threat status (left, un-bracketed) from *Threatened Birds of the World* (Birdlife International 2000) and sourced from Watling (2004):

EN = Endangered
VU = Vulnerable

NT = Near Threatened
LC = Least Concern.

National threat status (right, in brackets) is sourced from Watling (2004) and is based on subjective assessment, local knowledge or interpretation of published information:

EN = Endangered
VU = Vulnerable
AR = At Risk
NT = Near Threatened
CC = Conservation Concern.

† Recorded on the island named but not the other.

Reptiles

Six skinks, two geckos and one snake species are present on Nu'utele and Nu'ulua. Parrish *et al.* (2004) comment that while the gecko fauna is likely to be the same on each island in the Aleipata Group, the Samoan boa appears to be confined to Nu'utele Island and the Samoan skink (Nu'utele Island), Murphy's skink (Nu'utele Island) and the Micronesian skink (Nu'ulua Island) are confined to single islands. None of the lizard species are threatened (Stringer *et al.* 2003b).

Skinks

Common name	Scientific name	Island†
White-bellied skink	(*Emoia cyanura*)	
Pacific black skink	(*E. nigra*)	Nu'utele
Dusky-bellied skink	(*E. impar*)	Nu'ulua
Micronesian skink	(*E. adspersa*)	Nu'ulua
Samoan skink	(*E. samoensis*)	Nu'utele
Murphy's skink	(*E. muphyii*)	Nu'utele

† Recorded on the island named but not the other.

Geckos

The oceanic gecko (*Gehyra oceanica*) and mourning gecko (*Lepidodactylus lugubris*) have been recorded on both islands. Parrish *et al.* (2004) comment that the gecko fauna of the Aleipata Islands is likely to be limited to these two species.

Snakes

The Samoan boa (*Candoia bibroni*) is the only species of snake recorded. It has only been recorded on Nu'utele (Stringer *et al.* 2003a, 2003b; Parrish *et al.* 2004).

Turtles

Hawksbill turtles (critically endangered) nest on the beaches of Nu'utele and Nu'ulua (Andrews and Holthus 1989) and they and green turtles (*Chelonia mydas*) are often observed in the seas around the islands.

Bats

Two species of bat are present, the Samoan fruit bat and the Tongan fruit bat (*P. tonganus*).

Invertebrate fauna

The invertebrate fauna of Nu'utele and Nu'ulua has not been comprehensively studied and information on rarity and endemism levels are not known. Stringer *et al.* (2003a, 2003b) recorded invertebrates that were caught in pitfall traps on Nu'utele Island.

Common name	Order
Earthworms	Oligochaeta
Earwigs	Dermaptera
Slaters	Isopoda
Sand hoppers	Amphipod
Springtails	Collembola
Centipedes	Chilopoda
Crickets	Gryllidae
Plant hopper	Hemiptera: Flatidae
True bugs	Hemiptera
Rove beetles and sucking bugs	Coleoptera
Other beetles	Coleoptera
Beetle larvae	Coleoptera
Moths	Lepidoptera
Caterpillars	Lepidoptera
Land snails	Gastropoda
Higher fly	Diptera: Cyclorrhapha
Lower fly	Diptera: Nematocera
Moth fly	Diptera: Psychodidae
Ants	Hymenoptera, Formicidae, Ponerinae
Spiders	Araneae
Parasitic wasps	Hymenoptera
Mites	Acarina
Book lice	Psocoptera
Thrips	Thysanoptera

Crustaceans

Coconut crabs (vulnerable), *Grapsid* crabs, hermit crabs (*Anomura*) and at least one other species of crab are common (Stringer *et al.* 2003a, 2003b; Parrish *et al.* 2004).

Freshwater aquatic fauna

The absence of permanent water on the islands precludes the presence of freshwater fauna.

Marine environment

The marine environment of the Aleipata area (including Nu'utele and Nu'ulua Islands) contains typical Pacific Island shallow lagoons and reefs. It supports plant and animal communities normally found in Samoan shallow lagoon and reef slope situations. A marine survey of the area found no unusual, unique or unknown fish or other organisms (Andrews and Holthus 1989). Fish populations and diversity were consistent with what would be expected for this type of marine environment. Large populations of herbivorous and corallivorous fish are present. Damsel fish (*Pomacentrids*), *Scarids* (particularly *Bolbometopon bicolour*), wrasses (*Labridae*) and *Cheilinus undulates* are abundant. *Epinephelus* and *Cephalophis* species are common reef piscivores and are more abundant and of a larger size around Nu'utele and Nu'ulua. The coral trout *Plectropomus leopardus* and *Variola louti* were uncommon in the area, except around Nu'utele Island (Andrews and Holthus 1989).

Other non-native animals present

Pigs (*Sus scrofa*) and chickens (*Gallus domesticus* or *G. gallus?*) have recently escaped and are now wild on Nu'utele. The red-vented bulbul (*Pycnonotus cafer*) was recorded as being common on Nu'utele by Stringer *et al.* (2003a).

Section 3.4 Significance of the islands to local communities

Land ownership

Both islands are customarily owned (ownership rests with key Matai (chiefs)) and involve at least four key families/titles from the villages of the Aleipata district.

Land use

The islands are uninhabited and covered in lowland coastal forest. Coconut, banana, taro, coconut crabs, young seabirds, Pacific pigeons (lupe), chickens and flying fox are intermittently harvested from Nu'utele (Park *et al.* 1992, D. Butler pers. comm. 2006). None are currently cultivated and they are all growing or living in a wild state. There are two temporary fale at Vini beach on Nu'utele Island.

Adjacent land uses

There is no adjacent land. The marine environment surrounding the islands forms part of the Aleipata Marine Protected Area.

Significance of the area to local communities

Both islands are uninhabited and visited very infrequently by one of the families. Nu'ulua is visited much less frequently than Nu'utele (F. Sagapolutele pers. comm. 2006).

Historical or cultural significant features

There are two graves from the pre-1900s on Nu'utele but no other cultural or spiritual values have been identified. The remains of a former leper colony are present behind Nu'utele beach.

Section 3.5 Recreational and commercial interests

Recreational values and public access

The islands have no recreational values and public access is limited. Permission to visit the islands must be granted by the families that have customary ownership.

Commercial values

The islands are not used for commercial purposes. A kayaking company (Green Turtle Tours) runs trips around the islands but clients do not go ashore. The islands may be used for ecotourism in the future following restoration.

Chapter 4 Alternative Options for Control/Eradication

Section 4.1 Criteria to guide the selection of methods and pesticides

Project decision criteria can help assess and select an appropriate control method from the options available. This EIA uses the following criteria to assess the alternatives available:

- must be effective at killing the target species
- must be cost effective
- adverse effects on non-target wildlife must be known to be minor and/or can be prevented or mitigated, and
- any risks to human health and community well-being can be avoided, remedied or mitigated.

Section 4.2 Alternative options for management of Pacific rats and yellow crazy ants

Alternative locations

Nu'utele and Nu'ulua are Samoa's only uninhabited offshore islands large enough and far enough offshore to be considered as refuges for the conservation of threatened species. There are no alternative locations.

Alternative strategies for management of Pacific rats

Alternative strategies to Pacific rat eradication include doing nothing, and control.

Do nothing

Doing nothing would result in continued predation on forest bird and seabird eggs and nestlings, lizards, crabs, invertebrates, seeds and fruits and continued competition with birds, crabs, invertebrates and lizards. Natural processes such as regeneration would not be restored, several species may become locally extinct on the islands and the potential of the islands as offshore refuges for other threatened species would not be realised. This option is not considered to be acceptable.

Control

Control will lower Pacific rat numbers on the islands for a short time following the control operation. Even at reduced numbers, Pacific rats will continue to have an adverse effect on the islands' native flora and fauna. Within several months to a year after control has stopped rat numbers will increase to pre-control densities and continue to impact on the islands' ecosystems. In the long-term, eradication is the most cost-effective management strategy. Control would need to be continued if any benefits were to be maintained while eradication is a one-off cost. Control using toxins will mean that toxins will be present in the environment on the islands for a longer time period than for a one-off eradication.

Eradication

Eradication is the best option for the restoration of Nu'utele and Nu'ulua Islands. Eradication will ensure the protection of threatened species, guarantee that no more local extinctions are caused by Pacific rats and will restore the island's natural processes (in conjunction with yellow crazy ant control). Eradication is the most cost-effective strategy for management of the islands and means that any impacts of the brodifacoum rat baits are one-off effects that are confined to a short time interval. Eradication of rats is feasible and the probability of success is very high.

Alternative strategies for management of yellow crazy ants

The alternatives to the proposed yellow crazy ant control are to do nothing or to pursue eradication.

Do nothing

This option is not considered to be acceptable. Doing nothing carries an unacceptably high risk of substantial and possibly irreversible impacts on the ecosystem of Nu'ulua through continued predation on invertebrates, crabs, lizards, and some bird's nests. It could lead to changes in the islands nutrient cycling, forest structure and composition and significant changes in the composition and abundance of the native fauna. Population reductions or extinctions of many native species including seabirds, for which the island is the key nesting habitat in Samoa would be likely to occur. In addition, it would render the proposal to eradicate Pacific rats from the island a waste of time and resources and the goal of restoring it as a key site for conserving native species unachievable.

Control

Effective control would lower ant numbers and reduce the magnitude and extent of yellow crazy ant impacts on the islands ecosystem. Control to very low levels will provide significantly reduce or almost eliminate impacts on native biodiversity, but control would need to be conducted annually if benefits were to be maintained long-term. Regular control of yellow crazy ants should avoid irreversible damage to Nu'ulua's ecosystem until eradication becomes a feasible option. Control to very low levels is currently the best management option available.

Eradication

Eradication is generally the preferred option if achievable. Long-term it is the most cost-effective strategy. Eradication would prevent irreversible damage to the ecosystem of

Nu'ulua and restore the island's natural processes. It would mean that any impacts associated with the use of indoxacarb are one-off effects. However, it is doubtful that eradication can be achieved on Nu'ulua by one aerial baiting operation given that any surviving queen can establish a new colony. To eradicate yellow crazy ants from the whole island it would need to be aerially baited at least twice a year for 3 years, and preferably 3-4 times per year (Vanderwoude 2006 *in* Butler 2006). This would be prohibitively expensive. Further, the ability to prevent human-aided re-introduction is not certain, and is in fact unlikely at present.

Section 4.3 Evaluation of alternative methods for Pacific rat eradication

Introduction to the methods available

This section describes the range of potential methods available to eradicate Pacific rats from Nu'utele and Nu'ulua Islands. The methods include: trapping; bait stations; hand laying baits and aerial baiting.

A detailed evaluation of the advantages and disadvantages of using these methods for this operation are evaluated in Appendix 2.1. A summary of the evaluation of each of the methods is provided below:

Trapping

Trapping rats to a point of eradication is simply not possible due to the inaccessibility the steep cliffs and bluffs on both islands. Rats would survive in these areas and re-invade previously trapped areas.

Bait stations

Again, it is not practical or cost effective to establish tracks and place and maintain bait stations on the steep cliffs and bluffs of either island. Rats in these areas would not have access to baits and the probability of the operation failing would be high.

Hand laying baits

Hand laying baits on the steeper cliffs of both islands is not physically possible. Rats in these areas would not have access to baits and the probability of the operation failing would be high. Achieving acceptable bait coverage on the remaining areas of the islands would be difficult given the terrain and thick vegetation.

Aerial baiting

Aerial baiting is the only method that will ensure complete bait coverage over all parts of both islands and achieve the objective of eradication. Risks to non-target species are increased so appropriate measures must be put in place to mitigate these.

Section 4.4 Evaluation of alternative methods for yellow crazy ant control

Introduction to the methods available

This section describes the range of potential methods available to control yellow crazy ants on Nu'ulua Island. Because extensive coverage is required to achieve effective ant control, the methods are limited to hand laying baits and aerial baiting.

Hand laying baits

See Appendix 2.1 for an introduction to, and the advantages and disadvantages of hand laying baits.

Hand laying could be undertaken in the more accessible parts of the island, and if a staged approach was used would give coconut crabs a better opportunity to recover between baiting as they would rapidly repopulate treated areas from those areas that had not been treated (Vanderwoude 2006 *in:* Butler 2006). Hand laying baits on the steeper cliffs is not physically possible. Yellow crazy ants in these areas would not have access to bait and would re-colonise the rest of the island. Achieving acceptable bait coverage on the remaining areas of the island would also be difficult given the terrain and thick vegetation.

Hand laying baits in accessible areas and aerial baiting the inaccessible cliffs

This method would result in good bait coverage over the steeper, inaccessible cliffs on the island but would not prevent the risk of non-target impacts on the intertidal and near shore marine environment. To minimise non-target impacts on the marine environment, the reverse of this - hand laying baits on the coastal areas (which are predominantly the steep inaccessible cliffs) - would be desirable. This is clearly impossible. Ground baiting of parts of the island could make it easier to protect crabs from baits if this is considered necessary, but bait coverage would be reduced, risking leaving pockets of surviving yellow crazy ant nests. This method would be more labour intensive and time consuming. It is cheaper and easier to aerial bait the whole island rather than aerial parts of it.

Aerial baiting

See Appendix 2.1 for an introduction to, and the advantages and disadvantages of aerial baiting.

Aerial baiting is the only method that will ensure complete bait coverage over all parts of the island and hence is the most likely method to achieve extensive and effective yellow crazy ant control. Accurate bait coverage is assured, it is less time consuming and labour intensive and not dependent on sea conditions allowing regular access to the island. It is the most cost-effective method, particularly because a helicopter will be on site for the rat eradication operation. Risks to non-target species are increased and the likelihood of baits falling into the sea and potentially having an adverse impact on marine species is higher. Appropriate mitigation measures must be put in place to manage these impacts.

Section 4.5 Evaluation of alternative toxins for Pacific rat eradication

Introduction to the methods available

This section evaluates the range of potential toxins available to eradicate Pacific rats from Nu'utele and Nu'ulua Islands. The toxins include: sodium monofluoroacetate (1080);

cholcalciferol; first generation anticoagulants (coumatetralyl, diphacinone, pindone and warfarin) and second generation anticoagulants (including bromodiolone, flocoumafen and brodifacoum).

A detailed evaluation of the advantages and disadvantages of using these toxins for this operation are provided in Appendix 3.1. A summary of the evaluation of each of the toxins is given below:

Sodium monofluoroacetate (1080)

1080 can be highly effective for rodent control but some doubts exist regarding the consistency of rodent kills. Although data on non-target impacts are well known and it is available in large quantities and manufactured in a form suitable for aerial baiting, 1080 remains untested for island rodent eradications. Because it is an acute toxin, there is an increased risk of bait shyness developing if a sub-lethal dose is ingested. 1080 is unlikely to kill every rat present which is essential to achieve eradication.

Cholecalciferol

Because it is a relatively new product, there is high uncertainty across most parts of the risk assessment for cholecalciferol. Although the risk of non-target poisoning and secondary poisoning appears to be reduced, knowledge of non-target effects is poor. Cholecalciferol is an acute toxin so there is an increased risk of bait shyness in sub-lethally poisoned rats. It is largely untested for rat eradications and knowledge of its efficacy is poor. Due to the cost of this particular operation failing it would be unwise to use cholecalciferol.

First generation anticoagulants

First generation anticoagulants are less potent than secondary generation anticoagulants. This means they generally have a reduced risk of lethal non-target poisoning and a lower tendency to cause secondary poisoning than second generation anticoagulants. Rats need to ingest anticoagulant baits over several days before a lethal dose is taken and the ingestion rate must exceed the rate of metabolism. First generation anticoagulants are not a good option for this operation because maintaining baits in sufficient quantity in good enough condition to allow this in the presence of competition from land crabs and adverse climatic factors would be very difficult and repeat applications would be required at significant extra cost. Using first generation anticoagulants would significantly increase the chance of operational failure if sufficient baits could not be maintained on the ground.

Second generation anticoagulants

Brodifacoum

Brodifacoum has been selected as the preferred toxin. It is one of the most widely used rat poisons worldwide. Of the 274 commensal rodent eradications undertaken to date on more than 233 islands, brodifacoum has been the most commonly used poison (64%) (Galvan *et al. in press*?). All attempted rat eradications using aerial baiting of brodifacoum have been successful. Brodifacoum is a very potent rat poison and only a single feed is required. Importantly for eradication, brodifacoum is a chronic toxin so there is reduced risk of bait shyness and operational failure. Efficacy data and data on non-target impacts are well known and brodifacoum baits are available in large quantities and are manufactured in a form suitable for aerial baiting. Brodifacoum is the only pesticide registered for aerial rodent control on offshore islands in New Zealand. The costs of failure for this operation are too high to consider using anything other than brodifacoum. Any approach that minimises the risk of the eradication failing must be taken in Samoa because of the difficulties and costs of having to repeat any operation.

Bromodiolone

Bromodiolone is very similar to brodifacoum but not as potent. It is not as readily available and there are no advantages of using bromodiolone over brodifacoum which has a proven track record for rodent eradications.

Flocoumafen

The chemical and biological effects of flocoumafen are almost indistinguishable from brodifacoum, however it has not been as widely used in rodent eradications. As for bromodiolone, there are no advantages of using flocoumafen over brodifacoum.

Section 4.6 Evaluation of alternative toxins for yellow crazy ant control

Introduction to the toxins available

There are numerous insecticides available for ant control. They include: fipronil (Presto 01®, Presto 001®, Xtinguish®); hydramethylnon (Amdro®); methoprene (Engage®); pyriproxyfen (Distance®); and indoxacarb (Advion®, and an un-registered bait).

The organochlorine insecticide Aldrin was used successfully in large scale control of yellow crazy ants in the Seychelles in the 1970s reducing ant populations by 90 % in a few days, but due to its persistence in the environment it is no longer an appropriate insecticide for ant control. It is not considered further here. The hydramethylnon bait Amdro® appears to be unattractive to *Anoplolepis* sp. Pyriproxyfen (an insect growth regulator) is being trialled on Christmas Island but an optimal baiting matrix, dosage and application frequency has not been determined (Stanley 2004). Of the insecticides above, fipronil and indoxacarb were considered to be the most appropriate for yellow crazy ant control on Nu'ulua (Butler 2005b).

A detailed evaluation of the advantages and disadvantages of using these toxins for this operation are evaluated in Appendix 3.2. A summary of the evaluation of each of the toxins is provided below:

Indoxacarb

Although a relatively new toxin, indoxacarb has been designated a 'reduced risk insecticide' by EPA. It effectively kills ants, trials on red imported fire ants have shown promising results (Barr 2002a, 2002b, 2004). Non-target risks are likely to be lower than the alternative, fipronil. Indoxacarb is poisonous to fish and aquatic invertebrates and pre-operational trials to determine the level of impact would need to be undertaken or appropriate mitigation measures and monitoring put in place. If results of recent trials on yellow crazy ants in the Tokelau Islands and on Christmas Island are successful, indoxacarb will be the preferred toxin for this operation.

Fipronil

Fipronil is a widely used insecticide for ant control and has been used to successfully control yellow crazy ants on Christmas Island. However it failed to eradicate yellow crazy ants allowing redevelopment of supercolonies. Parks Australia North is now searching for alternatives control methods. Like indoxacarb, fipronil is highly toxic to fish and aquatic invertebrates. Terrestrial non-target risks are considered to be higher.

Section 4.7 Conclusion

Aerial baiting by helicopter is the only method likely to successfully eradicate Pacific rats from Nu'utele and Nu'ulua Islands and is the most likely method to effectively control yellow crazy ants. Previous experience eradicating rats from islands using this method proves it is highly effective. All other techniques have a high risk of failure. Brodifacoum is the best toxin option for rat eradication. The costs of failure for this operation are too high to consider using alternative baits. Indoxacarb is expected to be selected as the preferred toxin for the yellow crazy ant operation. The chances of controlling yellow crazy ants to very low densities on Nu'ulua are considered to be higher and non-target risks are likely to be lower than if the alternative toxin, fipronil is used.

Further evaluation is required to assess the environmental impacts of the rat and ant operations on Nu'utele and Nu'ulua and to determine whether these impacts can be adequately avoided, remedied or mitigated. This assessment is contained in Chapter 5.

Chapter 5 Impacts on the Environment

Section 5.1 Introduction

This chapter:

1. Summarises the known risks of actual and/or potential impacts of aerial baiting with brodifacoum and indoxacarb on:

    - air, water and soil quality
    - non-target species
    - marine species
    - ecosystems
    - human health and community well-being, and
    - cultural and spiritual values.

2. Assesses the significance of the risks for each of the above on Nu'utele and Nu'ulua.

There is a large body of literature available on brodifacoum and brodifacoum aerial baiting operations, however indoxacarb is a relatively new toxin. Consequently, the literature on indoxacarb is scarce and accurately determining the environmental impacts of aerial baiting using indoxacarb baits is more difficult.

Section 5.2 Impacts of the proposed operation on air, water and soil quality

Air quality

Both indoxacarb and brodifacoum have a low vapour pressure and will be spread in a solid form. Neither will disperse into the air. Air pollution will be negligible and limited to helicopter exhaust fumes and the production of soil and bait dust from helicopter rotor wash duration of the operations. The extent of any air pollution will be limited to a zone within approximately 50 m of the helicopter and only for several hours on the three days (two applications of rat baits, one application of ant baits) when the helicopter is operating. The potential impact of bait dust on human health is discussed in section 5.5.

Water quality

All the streams on Nu'utele and Nu'ulua are ephemeral (only contain water following rainfall) and there is no permanent water on either island. No impacts on water quality on the islands will occur.

To ensure that baits are available to all the rats and ants, it will be necessary to apply the bait along the islands' coastlines. This will mean that a small number of rat and ant baits will inevitably fall into the surrounding sea. Both brodifacoum and indoxacarb are highly insoluble in water and will not affect the water quality of the sea. The potential impacts of the operation on the marine environment are discussed in section 5.3.

Soil quality

Brodifacoum is not readily soluble. When baits disintegrate, brodifacoum remains in the soil where it binds strongly to soil particles where it is broken down by microbial activity over 1 to 6 months. Soil contamination is likely to be localised and limited to soil directly under decaying baits. Microbiological breakdown of brodifacoum is dependent on the climate, particularly temperature and the presence of microbial species. Samoa's warm, humid climate will encourage the breakdown of brodifacoum. The presence of brodifacoum traces in the soil over this period is unlikely to have any adverse effects on invertebrates (section 5.3).

Like brodifacoum, indoxacarb is not readily soluble and is relatively immobile in soil. Indoxacarb is not persistent in the soil and is broken down by microbial activity over several months (Moncada 2003). As for brodifacoum, contamination is likely to be localised and limited to soil directly under and around decaying baits.

Section 5.3 Impacts of the proposed operation on non-target species

Impacts on vegetation

Neither the Pacific rat nor yellow crazy ant operations will have any direct impact on the islands' vegetation cover. Neither indoxacarb nor brodifacoum have any reported adverse impact on plants and the low solubility of both toxins in water means that plant up-take is very unlikely.

Impacts on native birds

Land birds

The risk to land birds on Nu'utele and Nu'ulua depends on each species' susceptibility to brodifacoum and indoxacarb, the probability they will encounter baits and their diet. Generally speaking, they fall into three categories: 1) those that will not be affected by the operation; 2) those at risk of primary poisoning from directly eating baits, and; 3) those at risk of secondary poisoning from eating other animals that have eaten baits. Birds that forage on the ground, are omnivorous, eat seeds and grains and/or are inquisitive are considered to be at greatest risk from primary poisoning. Those birds that feed on ground dwelling animals that eat baits (i.e. invertebrates, crabs, lizards, rats) or scavenge poisoned carcasses are at the greatest risk of secondary poisoning. A simple risk assessment was undertaking examining the risk to the land birds on Nu'utele and Nu'ulua, and the consequence of potential impacts (Appendix 4).

Of the pigeon and dove species, the friendly ground dove is at the greatest risk as it forages extensively on the ground and its diet suggests there is a high chance it will eat brodifacoum baits. A species with a similar ecology, the barred ground dove (*Geopelia striata*) had an estimated mortality of between 40 and 80 % on four different islands in the Seychelles following aerial brodifacoum baiting (Merton *et al.* 2002) suggesting that ground doves as a group are particularly vulnerable. Despite its threat status of vulnerable, the friendly ground dove is currently considered to be the most endangered of all the Samoan birds. Nu'utele and Nu'ulua hold populations that are considered nationally significant. The complete loss of these populations would threaten the survival of the taxon in Samoa. Some authors consider the Samoan doves to be a separate race (*Gallicolumba s. stairi*) from those in Fiji and Tonga (Watling, 2004). Outside Samoa, the race is only found on the small island of Ofu, American Samoa where it is threatened. The loss of friendly ground doves on Nu'utele and Nu'ulua could threaten the race with extinction (Butler 2005b), hence the consequence of any population level effects on the islands is considered to be extremely high. Bait feeding trials were considered but investigations suggest that no friendly ground doves are available in captivity in the region (Butler 2005b). Attempts to watch or video the dove's reaction to baits were not successful during a recent expedition to the islands due to technical problems and the low densities of ground doves (Butler, 2003).

The white-throated pigeon and pacific pigeon may eat bait. Both species occasionally feed on the ground and the white-throated pigeon also eats seeds indicating there may be a risk that it will eat baits. While the tooth-billed pigeon appears to spend some time foraging on the ground (Watling 2004) it is a frugivore (fruit-eater) and considered unlikely to eat baits. Likewise, the many coloured, and crimson crowned fruit doves are entirely frugivorous and considered unlikely to be affected.

The vea (banded rail) occurs in small numbers on the two islands. It eats insects, crustaceans, snails and fruits and is at risk from eating baits, contaminated crabs and insects and probably from scavenging dead rat carcasses. Weka (*Gallirallus australis*), a New Zealand rail is known to eat cereal baits (Eason and Spurr 1995) and significant population level impacts have occurred (Taylor 1984 *in:* Eason and Spurr 1995). Based on impacts on weka, there is a moderate chance that the banded rail populations on Nu'utele and Nu'ulua will be impacted upon at a population level. The chances of all the banded rails on either island dying are low and banded rails are abundant on the adjacent main island of Upolu and not threatened. If necessary, birds could be re-introduced to the islands.

The only predatory bird that may be present is the lulu (barn owl), but only a few pairs (at most) are likely to occur on the islands. Barn owls feed almost exclusively on rats, but also on insects. Consequently the risk of secondary poisoning is very high. Barn owls have died after being fed rats that had eaten brodifacoum and significant declines in their populations have been observed in field trials. Because this operation is a one-off, brodifacoum will not be present in the environment for long so the risk of secondary poisoning is reduced. Barn owls are regionally and globally widespread and locally common and they move easily between islands (Watling 2004), so if birds on the islands are killed, others from Upolu will re-establish on Nu'utele and Nu'ulua.

The flat-billed kingfisher has a high risk of secondary poisoning. It feeds on large insects, crabs and lizards which it usually catches on the ground. New Zealand kingfishers have been found dead after brodifacoum operations. Individuals may be poisoned but population impacts are not expected. One five-minute bird count study in New Zealand indicated an increase in numbers following a brodifacoum operation while a second indicated a significant decline (Fairweather and Fisher 2005). The expected increase in invertebrates following the removal of rats is likely to be beneficial to kingfishers.

Some insectivorous species, though unlikely to eat cereal baits, may occasionally do so. For example the New Zealand robin (*Petroica australis*) is primarily an insectivore but is an inquisitive species that is known to eat cereal baits and has been found dead after poisoning operations (Eason and Spurr 1995). However, insectivorous birds are more likely to be exposed to brodifacoum by eating invertebrates that have fed on baits. On Nu'utele and Nu'ulua, the Samoan triller, Samoan whistler, Polynesian triller, and scarlet robin probably have a moderate to high risk of secondary poisoning as they obtain insects from the sub-canopy or ground. The Samoan triller has a threat status of 'near threatened' but the others are not threatened. The Samoan broadbill (vulnerable) has a lower risk of receiving secondary poisoning as it generally feeds higher in the sub-canopy and canopy (Watling 2004) but the consequence of any deaths are higher given its threat ranking. Population impacts on these species are not expected. Research has shown that brodifacoum does not persist in some arthropods (Fisher and Fair-weather 2005) so the period of risk may be relatively short lived for these insectivorous species, but there may be heightened risk from snails slugs and earthworms that can accumulate toxins in fat-soluble compounds (Eason and Wickstrom 2001).

No other land bird species are considered to be at risk from the brodifacoum operation.

Indoxacarb is moderately toxic to birds (Moncada 2003), but relative to alternative ant baits the risk of poisoning is low (the lowest avian LD_{50} for indoxacarb on an acute oral basis is 808 mg/kg for bobwhite quail. In comparison the LD_{50} for fipronil for the same species is 11.3 mg/kg). Following aerial baiting of fipronil-based baits on Christmas Island (Stork *et al.* 2003, Green *et al.* 2004) there were no adverse impacts on land bird species including the Christmas Island thrush, Christmas Island white-eye (*Zosterops natalis*) and emerald dove – a similar bird to the friendly ground dove. The non-target risks of indoxacarb to birds are considered to be extremely low at the concentrations used in this baiting operation.

Seabirds

The direct risk posed to seabird populations by brodifacoum and indoxacarb baits are extremely low to negligible, but the helicopter itself may temporarily disturb nesting birds. This disturbance is likely to be greater for birds nesting in the open. Although breeding times are not well known, red-footed and brown booby, greater and lesser frigatebird, common, black and blue-grey noddy and white terns are thought to nest year round (Watling 2004). Some or all of these species may be nesting in the seabird colonies on the islands at the time of the aerial bait drop.

Adult birds may be scared off nests by helicopter engine and rotor noise leaving eggs or chicks exposed. However, during the aerial baiting for yellow crazy ants on Christmas Island there were no significant adverse impacts on nesting seabirds (from baits or helicopter activity). None of the birds under observation took flight or abandoned nests, and few showed signs of having noticed the aircraft at all. Red footed boobies and great frigate birds occasionally took flight as a result of helicopter operations (Green *et al.* 2004). If seabirds are disturbed, they are likely to return directly to their nests after the disturbance has passed, and the risk to eggs and nestlings should be minimal. Rotor downwash will be negligible at the height the helicopter will be flying while sowing baits. Bird strike is another possible, but unlikely eventuality. No mitigation measures are considered necessary for seabirds.

Impacts on reptiles

Reptiles are susceptible to brodifacoum poisoning. They are known to feed on brodifacoum cereal pellets (Merton *et al.* 2002) and are likely to eat insects that have eaten brodifacoum baits. Telfair's skinks were found dead after eating rain-softened brodifacoum baits on Round Island, Mauritius, and residues were detected in their livers (Eason and Wickstrom 2001). There was a 15 % mortality of the Caribbean gecko species *Sphaerodactylus macrolepis* when it was exposed to brodifacoum cereal pellets in laboratory trials (Garcia et al. 2002 *in:* Fisher and Fairweather 2005). Both skinks and geckos on Nu'utele and Nu'ulua are likely to eat baits and individuals may die. However, Merton (2002) did not observe any mortality to skinks on the Seychelles, and the risk to lizards is considered to be low. None of the species are expected to be affected at the population level and the benefits of eradicating Pacific rats and releasing lizards from rat predation should outweigh any losses as a result of brodifacoum poisoning. Studies have shown that lizard populations increase notably following the removal of rats (Towns *et al.* 1993, Brown 1997).

The author could find no published information on the impacts of indoxacarb baiting on lizards. Skinks and geckos are at risk of consuming baits. However, it is likely yellow crazy ants will rapidly locate and remove most of the bait before lizards can eat significant amounts. Skinks and geckos are probably at greater risk of receiving secondary poisoning from contaminated insects. No changes in the abundance of the nocturnal Christmas Island gecko (*Cyrtodactylus sadleiri*) were detected five months after aerial baiting with fipronil baits on Christmas Island (Stork *et al.* 2003, Green *et al.* 2004) which would indicate it is unlikely geckos on Nu'ulua will be adversely affected. The potential impact on skinks could be determined but is likely to be negligible.

The Samoan boa is a carnivore and will not eat either bait types. It is potentially at risk of secondary poisoning from eating rats and lizards contaminated with brodifacoum. The impact of this, while unknown, is likely to be insignificant.

Hawksbill turtles are omnivorous scavengers. Their diet consists primarily of sponges, anemones and marine invertebrates. There is a very small chance that Hawksbill turtles may eat baits that have fallen directly into the water, but the small number and their rapid disintegration (15 minutes or less) (Empson and Miskelly 1999) mean the risk of poisoning is extremely low to negligible. Hawksbill turtles coming ashore to nest are very unlikely to eat baits.

Impacts on bats

The Samoan and Tongan fruit bat are frugivorous. The likelihood of these bats consuming either rat or ant baits is very low. No other impacts are anticipated.

Impacts on invertebrates

A wide range of invertebrates have been recorded feeding on and near brodifacoum cereal baits and brodifacoum residues have been found in a number of insect species (i.e. Spurr and Drew 1999, Bowie and Ross *in press*) but they are generally not considered to be at risk from brodifacoum poisoning as they have a different blood clotting system to vertebrates (Shirer 1992 *in:* Booth *et al.* 2003). Brodifacoum lacks insecticidal properties in arthropods and is rapidly metabolised or excreted (within 3 -4 days). Species exposed to brodifacoum were unaffected (Fisher and Fair-weather 2005). Worms were only affected at extreme doses and garden snails were unaffected (Booth *et al.* 2003) but some snail species tested overseas did show toxic affects (Gerlach and Florens 2000, *in:* Fisher and Fair-weather 2005). Potentially, short term losses of individuals of the native snail species on Nu'utele and Nu'ulua could occur, but these will be offset by the longer term benefits of removing the rats. Population level impacts on invertebrates are not expected.

Indoxacarb is principally an incesticide, and is potentially highly toxic to a wide range of invertebrates. However, Green *et al.* (2002) considered many terrestrial invertebrates were probably not at risk from a similar aerial baiting operation using fipronil baits on Christmas Island because it was considered extremely unlikely that they would consume the bait (Appendix 5). Although the composition of the invertebrate fauna on Nu'ulua may be different, it is not well known and generally, the same invertebrate groups are likely to be susceptible. Invertebrates that Green *et al.* (2002) considered unlikely to eat baits were:

- Spiders, because they generally prefer live prey
- Herbivores, including many beetles, some orthoptera and stick insects
- Collembolans, because they mainly feed on micro-organisms
- Flies, bugs, bees, moths (adults) and butterflies (adults), because they are all liquid feeders
- Dragonflies, because they are predatory and take their prey on the wing
- Some ant species that are not attracted to the bait.

Most other invertebrates are potentially at risk, so it is possible that there will be negative impacts on a range of non-target invertebrate species. Intensive monitoring of litter and canopy invertebrates was undertaken following the Christmas Island aerial baiting operation programme (Stork *et al.* 2003, Green *et al.* 2004). The studies indicated there were no detectable adverse impacts on canopy insects, and no impact on litter insects, largely because yellow crazy ants dominated the baits. Yellow crazy ants are also expected to monopolise the bait in most areas they are present on Nu'ulua reducing its availability to other species. It is highly probable that there are sufficient ants to rapidly locate and remove most baits before they can be eaten by non-target species. Because indoxacarb produces an even more toxic product when digested by ants, the risk to other non-target species is considered to be lower than those of the fipronil baits used on Christmas Island.

Given the catastrophic impact yellow crazy ants are known to have on island invertebrate composition, abundance and species richness (Hill *et al.* 2003), the benefits of controlling yellow crazy ants will outweigh any losses caused by the indoxacarb baiting.

Impacts on crustaceans

Crabs are likely to consume eat baits and scavenge poisoned rat carcasses. However, no adverse impacts on crabs and other crustaceans are expected as a result of the brodifacoum operation. Like invertebrates, crustaceans have a different blood clotting system and are not considered to be at risk from brodifacoum poisoning. Pain *et al.* (2000) investigated the direct effects of brodifacoum upon the native land crab (*Gecarcinus lagostoma*) on the Ascension islands. Crabs were fed Talon pellets (0.02 g/kg brodifacoum) to simulate maximum exposure during a rodent eradication operation. No crabs died as a result of exposure to brodifacoum, only very low concentrations were found in their bodies and no residues were detected in any body tissues after 1 month.

Land crabs could potentially be affected by the indoxacarb operation. Monitoring following the use of fipronil-based baits on Christmas Island (Green *et al.* 2004) suggests that land crabs, including coconut crabs may be at risk on Nu'ulua. However, there is preliminary evidence that indoxacarb has little impact on hermit and coconut crabs (K. Abbott pers. comm. 2006). On Christmas Island a likely mortality of 15% was reduced to 5.4% by providing poultry food lures to attract coconut crabs away from baits (Green *et al.* 2004). A similar strategy could be used on Nu'ulua if indoxacarb is found to adversely affect coconut crabs. Daytime feeding activity by land crabs suggests that the aerial drops should be timed for late in the day (yellow crazy ant activity is consistently high 24 hrs a day (Abott 2005)).

Given that yellow crazy ants have a significant impact on land crabs (Green *et al.* 2002, O'Dowd *et al.* 2003) the mortality associated with the ant baiting program is likely to be insignificant in comparison to the impact of yellow crazy ants on land crab populations on Nu'ulua. Population level impacts are not anticipated and with the exception of the coconut crab, these species are not threatened.

Impacts on marine flora and fauna

No impacts on the marine environment are expected from the brodifacoum operation. In a field trial conducted off Kapiti Island (NZ) cereal baits disintegrated within 15 minutes and three species of fish were observed eating them (Empson and Miskelly 1999). The authors concluded that in most circumstances baits would fall into the sea along the turbulent coastal fringe, where it was unlikely they would remain intact for more than a few minutes. In the same study, surveys conducted before and after an aerial brodifacoum operation found no evidence that fish densities were affected, no dead fish were observed and no changes in marine assemblages resulted.

No impact on marine life was observed following the accidental spillage of 18 tonnes of Pestoff 20R brodifacoum baits into the sea at a single point at Kaikoura, (NZ) in 2001.

Given the insolubility of brodifacoum and the small number of baits that are anticipated to fall into the sea around Nu'utele and Nu'ulua Islands, the brodifacoum operation poses little risk to marine species, including fish.

There is no literature available on the potential impacts on the marine environment of aerial baiting with indoxacarb. The Advion product label states "Do not apply where conditions could favour run-off…, Do not apply directly to water, to areas where surface water is present or to intertidal areas below the mean high water mark". Although indoxacarb is 'moderately to very highly toxic' to estuarine and marine fish and invertebrates on an acute basis, chronic toxicities range from 0.0006 to 0.0184 ml/L. It is highly insoluble in water and is rapidly degraded by sunlight suggesting low persistence in aquatic environments. This indicates chronic exposures in aquatic (and marine) environments may not be significant (Ferraro and McEuan 1997 *in:* Moncada 2003). The marine environment surrounding Nu'ulua is turbulent, open ocean with significant wave action. Only a small number of baits will fall into the sea and these baits will fall into the most turbulent areas around the islands' coastline so bait breakdown will be rapid and the dilution factor enormous. However, baits should be sown at high tide to avoid baits falling in the intertidal area below the mean high water mark. There is a potential for adverse impacts on marine fish and invertebrates around the islands, but they are considered to be low given the nature of the receiving environment. Measures are proposed to mitigate these impacts (section 7.3). There are no issues regarding fish bioaccumulation (U.S. EPA).

A survey of the Aleipata Islands marine area (Andrews and Holthus 1989) revealed that the marine environment supports typical coral reef habitats and associated plant and animal communities, and does not contain particularly unique or spectacular organisms or communities. As such, no rare or threatened marine species or ecosystems are at threat and if any impacts were to occur, the nature of dispersal in the marine environment would enable rapid and complete re-colonisation by marine organisms.

Neither the brodifacoum or indoxacarb operations will have any direct impact on marine flora.

Impacts on other non-native animals present

The family that took the pigs to Nu'utele have advised that they will be removed before the operation. If any pigs remain on Nu'utele at the time of the operation they will eat the baits used for rat control. An average pig would need to eat approximately 3 kg of cereal pellets to die (Fisher and Fair-weather 2005). Although pig deaths have not been reported after aerial brodifacoum operations and it is unlikely that a pig will be able to consume this quantity of bait, particularly as baits will also be consumed by rats, crabs and invertebrates, it is possible that any pigs remaining on Nu'utele may die from brodifacoum poisoning. Pigs are an introduced species and are known predators of ground and burrow nesting birds and invertebrates and are modifying the structure of the vegetation on the island. F. Sagapolutele, a member of one of the local families has commented that he would not be concerned if the remaining pigs and chickens were killed by the rat operation. No mitigation measures are proposed to prevent pig deaths if any remain on the island at the time of the operation.

Relative to mammals, chickens are less susceptible to brodifacoum poisoning. A chicken would need to eat 450 grams of bait to die (Fisher and Fair-weather 2005). Again, it is unlikely, but possible that some chickens on Nu'utele may eat enough bait to be killed by the brodifacoum operation. Chickens are an introduced species and are undoubtedly having a detrimental impact on Nu'utele's ecosystem, particularly its lizards and invertebrates. No mitigation measures are proposed to prevent chicken deaths.

Brodifacoum will be present in both pigs and chickens after the operation (the potential impact of this on human health is discussed in section 5.5).

Red-vented bulbuls are only occasional seen on Nu'utele and Nu'ulua. They are at some risk of primary and secondary poisoning as they are omnivorous, eating berries and fruits, insects and occasionally small lizards. The risk of population level impacts is low, and this species is generally considered to be a pest. Dying baits green will help to mitigate impacts on bulbuls.

At the concentrations used in this operation the impacts of indoxacarb on non-native species will be negligible.

Section 5.4 Impacts of the proposed operation on the ecosystem

The impact of eradicating Pacific rats and controlling yellow crazy ants will have *substantial* ecosystem benefits for Nu'utele and Nu'ulua. It will restore more natural ecosystem processes to the islands (i.e. regeneration and leaf litter turnover) and allow for the recovery of existing invertebrate, lizard, turtle and bird populations (see section 2.4).

Unanticipated ecosystem impacts can occur when species' are eradicated from islands (or controlled to low numbers). By removing one component of an ecosystem, remaining species may be released from competition for resources or predation, or for example, mutualistic relationships may be broken. Individual species respond in a variety of ways and complex relationships with other species mean potential ecosystem impacts are often difficult to predict.

Pacific rats are probably a significant food source for Samoan boa and the few barn owls that occur on the islands. (Stringer *et al.* 2003b) have suggested that eradicating Pacific rats will reduce their food resource and could cause population declines. Rats are not a natural component of the islands' ecosystem and their removal will ensure barn owl and Samoan boa populations (if elevated) will ultimately return to natural levels. By eradicating rats and controlling yellow crazy ants, large invertebrate, lizard and bird numbers are expected to increase and become a more substantial component of their diet.

Any impacts on the abundance of insects could have adverse impacts on insectivorous bird and lizard species. For example, in Madagascar fipronil use caused severe non-target impacts on several invertebrates. It also had severe impacts on a skink and an iguana. It was concluded that the reduction in invertebrates, the principal food of these reptiles was the cause of their decline (Peveling 2000 *in:* Green *et al.* 2002). The impact of indoxacarb baits on invertebrates is not expected to be as high, and the effect (if any) will be short-lived because insect abundance is expected to increase as a result of both rat eradication and any control.

There is a possibility that some introduced weeds will increase after rats are removed. Although Nu'ulua appears to be relatively weed free, a diverse range of exotic planted garden species and weeds occur at Vini flat, Nu'utele Ogle (2001). Rats are almost certainly preying on seeds and fruits of these species and may be limiting their recruitment and spread.

The ecosystem impacts described above may not eventuate. They are potential impacts only, but they cannot be easily mitigated. The benefits of removing rats and yellow crazy ants from Nu'utele and Nu'ulua outweigh the potential ecosystem impacts outlined above.

Section 5.5 Impacts of the proposed operation on human health and community well-being

Neither the rat or ant operations pose significant risks to human health. The risks of brodifacoum to human health are low. Brodifacoum is classified as non-mutagenic and unlikely to be carcinogenic and there is no evidence that brodifacoum has sub-lethal effects on reproduction. Based on conservative calculations, to have a 50% chance of death, a child would have to eat over 180 g of bait in one sitting and an adult human would have to eat over 1.1 kg (Fisher and Fairweather 2005). Vitamin K1 is an effective treatment, but treatment has to be maintained for a relatively long time.

Indoxacarb is designated by the U.S. EPA to be a “reduced-risk” insecticide. It is used worldwide on a range fruit and vegetable crops grown for human consumption (Moncada, 2003). It does not cause mutagenic, carcinogenic, developmental or reproductive effects. The bait is not considered to be hazardous if inhaled, in contact with the skin or eyes or ingested (Dupont, Advion MSDS). The potential risks to human health for workers wearing appropriate protective clothing (long pants, long sleeves and gloves) are negligible (U.S. EPA).

The risks to human health are reduced because both islands are uninhabited, visited infrequently and there is 1.3 km of open ocean between the nearest island Nu’utele, and the inhabited coastline on Upolu. The helicopter flight path to the island will be over the sea and will avoid residential areas, waterways and stock. The highest risks to human health during the rat and ant operations are through worker exposure, accidental poisoning and people harvesting and eating poisoned animals (pigs, chickens, coconut crabs, and potentially Pacific pigeons (lupe)) from the islands. Exposure of any significance (i.e. which may cause harm) is only likely if baits or contaminated animals are eaten in substantial quantities. Comprehensive mitigation measures will be used to avoid human poisoning (see section 7.5). The risk of poisoning through drinking contaminated water on the island is non-existent because there is no fresh water on either island and because both toxins are highly insoluble. Rainwater collection devices associated with the two temporary fale on Nu’utele will be disconnected during the aerial baiting and their roofs will be checked for baits before they are reconnected.

The rat and ant operations will be beneficial to community well-being. They offer an opportunity to involve people from the local communities and demonstrate best practice for rat and ant management to Samoan Department of Environment and Conservation Officers, SPREP staff and the Marine Protected Area Officer from the Aleipata District so that it can be applied elsewhere in the region. Through involving local people in the operations, monitoring and subsequent management of the islands, there is an opportunity to develop the skills and understanding of the local people so that they can apply it to the future management of the islands. If conservation management is successful the islands will become refuges for endangered fauna, and hence important sites for conservation. This is likely to generate ecotourism opportunities for people living in the local communities.

The use of pesticides can distress some people who fear or perceive a more toxic effect. These effects need to be managed carefully and sensitively by staff managing the operation.

Section 5.6 Impacts of the proposed operation on cultural and spiritual values

Neither the rat nor the ant baiting operations will have any physical impact on the two graves or the remains of former leper colony. No concerns about the aerial baiting on cultural or spiritual values have been raised by the local Aleipata communities.

Section 5.7 Other impacts of the proposed operation

Noise

The only significant noise will be helicopter engine and rotor noise. This will be limited to when the helicopter is operating (three days spread across a week or more). The potential impact of noise disturbance on wildlife from the helicopter is discussed in section 5.3.

Waste disposal

Samoa does not have the capability to dispose of unused or partially degraded baits or contaminated materials such as used bags or disposable protective clothing (F. Sagapolutele pers. comm. 2006). It is proposed that all contaminated materials will be shipped to an overseas location (i.e. New Zealand) for disposal in an appropriate facility. Consequently, there will be no adverse impacts associated with contaminated waste from the aerial baiting operations.

Biosecurity: Introduction of invasive species

In comparison to alternative control or eradication methods, for example hand laying baits, aerial baiting reduces the risk of the introduction of invasive species to Nu'utele and Nu'ulua because the frequency of visits to the islands will be less. However, prior to and following the operations it will be necessary to visit the islands for operational and monitoring purposes. The biosecurity risk to the islands is increased because these visitations will be more frequent than usual and stores and monitoring equipment will be transported to the islands. Introduced insect species (particularly ants), lizards, rats, plant seeds and disease, among others, all pose a direct and potentially severe risk to the islands' ecosystems. This risk needs to be carefully managed and appropriate quarantine procedures put in place before the operations are undertaken.

From a wider perspective, the importation of helicopters, bait and equipment for the operations poses a biosecurity risk to the Aleipata Islands, Upolu and Samoa. National quarantine procedures are expected to mitigate this risk.

Cumulative impacts

Unless the Pacific rat eradication is unsuccessful, the brodifacoum operation is a one-off. There will only be two bait applications within 1-2 weeks of each one another. Consequently, there will be no cumulative impacts.

Future applications of indoxacarb are likely to be required to maintain yellow crazy ants at low densities on Nu'ulua. Indoxacarb does not persist in the environment (Moncada 2003) and will breakdown between repeat applications. Potentially, long-term cumulative population impacts on susceptible invertebrates and crabs (i.e. coconut crab) could occur if they are unable to recover between control operations. Recovery will be determined by each species' life history traits. If the continued use of aerial baiting with indoxacarb for yellow crazy ant control occurs, monitoring of invertebrates, and crab species that are found to be susceptible to the insecticide and are long lived with slow reproductive rates would be warranted.

The cumulative environmental impact of applying brodifacoum and indoxacarb within a short time period is unknown, but no adverse reactions are foreseeable.

Section 5.8 Conclusion

This chapter has discussed the risks the proposed Pacific rat and yellow crazy ant operations could pose to: the quality of air, water and soil; native species, the marine environment, introduced animal species; ecosystems; human health and community well-being; cultural and spiritual values and the potential impacts of noise, waste disposal, introduction of invasive species and cumulative impacts on Nu'utele and Nu'ulua Islands and the surrounding environment. Areas of concern are primarily limited to impacts on some non-target species, i.e. friendly ground doves, banded rail, barn owls, invertebrates, coconut crabs and the marine environment. However, with the exception of the friendly ground dove and banded rail none of the species are expected to be affected at the population level and the benefits of the proposed operations outweigh any potential or actual impacts on non-target species. Risks to human health are low but need to be carefully managed, as will the risk of introducing invasive species to the islands. Appropriate mitigation measures are proposed to prevent, mitigate or remedy actual, or potential environmental impacts in Chapter 7.

Chapter 6 Consultation

Section 6.1 Introduction

Public consultation is necessary to inform the public and other potentially affected groups or agencies of the proposed operation, to discover the significant issues, and to constructively discuss the means by which any concerns may be addressed.

This chapter outlines:

- information made available to people about the proposed operation
- who has been consulted about the proposed operation
- how people have responded to the proposal, and
- mitigation measures adopted to mitigate the concerns, if any, raised through the public consultation process.

Section 6.2 Consultation process

Between Monday August 7 and Friday 11, 2006 the consultant preparing the EIA met with:

- representatives from a number of Government Agencies (the Ministry of Resources, Environment and Meteorology, the Planning and Urban Management Agency, the Ministry of Agriculture and Fisheries and the Ministry of Health)
- the Director of the Consultancy firm working on the Aleipata Island Restoration Plan, and

- a National Stakeholder Group (Samoan National Invasives Taskforce).

An overview of the project including the location, baits, aerial baiting techniques and reasons for the operation was provided at each meeting so those consulted understood why and how the operation would proceed and what the likely environmental impacts would be. The consultation record is attached in Appendix 6.

Pacific Environmental Consulting Ltd. have been working with the Aleipata communities on the Aleipata Islands Restoration Plan, the core of which is the rat eradication and ant control work. Pacific Environmental Consulting Ltd. have held three meetings with representatives from four Aleipata villages (in March, April and June) and one meeting with the District Committee in July. The local dive operator and a fale owner have also been involved in consultation on the plan. Meetings with the villages are now complete and a draft of the AIREP is being prepared for review. None of the details of the operation have been discussed with the local communities yet. The draft of this EIA will used as the basis for this consultation.

Section 6.3 Outcomes of consultation

All the Government Agency representatives spoken to were supportive of the proposed operation. Most were genuinely interested and offered their thoughts on a range of issues. Some concerns were expressed. These related to potential impacts on: nesting hawksbill turtles; the near-shore marine environment; coconut crabs; the islands' wildlife; bait storage; the usefulness of standard notification methods in Samoa and post-operational quarantine and the threat of re-invasion. Mitigation measures adopted as a result of consultation include approaching the chiefs (matai) in the local communities and asking them to ensure local people do not harvest meat from the islands until the risk of secondary poisoning has passed. As a result of concern expressed over the unknown impact of indoxacarb on the marine environment trials may be undertaken prior to the operation or pre- and post operational monitoring will be conducted.

The local people who own and use the islands have given their initial support to the rat eradication as part of a larger, successful marine protected areas (MPA) project along the Aleipata coast (Butler 2005a). Pacific Environmental Consulting Ltd. are meeting with the Aleipata District Committee to finalise the Aleipata Islands Restoration Plan.

Discussion with Faafetai Sagapolutele, a member of one of the families with customary ownership of Nu'utele and Nu'ulua revealed that he had no concerns about the operation and would not be concerned if the remaining pigs or chickens were removed or eradicated or if baits were sown over the two graves on Nu'utele.

During discussions with Pacific Environmental Consulting Ltd. representatives from the local communities have expressed interest about where bait would be stored, what roles they would have in the operation, how long the operation would take, and the impact of the operation on the islands' wildlife. The dive operator and fale owner have expressed concern about the potential impact of the operation on the Marine Protected Area.

Chapter 7 Mitigation Measures

Section 7.1 Introduction

This chapter outlines options to mitigate the risks and identifies proposed measures to prevent, mitigate or remedy the actual or potential environmental impacts of the proposed rat and ant operations.

Section 7.2 Proposed mitigation measures for impacts on air, water and soil quality

No mitigation measures are necessary to prevent, mitigate or remedy the risk of actual or potential adverse effects on air, water or soil quality.

Section 7.3 Proposed mitigation measures for impacts on non-target species

The following mitigation measures will be used to prevent, mitigate or remedy the potential impacts on non-target species:

- Baits shall be handled in a manner that, as far as is practicable, minimises the production of small fragments.
- Low toxicity brodifacoum baits shall be used (0.02 g/kg versus 0.05 g/kg).
- Low toxicity indoxacarb baits shall be used (0.045%).
- Baits used will be of a formulation that breakdown relatively rapidly.
- The average sowing rate for brodifacoum baits shall be no greater than 12 kg/ha/application and the number of applications shall not exceed two.
- The average sowing rate for indoxacarb baits shall be no greater than 8 kg/ha and the number of aerial applications shall not exceed one.
- Prior to the operation, the spreading bucket will be calibrated to ensure accurate bait coverage.

More specific mitigation measures for each of the non-target species groups are listed below.

Native birds

Land birds

- Brodifacoum baits will be dyed green. Baits dyed this colour have been shown to be the least attractive to birds.
- Friendly ground doves will be captured before the rat and ant operations and held in captivity in a temporary aviary on Nu'utele until baits are no longer toxic. Twenty three ground doves were recorded on a recent survey of Nu'utele Island in August 2006 indicating that there were at least six pairs on the island and potentially between 16 and 26 individual birds on Nu'utele and Nu'ulua Islands (Parrish and Tupufia 2006). One bird was caught in a mist net and another three were temporarily caught suggesting capture should be feasible.

Seabirds

No mitigation measures are necessary to prevent, mitigate or remedy adverse impacts on seabirds.

Reptiles

No significant impacts are expected on the Samoan boa or hawksbill or green turtles.

No additional mitigation measures are available to prevent, mitigate or remedy potential adverse impacts on skinks and geckos. None of the species are expected to be affected at the population level and the benefits of releasing lizards from rat and ant competition and predation outweigh any losses that may occur as a result of the aerial baiting operations.

Bats

No impacts on bats are expected. No mitigation is proposed.

Invertebrates

No additional mitigation measures are available to prevent, mitigate or remedy the potential adverse impacts of the rat and ant operations on native invertebrates. Given the catastrophic impact yellow crazy ants are known to have on island invertebrate composition, abundance and species richness (Hill *et al.* 2003), the benefits of controlling yellow crazy ants will outweigh any losses resulting from aerial indoxacarb baiting.

Crustaceans

Land crabs, including coconut crabs may be at risk from the indoxacarb baits on Nu’ulua.

- Poultry food baits or similar may be used to attract coconut crabs away from indoxacarb baits.
- If practicable, aerial baiting shall be undertaken in the afternoon to avoid peak land crab feeding activity during the day.

Given that yellow crazy ants have a significant impact on land crabs (Green *et al.* 2002, O’Dowd *et al.* 2003) crab deaths associated with the ant baiting program is likely to be insignificant in comparison to the impact of yellow crazy ants.

Marine flora and fauna

A number of mitigation measures are proposed to minimise the amount of bait that falls into the sea:

- The helicopter used to discharge the baits shall be guided by a differential global positioning system (DGPS) to reduce the likelihood of baits falling into the sea surrounding the islands.
- The flight paths of the helicopter used to sow the baits shall be recorded by the DGPS and shall be checked for any possibilities of baits falling into the sea surrounding the islands.
- The helicopter pilot shall:

  - have appropriate experience sowing bait aerially from a helicopter with an underslung spreader bucket using DGPS.
  - hold appropriate aviation, chemical and agricultural ratings to undertake the aerial sowing.
  - upload a digital copy of the treatment boundary.
  - have flown the boundaries around the islands with the project supervisor to confirm that the electronic boundary is correct.
  - have been briefed regarding the importance of preventing indoxacarb baits falling into the sea
  - received copies of all consents and approvals
  - shut down the spreading bucket before leaving the operational area.

- The spreader bucket shall, as far as practicable:

  - be of an appropriate capacity to match the helicopter and loading equipment
  - have a spinner that is designed for distributing cereal pellets of the size being sown (brodifacoum operation only)
  - have a proven reliable system for the pilot to start and stop bait sowing, such as a bucket on/off switch.

- If practicable, indoxacarb baits shall be trickle sown around the coastline of Nu'ulua Island.
- If practicable, indoxacarb baits shall only be applied one hour either side of high tide to avoid potential impacts the on the marine intertidal area.
- Either, trials of the impact of the indoxacarb baits on the marine environment shall be undertaken before the operation, *or* pre- and post operational monitoring of the marine environment shall be undertaken to identify any adverse impacts of the aerial indoxacarb baiting.

Other non-native animals present

- If practicable, pigs shall be removed from Nu'utele Island before brodifacoum baits are applied.

No additional mitigation measures are proposed to prevent non-native animal deaths. These species are not a natural part of island's ecosystem and for conservation purposes their removal is considered beneficial.

Section 7.4 Proposed mitigation measures for impacts on the ecosystem

No mitigation measures are available to prevent, mitigate or remedy potential adverse impacts on the islands' ecosystems. Several different components of the ecosystems will be monitored to determine whether ecosystem impacts occur (chapter 8). If ecosystem impacts are detected appropriate management responses will be taken.

Section 7.5 Proposed mitigation measures for impacts on human health and community well-being

The following mitigation measures will be used to prevent, mitigate or remedy potential impacts on human health and well-being:

Bait transport

- Baits shall be transported in a covered vehicle or trailer and held securely.
- Baits shall not be kept in the driver's cabin.
- Appropriate signage shall be visible on the vehicle.
- The transport company shall be advised of the product they are transporting.
- Emergency response information (e.g. Material Safety Data Sheet (MSDS)) shall be available in the vehicle.
- The vehicle shall carry equipment to deal with small spillages.
- A following vehicle shall accompany the vehicle transporting the bait.

Bait storage

- Bait shall be stored in an appropriate locked storage facility.
- Appropriate hazardous substances signage shall be clearly visible.
- No unauthorised person is to have access to the storage area.
- Any container holding baits shall not be left open unless the container is being filled or the pesticide in the container is being used.
- Pesticide label instructions shall be followed at all times.

Accidental poisoning

- Water collection devices associated with the two temporary fale on Nu'utele shall be disconnected during the aerial baiting.
- The roofs of the fale will be checked and cleared of any baits before water collection devices are reconnected.
- All bait packages shall be appropriately labelled.
- The pesticides shall not be used, stored or prepared, with any bait or attractant which is likely to lead people to believe that the substance is intended for human consumption.
- Pesticides shall not be stored in a container that is likely to lead any person to believe that the contents of the container are intended for human consumption.

Notification

- The public and local communities shall be notified of the operations by:
    - The most appropriate of:

        (a) Local word of mouth through the matai (local chiefs)
        (b) Mailing out a letter, newsletter, or fact sheets
        (c) Public talks at suitable venues.

    - Warning signs in English and Samoan
    - Public advertisement in appropriate newspaper(s)
    - Public advertisement on the radio and/or television

- Public advertisements shall be published or aired at least 2 weeks prior to the operations and shall identify:

- the nature of the operation
- the area to which baits are being sown
- the approximate timing of the operation
- a contact name and telephone number for enquires
- that anyone visiting the island should: not touch baits; watch children at all times and not harvest or eat meat, crabs or fish from the islands for 18 months following the operation.

- Warning signs shall be erected prior to the operation at every normal landing point on Nu'utele and Nu'ulua islands. They shall outline the nature of the operation, b) the area to which baits are being sown, c) the approximate dates that the poison baits will be sown, d) include a warning not to touch baits, to watch children at all times, and not to harvest or eat meat, crabs or fish from the islands for 18 months following the operation and, e) provide a contact name and telephone number for enquires. Signs shall be maintained for 18 months following the operation and shall be repaired/replaced within 24 hours of discovery or notification of damage.

Occupational exposure

The risks to staff involved in the operation can be managed through appropriate hazard planning, training, supervision and adherence to safe handling techniques and the use of protective equipment in good condition.

- Baits will only be handled by experienced staff or those under the direction of experienced staff.
- All workers shall receive a safety briefing from the project supervisor.
- Pesticide label instructions shall be followed at all times.
- Washing facilities and a supply of clean water shall be available during the operation.
- Protective clothing and equipment shall be removed and hands/arms/face thoroughly washed before eating, drinking, smoking or using the toilet.
- Appropriate personal protective equipment (PPE) shall be worn by all people handling baits during the operation.
- The boundaries of the helicopter loading area shall be marked and signs erected.
- No person who is not assisting in the operation shall remain in the vicinity of the operation.
- All equipment used to handle, dispense or carry pesticides shall be fit for the purpose and be free of defects.

Accuracy of bait application

- The helicopter used to discharge the baits shall be guided by a differential global positioning system (DGPS) to reduce the likelihood of baits falling into the sea surrounding the islands.
- The flight paths of the helicopter used to discharge the baits shall be recorded by the DGPS and shall be checked for any possibilities of baits falling into the sea.
- The helicopter pilot shall:

    - have appropriate experience sowing bait aerially from a helicopter with an underslung spreader bucket using DGPS.
    - hold appropriate aviation, chemical and agricultural ratings to undertake the aerial sowing (if relevant).

  - upload a digital copy of the treatment boundary.
  - have flown the boundaries around the islands with the project supervisor to confirm that the electronic boundary is correct.
  - have been briefed regarding the importance of preventing indoxacarb baits falling into the sea
  - received copies of all consents and approvals
  - shut down the spreading bucket before leaving the operational area.

- The spreader bucket shall, as far as practicable:

  - be of an appropriate capacity to match the helicopter and loading equipment
  - have a spinner that is designed for distributing cereal pellets of the size being sown (brodifacoum operation only)
  - have a proven reliable system for the pilot to stop bait sowing, such as a bucket on/off switch

Clean-up

- The loading area shall be thoroughly inspected for spilled baits and cleaned down following the operation.
- The helicopter, spreader bucket and loading equipment shall be thoroughly washed before leaving the area.
- Contaminated safety equipment, vehicles and any other equipment that has been in contact with baits shall be thoroughly washed.
- Surplus pesticide should be stored in its original packaging with manufacturers label attached and MSDS available.

Accidents

- Procedures shall be put in place for accidents, pesticide spillage and poisoning (protective clothing, first aid supplies, and emergency service phone numbers shall be readily available).
- The appropriate authorities shall be notified in the event of accidental spill.

Section 7.6 Proposed mitigation measures for impacts on cultural and spiritual values

No impacts on cultural or spiritual values are expected. No mitigation is proposed.

Section 7.7 Proposed mitigation measures for other impacts

Noise

No significant impacts are expected. No mitigation is proposed.

Waste disposal

- All contaminated waste material must be securely contained with the manufacturers label and MSDS.
- Surplus pesticide should be stored in its original packaging with manufacturers label attached and MSDS available.

- All contaminated materials will be shipped to an overseas location (i.e. New Zealand) for disposal in an appropriate facility.

Biosecurity: Introduction of invasive species

Appropriate quarantine procedures shall be implemented to prevent the introduction of invasive species to Nu'utele and Nu'ulua.

Cumulative impacts

If the continued use of aerial baiting with indoxacarb for yellow crazy ant control occurs, monitoring of invertebrates and crab species that are found to be susceptible should be undertaken.

Section 7.8 Conclusion

Mitigation measures are not required for air, water or soil quality. A number of mitigation measures are proposed for native non-target species. For some species, mitigation measures will not prevent the death of some individuals within some populations; however the long-term benefits of the proposed operations to these species will outweigh any impacts. If practicable, pigs shall be removed from Nu'utele, but no additional mitigation measures are proposed to non-native animal deaths. Mitigation measures have been proposed to limit impacts on the marine environment, but the potential impact is unknown. Trials or monitoring will determine whether any adverse impacts occur. Impacts on the islands' ecosystems are difficult to predict. Monitoring will identify if any adverse effects are occurring and appropriate management responses will be taken. Although the potential impacts on human health and well-being are considered to be low, comprehensive mitigation measures are proposed to prevent any risk of human poisoning. Mitigation measures are not required to protect spiritual or cultural values. Mitigation measures are proposed to reduce potential impacts associated with the introduction of invasive species and waste. In summary, mitigation measures are anticipated to prevent, mitigate or remedy all of the significant actual or potential, environmental impacts of the Pacific rat and yellow crazy ant operations.

Chapter 8 Monitoring

Section 8.1 Introduction to monitoring

Monitoring is important to determine:

- the achievement of the conservation and operational objectives
- whether adverse environmental impacts have been prevented, mitigated or remedied, and
- post-operational management decisions, such as giving the operational all-clear and removing warning signs.

Section 8.2 Bait monitoring

Monitoring of bait quality

Bait monitoring is an important component of the proposed operations and the toxicity, size and quality of the baits needs to conform to a quality standard. The range and average toxic loading and size of a sample of baits will be monitored via standard techniques.

Monitoring of aerial bait spread

A differential global positioning system (DGPS) will be used as an aid to guide and map the spread of bait. A map of bait spread will be available visually from a computer screen on the DGPS and will be recorded, downloaded and presented as a printed map.

Where DGPS monitoring of bait spread shows any gaps these will be checked visually from the ground. Bait coverage will be checked visually by people on the ground to ensure there are enough baits on the ground - this will be particularly important in the two beach/plantation areas of Nu'utele where rat and crab densities are high.

Monitoring of bait take

Bait take will be monitored visually and used to determine the timing of the second application of rat baits. The beach/plantation areas of Nu'utele will be carefully monitored to ensure enough baits are available for rats.

Bait breakdown monitoring

Baits will be monitored to determine when they are fully broken down and no longer toxic and when friendly ground doves can be re-released onto the islands. At the time of the operation several plots of baits will be placed on the ground (to allow soil decomposers to access them) in enclosures established in a range of habitats, elevations, aspects and exposures. The condition of the baits will be monitored until they have completely disappeared or only a few separated bait particles remain. Enclosures will prevent baits being eaten by rats, crabs and other non-target species.

Section 8.3 Result monitoring

Pacific rats

Rats will be monitored from the first poison drop onwards to determine the timing of the second bait application and then to determine the success of the eradication. Rats will be monitored using snap traps at Vini beach. Lines of snap traps will be set-up and baited with roasted coconut. The detail of trap lines and the frequency of the checking on each island are still to be determined. Mesh cage traps or raised traps will be used to prevent coconut crabs robbing traps of baits and rats (Butler 2005a).

The islands will be re-visited periodically after the operation to check for the presence of rats. In New Zealand a two year cut-off period is used, i.e. if rats are not detected after two years the islands will be formally declared rat-free. Further discussion will determine if the same approach is used in Samoa.

Yellow crazy ants

Pre- and post operational monitoring of yellow crazy ants will be undertaken to measure the effectiveness of control. The details of this monitoring have not yet been determined.

Section 8.4 Monitoring soil and water quality

No water quality monitoring is necessary (or possible) because there is no permanent fresh water on either island.

No adverse effects on soil quality are anticipated so soil monitoring will not be undertaken.

Section 8.5 Non-target species monitoring

Ground searches for dead non-target birds and animals will be undertaken during post-operational monitoring activities on both islands.

Section 8.6 Monitoring the marine environment

Pre- and post operational monitoring of the intertidal and inshore marine environment may be conducted to determine whether indoxacarb baits have any adverse impacts on the marine environment. The details of this monitoring have not yet been determined.

Section 8.7 Outcome monitoring

Three previous visits by New Zealand experts focused on monitoring species likely to benefit from rodent control and provided approaches that can be used for follow-up monitoring. These monitoring methods will be used to measure changes in the islands ecosystems that result from the eradication of Pacific rats and the control of yellow crazy ants. Unfortunately the effects on Nu'ulua's ecosystem of removing either rats or ants will be confounded by one another.

Bird monitoring

Five-minute bird counts (Dawson and Bull 1975) provide a good measure of the changing relative abundance of individual forest bird species providing an indication of the effectiveness of the Pacific rat eradication in reducing predation on birds. Division of Environment and Conservation (DEC) Parks and Reserves staff are undertaking five-minute bird counts on Nu'utele Island before and after the rat operation. A transect has been established between Nu'utele and Vini beaches on Nu'utele Island. Counts are not planned on Nu'ulua because of access problems.

Changes in seabird numbers will be monitored by staff who will make detailed observations of nesting seabirds and where possible, compare these with data sets collected by others.

Reptile monitoring

Although designed to determine species diversity rather than to set up a quantitative monitoring system, recent work by R. Parrish and colleagues will provide a rough baseline of lizard activity (Stringer *et al.* 2003a. 2003b, Parrish *et al.* 2004). Changes in the abundance of lizards and geckos will be monitored using lizard pitfall traps and visually during the day and by spot lighting at night.

Invertebrate monitoring

Pitfall trapping will be used to provide information on the response of ground-dwelling invertebrates to the removal of Pacific rats. Previous pitfall trapping by New Zealand experts (Stringer *et al.* 2003a. 2003b) has established a rough baseline with which to compare post-operational monitoring of invertebrates.

Vegetation monitoring

Photo points will be established on both islands to document any changes in forest and understorey structure and species composition (including any changes in weed abundance) following the removal of the Pacific rats and yellow crazy ants. Photo points have been located at the bird count stations established on Nu'utele.

Chapter 9 Relevant Planning Documents

Section 9.1 Introduction

This section assesses whether the proposed operation is consistent with relevant legislation, guidelines, plans and/or strategies.

Section 9.2 Consistency with relevant planning documents

Lands and Environment Act (1989)

Under Part VIII 95 (b) of the Lands and Environment Act (1989) the principle functions of the Department of Environment and Conservation are to:

(b) "Ensure and promote the conservation and protection of the natural resources and environment of Samoa"
(f) "To carry out investigations and research relevant to the protection and conservation of natural resources and the environment;
(g) To provide and promote training in the skills relevant to its functions;
(h) To promote public awareness to the importance of the environment and its conservation…"

Both the eradication of Pacific rats and the control of yellow crazy ant control operations are consistent with the principle functions listed above.

Section 104 describes the 'Powers of the Minister'. This section is of relevance, particularly (a), (c), (d), (e), (g) and (h).

Section 123 (2) relates to discharging noxious or hazardous substances into seas and inland waters:

> "…Except as otherwise permitted by regulation made under this Act, no person shall discharge or suffer or permit to be discharged any oil, noxious liquid or solid substances or other harmful substances by any method means, or manner into or upon any Western Samoan waters."

To meet the requirements of 95 (b) (above) rat and ant baits may accidentally fall into the sea as a direct result of this operation. However, it is expected that the number of baits will be small and will not result in any significant pollution of the surrounding seas.

Samoa's National Biodiversity Strategy and Action Plan

The eradication of Pacific rats and control of yellow crazy ants is consistent with Samoa's National Biodiversity Strategy and Action Plan (NBSAP) prepared as a commitment to the Convention on Biological Diversity. Within the plan is the action:

> "Develop a programme for the eradication of rodents from small islands which can be used for conservation of rare species such as the tuaimeo (friendly ground dove)".

Aleipata Marine Protected Area Management Plan 2002-2006

The Aleipata Marine Protected Area Management Plan recognises the biodiversity values of the Aleipata Islands. Priority working goal 3.3 states that:

> "by the end of 2006 our offshore islands (Nu'utele and Nu'ulua) will have had a restoration programme designed and begun implementation focusing on rat eradication, and endangered bird life (land and sea bird) and other native wildlife conservation and overall security of these islands for heritage conservation (natural and cultural)".

An action in section 5.3. (Special Aleipata Biodiversity - Offshore Islands/Turtles/Sea and Land Birds) confirms that the Aleipata MPA supports:

> "the rat eradication programme and the prevention/eradication/control of any invasive species that will endanger the natural flora and fauna of our islands…"

Section 9.3 Conclusion

The proposed operations are consistent with Samoa's National Biodiversity Strategy and Action Plan and the Aleipata Marine Protected Area Management Plan 2002-2006. Although *ultra vires* to Section 123 (2) of the Lands and Environment Act (1989), the number of baits expected to land in the sea will not result in any significant pollution and any discharge of baits into the sea is considered necessary to meet Section 95 (b) of the Act.

Chapter 10 Conclusions

Aerial baiting of brodifacoum cereal pellets and aerial baiting of indoxacarb granules are proposed as the preferred methods for eradicating Pacific rats from Nu'utele and Nu'ulua Islands and controlling yellow crazy ants on Nu'ulua, respectively.

Research has shown that the conservation benefits of eradicating Pacific rats and controlling yellow crazy ants on Nu'utele and Nu'ulua will be substantial. The purpose of the operations is to: restore more natural ecosystem processes to the islands; allow for the recovery of existing invertebrate, lizard, turtle and bird populations; allow for the re-introduction of species that may have been extirpated and to increase the islands potential as offshore refuges to which other threatened species can be introduced. The operations are expected to have benefits for the local communities through training opportunities, education, and ecotourism.

Consultation has been undertaken with numerous interest groups. Most parties were fully supportive of the proposed operations and did not express any concerns. Further consultation with local communities is to be undertaken.

This Environmental Impact Assessment has discussed and rigorously evaluated the potential impacts aerial brodifacoum and indoxacarb operations could have on the quality of air, water and soil; native species, the marine environment, introduced animal species; ecosystems; human health and community well-being; cultural and spiritual values and the potential impacts of noise, waste disposal, introduction of invasive species and cumulative impacts on Nu'utele and Nu'ulua Islands and the surrounding environment. Some areas of concern were identified. Appropriate mitigation measures will prevent, mitigate or remedy all of the significant actual or potential, environmental impacts of the Pacific rat and yellow crazy ant operations. Where mitigation measures are not available to prevent minor impacts, the long-term benefits of the proposed operations to these species, and to the island's ecosystems are considered to outweigh any impacts. An extensive result and outcome monitoring programme are proposed to monitor many aspects of the environment.

The assessment concludes that the operation is in accordance with the requirements of relevant legislation, will be beneficial to the species and ecosystems of Nu'utele and Nu'ulua and that the proposed mitigation measures will prevent, mitigate or remedy all significant adverse environmental effects.

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References

Abott, K. 2005. Supercolonies of the invasive yellow crazy ant (*Anoplolepis gracilipes*) on an oceanic island: Forager activity patterns, density and biomass. *Insect Sociaux* 52: 266-273.

Andrews, G.J, Holthus, P.F. 1989. *Marine environment survey: Proposed Aleipata Islands National Park, Western Samoa.* South Pacific Commission, Noumea, New Caledonia.

Barr, C.L. 2002a. The Active Ingredient Indoxacarb as a Broadcast Bait for the Control of Red Imported Fire Ants. Unpublished report. 3 Pp.

Barr, C.L. 2002b. Indoxacarb Bait Effects on Mound Activity and Foraging of Red Imported Fire Ants. Unpublished report. 3 Pp.

Barr, C.L. 2004. How Fast is Fast?: Indoxacarb Broadcast Bait. *Report for the Proceedings of the 2004 Imported Fire Ant Conference*. 4 Pp.

Booth, L.H., Fisher, P., Heppelthwaite, V., Eason, C.T. 2003. Toxicity and residues of brodifacoum in snails and earthworms. *DOC Science Internal Series 143*. Department of Conservation, Wellington, New Zealand. 14 p.

Bowie, R., Ross, J.G. *In press*. Identification of weta foraging on brodifacoum bait and the risk of secondary poisoning for birds on Quail Island, Canterbury, New Zealand.

Brown, D. 1997. Chetwode Island kiore and weka eradication project. *Ecological Management* 5: 11-20.

Buckle, A.P. 1994. Rodent control methods: chemical. Pp 127-160 *In*: Buckle, A.P., Smith, R.H. (eds). *Rodent Pests and their Control.* CAB International, Cambridge U.K.

Butler, D. 2003. Bait trials and trapping on Nu'utele and Nu'ulua – June 2003. Draft report to SPREP Invasive Species Programme. Unpublished report. 12 Pp.

Butler, D. 2005a. Draft Project Plan: Restoration of Nu'utele and Nu'ulua Islands, Aleipata Island Group, Samoa. Eradication of the Pacific rat (*Rattus exulans*). Unpublished report.

Butler, D. 2005b. Supporting Information: restoration of Nu'utele and Nu'ulua Islands, Samoa. Eradication of the Pacific rat (*Rattus exulans*) and management of yellow crazy ants (*Anoplolepis gracilipes*). Unpublished report. 10Pp.

Butler, D. 2006. Discussion Paper: options for managing yellow crazy ants on Nu'ulua. Unpublished report to the Critical Ecosystem Partnership Fund. 16 Pp.

Campbell, D.J., Atkinson, I.A.E. 1999. Effects of kiore (*Rattus exulans* Peale) predation on recruitment of indigenous coastal trees on northern offshore islands of New Zealand. *Journal of the Royal Society of New Zealand* 29: 265-290.

Campbell, D.J., Atkinson, I.A.E. 2002. Depression of tree recruitment by the Pacific rat (*Rattus exulans* Peale) on New Zealand's northern offshore islands. *Biological Conservation* 107: 19-35.

Dawson, D.G., Bull, P.C. 1975. Counting birds in New Zealand forests. *Notornis* 22:101-109.

Donlan, C.J., Howald, G.R., Tershy, B.R., D.A. Croll. 2003. Evaluating alternative rodenticides for island conservation: roof rat eradication from the San Jorge Islands, Mexico. *Biological Conservation* 114: 29-34.

Eason, C.T., Wickstrom, M. 2001. Vertebrate pesticide toxicology manual (poisons) (2nd ed.) *Department of Conservation Technical Series* 23. 122 Pp.

Eason, C.T., Spurr, E.B. 1995. The toxicity and sub-lethal effects of brodifacoum in birds and bats: a literature review. *Science for Conservation 6*. 16 Pp.

Empson, R.A.; Miskelly, C.M. 1999: The risks, costs and benefits of using brodifacoum to eradicate rats from Kapiti Island, New Zealand. *New Zealand Journal of Ecology* 23 (2): 241-254.

Fisher, P. and Fairweather, A. A. C. 2005. Brodifacoum: a review of current knowledge. *Department of Conservation Pesticide Information Reviews Series Part 6*. Department of Conservation, Hamilton, New Zealand.

Galvan, J.P., Howald, G., Samaniego, A., Keitt, B., Russell. J., Pascal, M., Browne, M., Broome, K., Parkes, J., Tershy, B. *in press?*. A review of commensal rodent eradication on islands.

Green. P., Slip, D., Comport, S. 2002. Environmental Assessment Christmas Island National Park: aerial baiting of crazy ant supercolonies on Christmas Island. Unpublished report. 43Pp.

Green, P.T., Comport, S., Slip, D. 2004. The Management and Control of the Invasive Alien Crazy Ant (*Anoplolepis gracilipes*) on Christmas Island, Indian Ocean: The Aerial Baiting Campaign September 2002. Unpublished Final Report to Environment Australia and the Crazy Ant Steering Committee.

Hill, M., Holm, K., Vel, T., Shah, N.J., Matyot, P. 2003. Impact of the introduced yellow crazy ant *Anoplolepis gracilipes* on Bird Island, Seychelles. *Biodiversity and Conservation* 12: 1969-1984.

King, W. 1985. Island birds: will the future repeat the past? *In*: *Conservation of Island Birds* (ed. Moors, P.J.) Pp. 3-16. International Council for Bird Preservation, Technical Publication No.3.

King, C.M. 2005. *The Handbook of New Zealand Mammals*. (2nd edn.). Oxford University Press, South Melbourne.

Merton, D., Climo, G., Laboudallon, V., Robert, S., Mander, C. 2002. Alien mammal eradication and quarantine on inhabited islands in the Seychelles. Pp 182-198 in Veitch, C.R. and Clout M.N. (eds). *Turning the Tide: the eradication of invasive species*. IUCN SSC Invasive Species Specialist Group, IUCN, Gland, Switzerland and Cambridge, UK.

Moncada, A. 2003. Environmental fate of indoxacarb. Unpublished report? 8 Pp.

MPA. 2002. Samoa Marine Biodiversity Protection and Management Project (2002). *Aleipata Marine Protected Area Draft Management Plan 2002-2006*, Unpublished Management Plan, Apia, Samoa.

O'Dowd, D., Green, P.T., Lake, P.S. 2003. Invasional 'meltdown' on an oceanic island. *Ecology Letters* 6: 812-817.

Ogle, C.C. 2001. Exotic plants of the Aleipata Islands, Samoa. *Institute of Applied Sciences Technical Report* No. 2001/08. The University of the South Pacific, Suva, Fiji. 10p.

Pain, D.J., Brooke, M. de L., Finnie, J.K., Jackson, A. 2000. Effects of brodifacoum on the land crab of Ascension Island. Journal of Wildlife Management 64: 380-387.

Park, G., Hay, R., Whistler, A., Lovegrove, T. 1992. The National Ecological Survey of Western Samoa. The Conservation of Biological Diversity in the Coastal Lowlands of Western Samoa.

Parrish, R., Stringer, I., Lester, P. 2004. Fauna survey of the Aleipata Islands, Samoa - 3rd Progress Report. *IAS Technical Report No. 2004/05*. Institute of Applied Sciences, University of the South Pacific, Fiji.

Parrish, R., Tupufia, S. 2006. Report on Friendly (Shy) Ground Dove (Gallicolumbia stairi) Work on Nu'utele Island and Upolu Island, Samoa – August 2006. Unpublished Report to David Butler Associates 11 Pp.

Pierce, R.J. 2002. Kiore (*Rattus exulans*) impact on breeding success of Pycroft's petrels and little shearwaters. *DOC Science Internal Series* 39. 24 Pp.

Spurr, E.B., Drew, K.W. 1999. Invertebrates feeding on baits used for vertebrate pest control in New Zealand. *New Zealand Journal of Ecology* 23: 167–173.

Stanley, M.C. 2004. Review of the efficacy of baits used for ant control and eradication. *Landcare Research Contract Report: LC0405/044* for the Ministry of Agriculture and Forestry, Wellington. 74 Pp.

Stork, N., Kitching, R., Cermak, M., Davis, N., McNeil, K. 2003. The impact of aerial baiting for control of the crazy ant, *Anoplolepis gracilipes*, on the vertebrates and canopy-dwelling arthropods on Christmas Island. Unpublished report, Cooperative Research Centre for Tropical Rainforest Ecology and Management, Cairns and Brisbane. 30 Pp.

Stringer, I., Parrish, R., Sherley, G.H. 2003a. Report on the first monitoring visit to Nu'utele and Nu'ulua Islands, Samoa 25-29 July 2000. *IAS Technical Report No. 2003/10*. Institute of Applied Sciences, The University of South Pacific, Fiji.

Stringer, I., Parrish, R., Basset, S. 2003b. Report on the second monitoring visit to Nu'utele and Nu'ulua Islands, Samoa 4-8 June 2001. *IAS Technical Report No. 2003/11*. Institute of Applied Sciences, The University of South Pacific, Fiji.

Towns, D., McFadden, I.G., Lovegrove, T.G. 1993: Offshore islands co-operative conservation project with ICI Crop Care Division: Phase one (Stanley Island). *DOC Science and Research Internal Report* 138. 22 p.

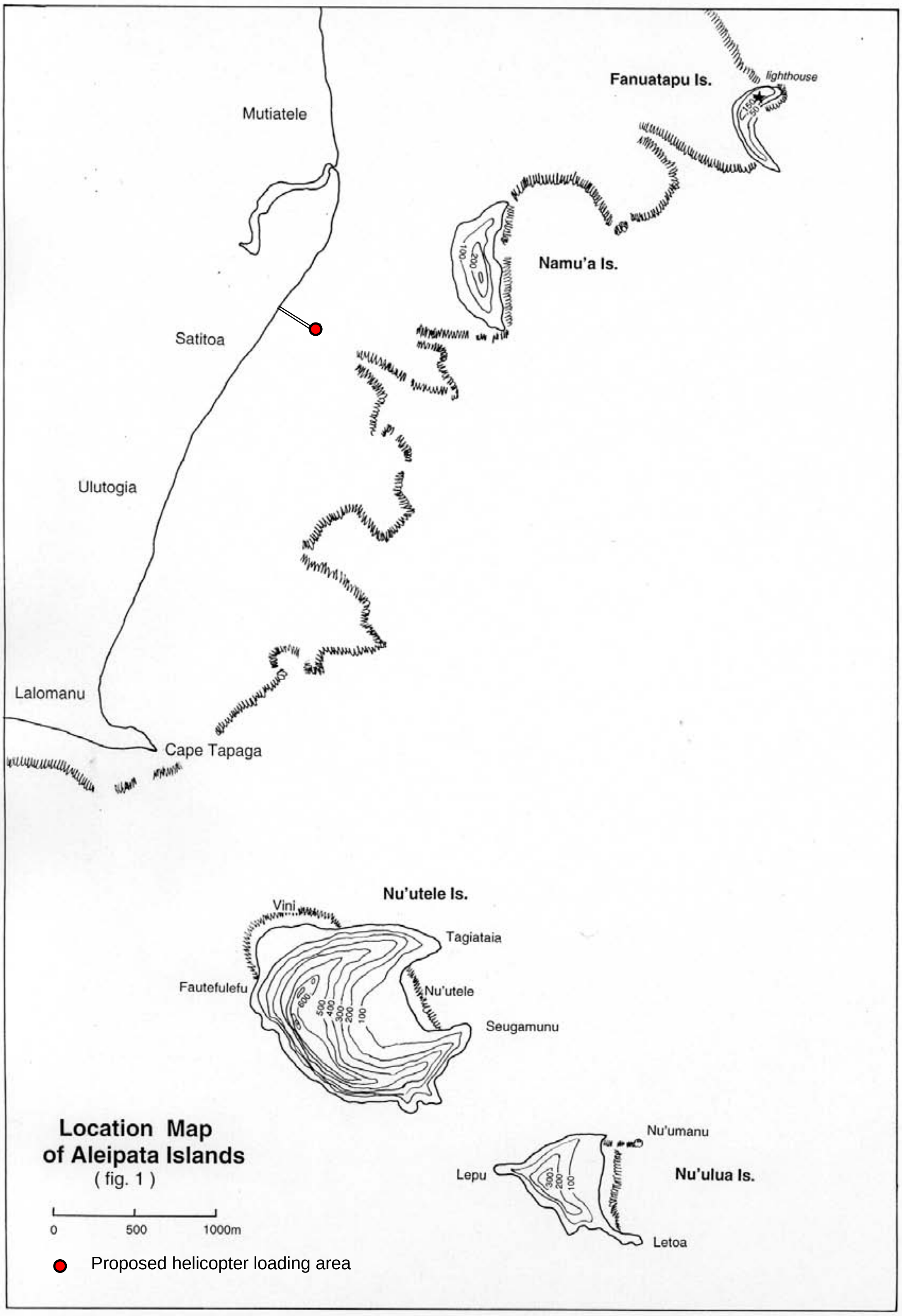
Towns, D.R., Broome, K.G. 2003. From small Maria to massive Campbell: forty years of rat eradications from New Zealand islands. *New Zealand Journal of Zoology* 30: 377-398.

Towns, D.R., Simberloff, D.S., Atkinson, I.A.E. 1997. Restoration of New Zealand islands: redressing the effects of introduced species. *Pacific Conservation Biology* 3: 99-124.

Watling, D. 2004. *A Guide to the Birds of Fiji and Western Polynesia: Including American Samoa, Niue, Samoa, Tokelau, Tonga, Tuvalu and Wallis and Futuna.* Environmental Consultants, Suva, Fiji. 272 p.

Whistler, A. 1983. The vegetation and flora of the Aleipata Islands, Western Samoa. *Pacific Science* 37(3).

Appendix 1 Map of Nu'utele and Nu'ulua Islands



Source: Parrish *et al.* (2004).

Appendix 2 Alternative Methods

Appendix 2.1 Evaluation of alternative methods for Pacific rat eradication

Introduction to the methods available

This section describes the range of potential methods available to eradicate Pacific rats from Nu'utele and Nu'ulua Islands. The methods include: trapping; bait stations; hand laying baits and aerial baiting.

Trapping

Rats are caught in a device designed to kill the animal which is usually set under a cover. A range of trapping techniques is available to kill animal pests. Of these, kill traps using either snap or Fenn traps are most commonly used for rat control operations.

Advantages of trapping

- The success of the operation is visible
- Animals are available for sexing, autopsy and/or body count
- No toxins enter the environment.

Disadvantages of trapping

- Risks to non-target species such as ground dwelling birds or inquisitive species
- Impractical on steep or rugged terrain
- Hindered by poor weather
- Can be time consuming to cover large operational areas
- High labour cost to set-up and check traps
- Risk of trap shyness if rats are not killed.

Evaluation of trapping for this operation

Trapping rats to a point of eradication is simply not possible due to the inaccessibility the steep cliffs and bluffs on both islands. Rats would survive in these areas and re-invade previously trapped areas.

Bait stations

Bait is housed in small pre-built stations and placed in a grid or line network throughout the control area to ensure all rats have an opportunity to feed from them. Tracks are usually needed to place and monitor the network of stations. A range of toxins are available for use in bait stations.

Advantages of bait stations

- Poisoning is more efficient than trapping
- Bait stations keep bait dry so the pesticide is available for longer periods and operations are not weather dependent
- Less bait may be used compared with aerial baiting
- Unused bait can be removed at the end of the operation

- Reduces access to bait for some non-target species and the impact of primary poisoning
- Bait take can be monitored
- Practical to avoid sensitive areas.

Disadvantages of bait stations

- Impractical on steep/rugged terrain where access becomes difficult or dangerous
- Rats initially avoid unfamiliar objects (i.e. bait stations) in a new environment, making pre-feeding essential
- Labour intensive and relatively expensive because of the initial setting up of lines and bait stations
- Cutting and marking tracks may have significant visual and physical impacts and pose some risk to vulnerable vegetation types (i.e. increased opportunities for invasive weed species to colonise).
- Extra staffing required is inappropriate in remote locations.

Evaluation of bait stations for this operation

Again, it is not practical or cost effective to establish tracks and place and maintain bait stations on the steep cliffs and bluffs of either island. Rats in these areas would not have access to baits and the probability of the operation failing would be high.

Hand laying baits

Baits can be distributed by hand by placing them on the ground, regularly spaced over the operational area.

Advantages of hand laying baits

- Cost effective for small operations
- Practical to avoid sensitive areas
- No risk of baits falling directly into the water.

Disadvantages of hand laying baits

- Time consuming and costly over larger areas
- Logistically difficult to land workers on the islands (particularly Nu'ulua) and regularly re-supply them.
- High risk that bait coverage will be poor
- Impractical on steep/rugged terrain where access becomes difficult or dangerous
- Baits are exposed to the weather
- There is a higher risk of occupational exposure to the toxin for people handling baits
- Baits are accessible to non-target species.

Evaluation of hand laying baits for this operation

Hand laying baits on the steeper cliffs of both islands is not physically possible. Rats in these areas would not have access to baits and the probability of the operation failing would be high. Achieving acceptable bait coverage on the remaining areas of the islands would be difficult given the terrain and thick vegetation.

Aerial baiting

Aerial baiting has been used in many successful island rat eradications. Baits are spread over the operational area from an under-slung bucket suspended beneath a by helicopter with using GPS navigational guidance.

Advantages of aerial baiting

- Not dependent on sea conditions allowing regular access to the islands
- The islands can be treated quickly (several hours)
- Steep inaccessible areas that cannot be treated from the ground can be baited
- No direct damage to habitat (i.e. no tracking)
- Less labour intensive than other methods
- Accuracy and density of bait coverage is assured.

Disadvantages of aerial baiting

- An operation can be affected by unpredicted rain leaching toxin from the baits
- Some baits are likely to fall directly into the sea
- Baits are accessible to non-target species so risks need to be appropriately managed.

Evaluation of aerial baiting for this operation

Aerial baiting is the only method that will ensure complete bait coverage over all parts of both islands and achieve the objective of eradication. Risks to non-target species are increased so appropriate measures must be put in place to mitigate these.

Appendix 3 Alternative Toxins

Appendix 3.1 Evaluation of alternative toxins for Pacific rat eradication

Sodium monofluoroacetate (1080)

1080 is an acute, broad spectrum toxin used on a variety of mammals. It is water soluble and readily breaksdown. It is absorbed through the gut and causes death through inhibition of the cellular energy cycle (Krebs cycle).

Advantages of 1080

- Effective at killing rodents
- Cheap compared to most other rodenticides
- Biodegradable in the environment
- Breaks down quickly allowing for early return of captive populations
- Sub-lethal doses are rapidly excreted and not accumulated in the body reducing the risk of secondary poisoning
- The lethal action is rapid and animals are therefore less likely to consume more than the lethal dose
- Populations of common bird species and invertebrates are not adversely affected

- There is a large body of regulatory toxicology information which gives us relatively high certainty for the risk assessment of this toxin
- Available in large quantities and manufactured in a form suitable for aerial baiting.

Disadvantages of 1080

- Generates bait shyness if target animals receive a sub-lethal dose
- Bait shyness can reduce effectiveness of an operation
- May weather too quickly, particularly in the tropics
- No effective antidote
- Untested for rodent eradications
- Non-targets risks are potentially significant so appropriate mitigation is essential.

Evaluation of 1080 for this operation

1080 can be highly effective for rodent control but some doubts exist regarding the consistency of rodent kills. Although data on non-target impacts are well known and it is available in large quantities and manufactured in a form suitable for aerial baiting, 1080 remains untested for island rodent eradications. Because it is an acute toxin, there is an increased risk of bait shyness developing if a sub-lethal dose is ingested. 1080 is unlikely to kill every rat present which is essential for successful eradication. It would be extremely unwise to depart from the proven use of second generation anticoagulants.

Cholecalciferol

Cholecalciferol is a subacute toxin with some advantages over others such as low secondary poisoning, and perhaps low toxicity to non-targets and humans. Cholecalciferol mobilises calcium stores from bones into the bloodstream; death results from hypercalcaemia and calcification of the blood vessels (Buckle 1994).

Advantages of cholecalciferol

- Reduced secondary poisoning risk
- Less toxic to birds than other toxins
- Less persistent in sub-lethally poisoned animals than anticoagulant poisons
- Effective treatment is available.

Disadvantages of cholecalciferol

- Relatively new product so poor knowledge of efficacy and non-target impacts
- Potential to generate bait shyness if target animals receive a sub-lethal dose
- Rats have been shown to detect cholecalciferol at levels as low as 0.1%
- Largely untested for rat eradications (one experimental eradication (Donlan *et al.* 2003)).

Evaluation of cholecalciferol for this operation

There is high uncertainty across most parts of the risk assessment for cholecalciferol. Because it is a relatively new product, knowledge of efficacy and non-target effects is poor. Cholecalciferol is a subacute toxin so there is an increased risk of bait shyness in sub-lethally poisoned rats. Cholecalciferol is largely untested for rat eradications. Due to the cost of this particular operation failing it would be extremely unwise to depart from the proven use of second generation anticoagulants.

First generation anticoagulants

Several first generation anticoagulants have been developed: coumatetralyl; diphacinone; warfarin and pindone. They are less potent than the second generation anticoagulants evaluated below, but their mode of action is the same. Anticoagulants act by interfering with the normal synthesis of vitamin K dependent clotting factors in the livers of vertebrates (Eason and Wickstrom 2001). Rats die within 5-8 days of ingesting a lethal dose.

The first generation anticoagulant toxins are not evaluated separately here. For more information on these toxins see Eason and Wickstrom (2001).

Advantages of first generation anticoagulants

- Less persistent than second-generation anticoagulants
- Reduced risk of lethal non-target poisoning. Some, i.e. diphacinone are significantly less toxic to birds
- Slightly lower tendency to cause secondary poisoning than second generation anticoagulants
- Delayed onset of symptoms minimises the risk of bait shyness
- Cheaper than second generation anticoagulants
- Antidote available.

Disadvantages of first generation anticoagulants

- Multiple feed toxins, most effective if ingested over 5 - 10 days
- Do not bind as tightly to enzymes in the liver as second generation anticoagulants so they are metabolised more quickly
- Less potent than second-generation anticoagulants, 1080 or cholecalciferol
- More labour intensive as baits have to be maintained for longer
- Higher chance of the operation failing if baits are not available for rats to fed on them for consecutive days
- Repeat applications significantly increase the cost of an operation.

Evaluation of first generation anticoagulants for this operation

First generation anticoagulants are less potent than secondary generation anticoagulants. This means they generally have a reduced risk of lethal non-target poisoning and a lower tendency to cause secondary poisoning than second generation anticoagulants. Rats need to ingest anticoagulant baits over several days before a lethal dose is taken and the ingestion rate must exceed the rate of metabolism. First generation anticoagulants are not a good option for this operation because maintaining baits in sufficient quantity in good enough condition to allow this in the presence of competition from land crabs and adverse climatic factors would be very difficult and repeat applications would be required at significant extra cost. Using first generation anticoagulants would significantly increase the chance of operational failure if sufficient baits could not be maintained on the ground.

Second generation anticoagulants

Second generation anticoagulants are very potent rodenticides that prevent the blood from clotting. Like first generation anticoagulant toxins, second generation anticoagulants act by interfering with the normal synthesis of vitamin K dependent clotting factors in the livers of vertebrates (Hadler and Shadbolt 1975 *in:* Eason and Wickstrom 2001). Death results from uncontrolled bleeding after a threshold level of the active ingredient concentrates in the liver. Animals usually die through haemorrhaging in the gut (Shirer 1992 *in:* Booth *et al.* 2003).

Bromadiolone

Bromadiolone has chemical and biological effects that are similar to brodifacoum. However, it is slightly less potent than brodifacoum and flocoumafen.

Advantages of bromodiolone

- Effective on rodents
- Delayed onset of symptoms minimises the risk of bait shyness
- Single feed toxin
- Antidote available
- Not readily soluble, binds strongly to soils where it is slowly degraded. Unlikely to contaminate waterways.

Disadvantages of bromodiolone

- Not readily available in large quantities like brodifacoum
- Slightly less potent than brodifacoum and flocoumafen
- More persistent than first generation anticoagulants, high risk of secondary poisoning of non-target species if risks not managed appropriately. Residues may persist for >9 months in animals that receive sub-lethal doses.

Evaluation of bromodiolone for this operation

Bromodiolone is similar to brodifacoum but not as potent. It is not as readily available as other second generation anticoagulants like brodifacoum. There are no advantages in using bromodiolone over brodifacoum which has a proven track record for rodent eradications.

Flocoumafen

Flocoumafen is extremely similar to brodifacoum in terms of its chemistry, biological activity, potency, persistence and risk of secondary poisoning (Eason and Wickstrom 2001). It is registered under the trade name 'Storm' but is not used as extensively for rodent eradications as brodifacoum.

Advantages of flocoumafen

- Effective on rodents
- Delayed onset of symptoms minimises the risk of bait shyness
- Generally available
- Very potent rodenticide, only a single feed required
- Antidote available, but long-term treatment is needed

- Not readily soluble, binds strongly to soils where it is slowly degraded. Unlikely to contaminate waterways.

Disadvantages of flocoumafen

- More persistent than first generation anticoagulants, high risk of secondary poisoning of non-target species if risks are not managed appropriately. Persistence in sub-lethally exposed animals is as great, or greater, than that of brodifacoum (>9 months) (Eason and Wickstrom 2001).
- High risk of secondary poisoning of non-target species
- Expensive.

Evaluation of flocoumafen for this operation

The chemical and biological effects of flocoumafen are almost indistinguishable from brodifacoum, however it has not been as widely used in rodent eradications. There are no advantages of using flocoumafen over brodifacoum which has a proven track record for rodent eradications.

Brodifacoum

Brodifacoum, like other anticoagulant toxins, acts by interfering with the normal synthesis of vitamin K dependent clotting factors in the livers of vertebrates (Hadler and Shadbolt 1975 *in:* Eason and Wickstrom 2001). It is one of the most widely used rodenticides world-wide.

Advantages of brodifacoum

- Very effective at killing rodents and extensively used to eradicate rodents from islands
- Efficacy data and data on non-target impacts are well known
- Delayed onset of symptoms minimises the risk of bait shyness
- Very potent rodenticide, only a single feed required
- Antidote available, but long-term treatment is needed
- Available in large quantities and manufactured in a form suitable for aerial baiting
- Not readily soluble, binds strongly to soils where it is slowly degraded. Unlikely to contaminate waterways.

Disadvantages of brodifacoum

- More persistent than first generation anticoagulants in sub-lethally poisoned animals, high risk of secondary poisoning of non-target species if risks not managed appropriately. Residues may persist for >9 months in animals that receive sub-lethal doses.
- Non-target impacts on individuals of a number of species have occurred following brodifacoum use for rodent control/eradication
- Expensive.

Evaluation of brodifacoum for this operation

Brodifacoum is widely and successfully used for rodent eradications on offshore islands. All attempted rat eradications using aerial baiting of brodifacoum have been successful. It is a very potent rodenticide and only a single feed is required. Importantly for eradication projects, brodifacoum is a chronic toxin so there is no risk of bait shyness. Efficacy data and data on non-target impacts are well known and it is available in large quantities and manufactured in a form suitable for aerial baiting.

Appendix 3.2 Evaluation of alternative toxins for ant control

Indoxacarb

Indoxacarb is a relatively new toxin registered in the U.S. in 2000. It is used as an insecticide on vegetables and other crops around the world. It kills by binding to a site on sodium channels and blocking the flow of sodium ions into nerve cells resulting in impaired nerve function, feeding cessation, paralysis and death (Brugger 1997, *in* Moncada 2003). It must be ingested to be effective (Stanley 2004).

Advantages of indoxacarb

- Effectively kills ants. Successfully tested on red imported fire ants
- Bait is carried below ground by worker ants killing subterranean colonies
- Ant's digestion produces an even more toxic product
- Non-target risks very low when compared to those of alternative ant baits
- Effective at low doses so it is not harmful to reptiles, birds or mammals
- Does not cause mutagenic, carcinogenic, developmental or reproductive effects
- Relatively immobile in soil and not persistent
- Does not bio-accumulate in fish
- Rapid decomposition in terrestrial environments through microbial activity.

Disadvantages of indoxacarb

- A new insecticide
- Not proven for use against yellow crazy ants (trials are currently underway in the Tokelau Islands and on Christmas Island (D. Butler pers. comm. 2006)).
- Moderate to very highly toxic to fish and marine invertebrates.

Evaluation of indoxacarb for this operation

Although a relatively new toxin, indoxacarb has been designated a 'reduced risk insecticide' by EPA. It effectively kills ants. Trials on red imported fire ants have shown promising results (Barr 2002a, 2002b, 2004). Non-target risks are likely to be significantly lower than the alternative, fipronil. Indoxacarb is toxic to aquatic fish and invertebrates and pre-operational trials to determine the level of impact would need to be undertaken or appropriate mitigation measures and monitoring put in place. If results of recent trials on yellow crazy ants in the Tokelau Islands and on Christmas Island are successful, indoxacarb will be the preferred toxin for this operation.

Fipronil

Fipronil is a neurological inhibitor. It disrupts the ant's central nervous system by blocking neuron receptors. It is used worldwide to control several ant species, including yellow crazy ants on Christmas Island (Green *et al.* 2004).

Advantages of fipronil

- Highly effective for yellow crazy ant control – aerial baiting on Christmas Island resulted in a mean decline in ant activity of > 99 % (Green *et al.* 2004).
- Slow-acting so that maximum transfer of bait occurs among workers ants, larvae and the queen
- Effective at low doses so the non-target risk to reptiles, birds or mammals is reduced
- Relatively immobile in soil and water
- Not persistent, but its metabolites are more persistent than fipronil itself.

Disadvantages of fipronil

- Highly toxic to fish and aquatic invertebrates
- Evidence of bioaccumulation in fish
- Toxic to other invertebrates and crustaceans
- Does not eradicate every nest allowing super colony redevelopment and subsequent re-invasion.

Evaluation of fipronil for this operation

Fipronil is a widely used insecticide for ant control and has been used to successfully control yellow crazy ants on Christmas Island. However it failed to eradicate yellow crazy ants allowing redevelopment of super colonies. Parks Australia North is now searching for alternatives. Like indoxacarb, fipronil is highly toxic to fish and aquatic invertebrates. Terrestrial non-target risks are considered to be higher than indoxacarb.

Appendix 4 Risk Assessment for Impacts of Aerial Baiting on Land Birds

Land birds – simple risk assessment of primary and secondary poisoning threat

Common name	Scientific name	Diet	Feeding stratum	Risk*	Conseq. †	Score
Tooth-billed pigeon	(*Didunculus strigirostris*)	Frugivorous	Ground/canopy	0	6	6
Friendly ground dove	(*Gallicolumba stairi)*	Seeds, fruit, buds, leaves	Ground/sub can	5	5	10
Many coloured fruit dove	(*Ptilinopus perousii*)	Frugivorous	Canopy	0	2	2
White throated pigeon	(*Columba vitiensis*)	Fruits, berries, seeds, shoots	Sub-can/ground	4	2	6
Pacific pigeon	(*Ducula pacifica*)	Frugivorous	Occ. ground	2	1	3
Crimson crowned fruit dove	(*Ptilinopus poriphyraceus*)	Frugivorous	Sub canopy	0	0	0
Samoan broadbill	(*Mylagra albiventris*)	Insectivorous	Sub/canopy	3	5	8
Flat-billed kingfisher	(*Todirhamphus recurvirostris*)	Large insects, crabs, lizards	Ground	4	0	4
White-rumped swiftlet	(*Aeroramphus spodiopygius*)	Exclusively insectivorous	Aerial	0	0	0
Samoan whistler	(*Pachycephala flavifrons*)	? Insectivorous, fruits	Any level	4	0	4
Polynesian triller	(*Lalaga maculosa*)	Insects, caterpillars, fruit	Incl. ground	4	0	4
Samoan triller	(*Lalage sharpei)*	Caterpillars, other insects	Incl. ground	4	3	7
Wattled honeyeater	(*Foulehalo carunculata*)	Nectivorous, fruit, insects, lizards	Sub-/canopy	2	0	2
Polynesian starling	(*Aplonis tabuensis*)	Fruit, berries, insects	Sub-/canopy -	2	0	2
Samoan starling	(*Aplonis atrifusca*)	Fruit, insects	Sub-/canopy	2	0	2
Scarlet robin	(*Petroica multicolor*)	Insectivorous	Incl. ground	4	0	4
Samoan fantail	(*Rhipidura nebulosa*)	Insectivorous	Aerial	0	0	0
Blue-crowned lory	(*Vini australis*)	Nectar, pollen, fruit	Sub-/canopy -	0	1	1
Banded rail	(*Rallus phillippensis*)	Insects, snails, crustaceans, fruit	Ground	5	0	5
Barn owl	(*Tyto alba*)	Exclusively rats, insects	Ground	5	0	5

* Risk score: 1-5 (5 = high risk) based on diet and feeding behaviour and hence risk of primary and secondary poisoning.
† Consequence: Highest of international or national threat ranking. 1-7: None = 0, LC = 1, CC = 2, NT = 3, AR = 4, VU = 5, EN = 6, CR = 7.

Appendix 5 Risk Assessment for Invertebrates: Aerial Fipronil Baiting on Christmas Island, Indian Ocean

Group	Common name	Feeding group	Risk
Araneida	Spiders	predatory, prefer live prey	low
Blattodea	Cockroaches	omnivorous	high
Coleoptera	Beetles, weevils	various	high, except herbivores
Collembola	Springtails	microrganisms	probably low
Dermaptera	Earwigs	predatory	high
Diptera	Flies	liquid feeders	very low
Hemiptera	Bugs, leafhoppers, aphids	liquid feeders	very low
Hymenoptera	Wasps and bees	predatory, pollen, nectar	high (wasps), low (bees)
Hymenoptera	Ants	predatory, liquid	high
Isoptera	Termites	detritivorous	high
Lepidoptera	Moths and butterflies	liquid feeders	very low
Mantodea	Praying mantids	predatory	high
Myriapoda	Millipedes	detritivorous	high
Neuroptera	Lacewings, ant lions	larvae predatory	high
Odonata	Dragonflies and damselflies	predatory, feed on wing	very low
Orthoptera	Grasshoppers, crickets	various	high, except herbivores
Phasmatodea	Stick insects	herbivorous	very low
Pseudoscopionida	Pseudoscorpions	predatory under bark	very low
Psocoptera	Booklice, barklice	omnivorous	high
Thysanoptera	Thrips	various	high
Thysanura	Silverfish	omnivorous	high
Zoraptera	Zorapterans	fungivorous	very low

Source: (Green *et al.* 2002)

Appendix 6 Consultation Record

A more detailed consultation report has been prepared by the consultant. This *may* be available upon request from the Division of Environment and Conservation, Apia, Samoa at the discretion of the Principal Terrestrial Conservation Officer.

Name and position	Agency/Organisation	Time and date	Issues Raised	Outcomes
La'Ifetoloai Yandall Alama - Principal Sustainable Development Officer	Planning and Urban Management Agency (Puma)	Meeting 9.30 am Monday August 7	• EIA regulations and guidelines • Relevant legislation • Parties for consultation.	• PUMA using sections 42 and 46 of the Planning and Urban Management Act • EIA regulations (1998) out of date • Confirmed agencies to be consulted • Tourism Authority to be notified • Need written consent from District Committee.
Malama Momoemausu - Principal Marine Conservation Officer	Ministry of Resources, Environment and Meteorology	Meeting 2.00 pm Monday August 7	• Affects on marine species and environment • Lack of information on indoxacarb • Hawksbill turtles • Baiting scenarios	• Support for proposal but, • Concerns about marine environment and hawksbill turtles • Pre-operational trials? • Pre- and post operational monitoring
Seumanutafa Malaki Iakopo - Chief Executive Officer	Ministry of Agriculture and Fisheries	Meeting 9.30 am Tuesday August 8	• Summary of proposal presented • Impacts of rats and ants.	• Support for proposal • No concerns about the proposed operation.
Pimalolo Maiava - Registrar of Pesticides	Ministry of Agriculture and Fisheries	Meeting 10.00 am Tuesday August 8	• Registration of brodifacoum, indoxacarb and fipronil.	• Pesticides registered by chemical and brand names • Proposed rat or ant baits not registered • Can apply to have a product registered (need to complete application form) • Can apply for a special use permit.
Mulipola Atonio - Assistant CEO, Fisheries	Ministry of Agriculture and Fisheries	Meeting 1.30 pm Wednesday August 9	• Summary of proposal presented • Impacts on marine environment • Risks to fish and risks to humans.	• Initially concerned about inshore reef fish • Support for proposal.

Andrew Peteru - Assistant CEO, Public Health	Ministry of Health	Meeting 3.45 pm Wednesday August 9	• Potential impacts on human health • Ownership of project: local communities and businesses • Quarantine procedures.	• Local chief's word more powerful than other notification methods • No need to close access to the islands • Important local people involved in operation • Important for local people to have ownership • Concerned about post operational quarantine.
Cedric Schuster - Director	Pacific Environment Consulting Limited (PECL)	Meeting 11.30 am Thursday August 10	• Consultation undertaken with local communities.	• Received summary of consultation undertaken • No consultation outlining details of proposal with people in local communities • PECL consulting on restoration plan.
Phillip Tafeamalii Kerslak	Samoa Water Authority	E-mail 12.15 pm Thursday August 10	• Potential impacts on water quality.	• Could not arrange meeting • No issues • Samoa Water Authority water systems do not include the islands.
Faafetai Sagapolutele - Principal Waste Management Officer	Ministry of Resources, Environment and Meteorology	Meeting 4.30 pm Thursday August 10	• Waste disposal (unused baits, contaminated PPE etc.) • Nu'utele and Nu'ulua – visits, pigs and chickens, cultural/spiritual values.	• Brodifacoum cannot be disposed of in Samoa • Unlikely ant baits can be either • Best option to dispose of material back to NZ • Only Faafetai's family visit the islands • Visits infrequent, during weekends only • No concerns about pigs or chickens • No concerns about cultural or spiritual values
Faumuina Pati Liu - Assistant CEO, Division of Environment and Conservation	Ministry of Resources, Environment and Meteorology	Meeting 8.30 am Friday August 11	• Community support/consultation • Sign-off on AIREP vs. sign-off on the operation • Monitoring.	• Community very supportive of the operation • Rat and ant operations a core part of the restoration plan (AIREP) • Monitoring an important part of the operation • MNREM: sign-off on the AIREP sufficient for community approval.
National Stakeholder Group	Samoa National Invasive Taskforce	Presentation /briefing 1.30 pm Friday August 11	• Presentation on EIA process and outcomes of consultation	• Number of questions raised • Concern from one attendee about impact on coconut crabs.