FEASIBILITY STUDY ON THE REMOVAL OF RATS FROM NUUTELE ISLAND, SAMOA.

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1.0. INTRODUCTION

This report presents the findings of a research project conducted on the island of Nuutele, an offshore uninhabited island lying east of the main island of Upolu, Samoa. The island is home and haven to sea birds and most endangered endemic and native land birds of Samoa. However, the invasion of the island by rat of unknown species, population and distribution has raised the concern for serious wildlife management actions to protect the islands` bio-diversity. In an attempt to investigate the feasibility of performing such an ecological management approach, a serious of field investigations were carried out from July 2000 to June 2001 on the island. These studies was funded by AusAid under the Nuutele Island Rodent Eradication Project through the Invasive Species Management Program currently coordinated and administered by SPREP. The fieldwork activities involved were coordinated and led by the author with strong technical support and advice from staff of the Department of Conservation in New Zealand, Massey University, International Wildlife Consultants, Local Consultants and staff, and the Invasive Species Management Project Manager of SPREP.

1.1 Objectives of the Study:

The main purpose of this study is to collect and gather sufficient relevant information from both field and literature sources to assist with decision-making. Not only that but also the required information as the following objectives highlight will help in the effective production of a operational plan for the successful execution of eradicating rodents from Nuutele Island. Therefore the main objectives of this study is to:

- Study the presence of rats by species, its abundance and distribution on the island.
- Study the ecological impacts of the target species on the island (researches on this is literature based, no special investigation on this was made because of limited time and resources).
- Identify potential non-target species to be at risk as consequences of rats predation and future poisoning.
- Determine the presence of any other predators on the island.
- Identify non-target species that likely to benefit from this project.
- Collect relevant existing sources of information available.
- Determine the management approach and actions to be considered and taken.

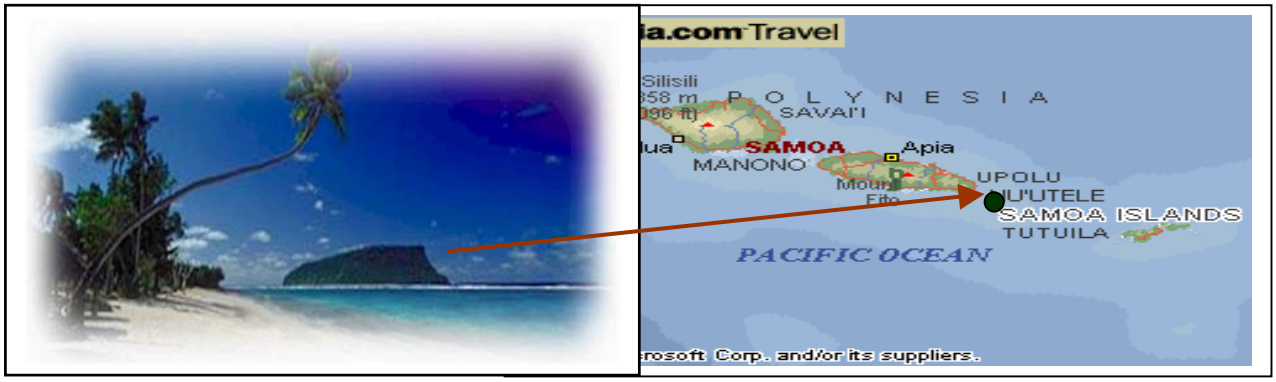
1.2. Background Information.

The island of Nuutele has been chosen by SPREP under the Regional Invasive Species Management Program as the target area to demonstrate this rodent eradication project. The decision is based on the fact that the island has been recommended during previous studies as haven and home of birds with special consideration to sea birds, and endangered endemic and native land birds. There is no question with regard to the eradication approach, since such wildlife management action is internationally recommended for island situation whenever a single rat is sighted on an island.

This sort of management action has been regularly performed in the temperate region and successes have been reported and confirmed from a number of these cases around the world. However, this schedule operation on Nuutele Island presents a number of issues to be well addressed and considered before such action is taken place. The eradication of rats on island using a massive application of toxic baits by aerial means or hands has not been performed in Samoa and any country in the South Pacific and Tropical Region. With the total lack of tropical experiences about Nuutele island and its rats, there is a growing need for sufficient extensive baseline information to generally address its importance and also provide guide lines for the successful implementation of such actions in the future. Having no information about the target species and area is a contradicting factor in the execution of this planned operation. Not only that but also the lack of local knowledge and understanding on the importance of this program may lead to poor support and participation from the landowners, local community, government, NGOs and other stakeholders involved.

1.3. Study Area / Location.

Figure 1. Nuutele Island and its Location.



The offshore island of Nuutele as the main basis of this study and biodiversity restoration project has a total land area of 108ha, locates about 150m from Nuulua island (25ha) which is also consider under these series of investigations. Nuutele island is about 1km from the mainland of Upolu which is already heavily occupied by rats of more than one species. The uninhabited island of Nuulua is rat free.

2.0. LITERATURE REVIEW.

2.1. Islands Significance For Biodiversity Conservation.

Islands do play a very special role to biodiversity conservation throughout the world (Brian.D.Bell 2000, pers:comm.). These remote landmasses with variety of landforms and landscapes highly support many of the worlds most important indigenous ecosystems. In contrast with the mainland the islands geographical remote locations from mainland and settlement areas plus their access difficulty and natural barriers make them good places for a variety of special and unique life forms to exist. "Most island ecosystems have developed in the absence of life forms that are common on the continents. They generally lack animals and plants that dominate mainland ecosystems.

They are the havens and homes of numerous distinctive species, interlocking in unique plant and animal communities" (P.J.Moors et al., 1989). Many islands become special places for conservation and protection of both plants and animals and probably present most areas and percentage of better remaining ecosystems with unique and distinctive values on earth today. In New Zealand, a number of islands are now playing a vital role for the protection of New Zealand endemic animals and plants. With the outbreak of rats on many islands there is so much global concern now with the impact that this will have on our islands bio-diversity (G.H.Sherley 2001, pers:comms.)

2.2. Rats Distribution in the World.

The invasion of islands by rats is becoming a major concern of scientists and conservationists today. Rats continually invade and colonize islands by several means through ships, planes and many more. At present " a very high proportion of oceanic islands or island groups has now been invaded and colonized by rats, the percentages being 75% for islands in the Atlantic, 83% in the Indian and 81% in the Pacific Region. Nevertheless, among groups having rats, some biologically valuable islands have remained rat-free for example 24% of islands in the Hawaii group, 30% of islands in the Seychelles group, and 53% of islands in the Galapagos group. Most of these rat-free islands are, however, small, low and uninhabited" (P.J.Moors et al., 1989).

2.3. Ecological and Economical Impact of Rats on Islands.

- Rats and Island Faunas.

The adverse effects of rats on native plants and animals, and on their habitats, are nowhere more apparent than on islands. Many different kinds of birds have been affected by rats, including surface-nesting and burrow nesting seabirds, shorebirds, wetland birds and forest birds. Eggs, juveniles and adults can all be eaten by rats (Taylor, G.A. 1986). On a few islands rat invasion has had a catasrophic effect on the avifauna, Lord Howe Island being a dramatic example. On other islands, extinction apparently caused by rats (*Rattus exulans)* occurred before the fauna were known to Europeans, for example, the loss of several species of wren and a snipe from mainland New Zealand (Brown, D.A. 1997). In addition, the extinction of the greater short-tailed bat from Big South Cape after 1965 in New Zealand has been attributed to the invasion of rats (*Rattus rattus)*. Other small mammals are vulnerable to rats, such as the native rats of the Galapagos Islands which have become extinct on several islands invaded by *Rattus rattus*. In the West Indies, the post Columbian spread of *Rattus rattus* probably explains the extinction of a number of small non-flying mammals. Many island reptiles and amphibians have also suffered heavily from rats. There is also strong evidence for *Rattus exulans* causing local extinction of several species of gecko in New Zealand, and similar evidence suggesting that *Rattus rattus* has eliminated a large skink from some islands in the Seychelles (Murphy et al, 1994). A recent study has shown that three species of endemic frog became extinct in New Zealand during the past 1000 years, a fate that can probably be attributed to *Rattus exulans* introduced by the Polynesians. Land Snails are also eaten by rats. A study of *Powelliphanta* species in New Zealand has shown that rats seriously threaten the survival of some populations in small forest remnants. Elsewhere in New Zealand there is circumstantial evidence for rats having caused declines of other large invertebrates including phasmids, wingless crickets, flightless beetles and weevils (Brown.D.A, 1997).

❑ Rats and Island Floras.

Rats eat many parts of plants, including flowers, fruits, stems, bark, leaves, roots, and seeds. When *Rattus rattus* established on Lord Howe Island, regeneration of the palm *Howea forsteriana* was curtailed by the rats eating the seeds. Regeneration is now possible only when rats number are controlled. In New Zealand, there is circumstantial evidence for a reduction in the distribution of the milk tree *Paratrophis banksii* (Moraceae) caused by *Rattus exulans*. (Brown.D.A, 1997).

❑ Rats and Islands Ecosystems.

"Where rats cause declines and extinction of a significant proportion of an islands fauna, the whole island is permanently changed. The loss of particular species of birds or mammals is obvious, but other types of change also occur which are less spectacular but just as damaging. For example, some of the animals lost, whether vertebrates or invertebrates, may be critical links in major food chains on the island, or the rats may bring with them new diseases and parasites which infect the native animals. Also, rats often feed on the nutritious reproductive parts of plants, thereby reducing dispersal and regeneration. Habitat composition and structure are then affected, and the whole biological community of the island is likely to suffer. Thus the total effect of introducing rats to an island is far reaching, with consequences that are difficult to predict (P.J.Moors an et., 1989).

2.4. Effects Of Rats on Samoa Islands.

There were no detailed studies conducted in Samoa to investigate the impact of rats ecologically to the indigenous ecosystems of the Samoa islands including Nuutele (Faumuina.S.P 2000:pers comm.). Many islands were rat free before human beings discovered and colonized them many years ago. However, during the earlier movement of people from island to island within the Pacific Region, rats were accidentally introduced spreading rats population throughout the two main islands of Upolu and Savaii. No one had ever concerned about it until rats began to destroy the nations economy by devastating the cocoa industry as a major export of Samoa in the 1970s (F.Isaia 2001:pers comm.). Damages by rats were only discovered and regularly seen with agricultural crops and stored food during this time but little knowledge was available with regard to the ecological impact of rats to plants and animals, particularly birds.

2.5. Rats Species an Island Invasion.

The adverse effects of the three rat species on island faunas differ, particularly their effects on birds. Birds nesting on or near the ground or in burrows are at greatest risk from *Rattus norvegicus*, whereas tree nesting birds area at greatest risk from *Rattus rattus*. *Rattus exulans* takes birds on or near the ground as well, but less is known about its predatory behaviour than for the other two species. On oceanic islands *Rattus rattus* has caused greater losses of forest birds in European times than any other rat, while in the same period *Rattus norvegicus* has caused greater losses among seabirds (Brown.D.A, 19976). Thus the core of our problem is to prevent either of these two old-world rats from reaching more islands, even those where on rat species or mice are already present. Although some island faunas are more vulnerable to a rat invasion than others, the circumstances that allow rats or mice to reach an island are all human induced: settlements, construction of wharves, boat slip ways and airstrips, importation of food stuffs, exploitation of the natural resources of the island and its surrounding waters (e.g fishing, mining, oil drilling), establishment of military bases or weather and research stations, shipwrecks, and sometimes boating associated with tourism and recreation (P.J.Moors an et, 1989).

2.6. Rat Identification, presence and abundance.

It is essential to know which species of rat is being dealt with in order to assess the overall severity of the threat to an island`s fauna and flora, and particularly for the planning of appropriate control or eradication projects. Identifications should be made only by examining specimens because sighting of rats are rarely conclusive, unless made by experts. Presence of rats can often be confirmed from natural evidence alone, for example tracks in soil or mud, feeding sign, remains of rat carcasses, droppings or burrows and runways (Bartholomew 2000, pers: comm.) Live and kill traps and tracking systems can also be used. The existence of a well established population can usually be readily confirmed. However, if rats have only recently arrived, or a new species lands on island already inhabited by other rodents, signs of the new arrival can be extremely difficult to discover. Information on the abundance and distribution of rats can aid the planning of campaigns, and is essential for assessing progress once eradication operations have started. An indirect estimate of numbers, usually called an index of abundance, can be obtained using either kill trapping or tracking tunnels. Tracking systems provide special surfaces on which rats leave their footprints. At its simplest the method requires only a smooth bed of fine moist sand or soil. However, if the tracks need to be preserved for identification or counting, a powder or paper and ink system should be used. *Rattus norvegicus* seems to be deterred by ink pads, but this system works well with the other two species. The frequency of tracking can be increased with all methods by supplying bait (Department of Conservation, NZ, 2000).

2.7. Effects of Behavioural Differences.

The behaviour of all three species of rat is strongly affected by age, sex, social status and experience. *R.norvegicus* is particularly wary and will avoid strange objects encountered in otherwise familiar surroundings. This new object reaction lasts at most a few days, but can substantially reduce trapping success or acceptance of poison baits. *Rattus rattus* is less wary of new objects, and *Rattus exulans* may even be attracted by them. If only one rat species inhabits an island, that species will occupy all available habitats. However, if predators or additional rodents ar present, rat distribution may become restricted to preferred habitats. For *Rattus norvegius* these are generally in wetter areas whereas *Rattus rattus* tends to favour forests, and *Rattus exulans* grassland and dense scrub. All species can infest crops. Home ranges vary greatly in area, but generally become larger with increasing size of rats. The density of baits and traps should be judged so that each rat is likely to have at least one in its home range, thus for example , trap density needs to be greater for *Rattus exulans* than for *Rattus norvegicus*. Large rats also tend to be socially dominant , and are able to monopolise centralised food sources . It is better, therefore, to offer baits at several separate sites rather than at a single central one. *R..rattus* and *R..exulans* are agile climbers, quite at home in tree-tops and ceiling. Arboreal stations may speed the removal of these rats, but they are not essential because all individuals visit the ground at some time. Where they co-exist, *R.norvegicus* usually remains on the ground or in the basements and ground floors of building, whilst the other two species occupy the trees (P.J.Moors, an et, 1989).

2.8. Eradication and Control of Rodents.

The wildlife management approaches for remote islands with acceptable distance (usually more than 200m) from mainland and rodent invaded islands as internationally recommended is the Eradication method.

The eradication of island can be sanctioned once a single rat is sighted (G.H.Sherley, 2000:pers comm.) because it is very difficult to control a small number of rats down to a zero level using the normal trapping method. The protocol emphasizes here the importance of totally eliminating all rats and their reproductive mechanisms so that the population of rats is brought down to zero. The eradication approach on mainland is not really supported because of the potential to rat re-invasion from other affected areas. The control method using normal trapping method at a control and well established manner is highly recommended here. The main different between eradication and control approaches is based on the theory that eradication aims for zero population whereas the control approach only regulates the population to a certain accepted level (G.H.Sherley, 2001:pers comm.).

2.9. Eradication Approaches

This technology of eradicating rats using massive application of toxin by aerial or ground based operation requires substantial resources. These resources in terms of funds, human, and many more are highly required from the beginning of this operation. A substantial effort and commitment of these resources begins right from the planning process. The most difficult part as usual in the planning of such project is the extraction of raw data and information to help decision-making. Usually such wildlife management project takes 90% of the time for planning and only 10% for the actual implementation of the planned activities. It may takes weeks, months and years to perform studies and researches to collect required information but it only takes one week or month to implement such operation. The eradication of rats can be carried out by aerial spraying of toxic baits using helicopters on ground or by ground based operations where toxic baits are evenly and systematically distributed to designed stations by hand. The designed station exposes only the target species to the bait while the non-target ones are restricted from accessing it. Therefore, the method of aerial spraying is more efficient and cheaper but too risky for the non target species that potentially exposed and attracted to the toxic baits. The ground based operation on the other hand is time consuming, expensive, labour intensive and sometime too risky for the people involved particularly with rugged and steep topography.

3.0. Baits / Poisoning.

Poisoning is the most cost effective means of killing rats in large numbers or isolated places. Rodenticides are of two general types: chronic poisons requiring several doses before a lethal concentration accumulates and taking 3-7days to cause death, and acute poisons which act within a few hours of a single dose. Chronic anticoagulant rodenticides are the first choice for island conservation campaigns. When selecting a poison consider cost, toxicity and palatability to rats , the type of operation being mounted, whether a single dose poison is needed, toxicity to other animals and the chances of accidentally poisoning them, and the types of bait being offered.

Warfarin is cheap and readily available. It is also much less toxic to birds than to rats and so reduces the dangers of accidentally poisoning. It is therefore suited to many situations where only a reduction in rat numbers is required. Recent eradication campaigns in New Zealand, however, have relied on brodifacoum and bromadialone particularly because of their single dose effectiveness. However the greater toxicity of these rodenticides brings increased dangers of killing non target animals, especially birds of prey feeding on carcasses of poisoned rats (Department of Conservation, NZ, 2000)..

3.1. Nuutele Island a Propose National Park.

Nuutele island has been identified 26years ago as a National Park (Floyd and Holloway, 1975), because of its importance to biodiversity conservation with the special emphasis on birds protection and conservation. This move was highly supported by Ollier, Whistler and Amerson (1979) whose recommendations was based on the importance of the islands for both fauna and flora conservation. A number of studies conducted in Samoa have identified the island as probably the best remaining breeding site and home for both Samoan land and sea birds (Brian.D.Bell 2000). The islands are haven for a number of endemic birds, including some vulnerable species such as the tooth billed pigeon (*Didunculus strigirostris*) and Samoa flycatcher (*Myiagra albiventris*), and the near threatened shy ground dove (*Gallicolumba stairi*).

They also hold a number of other endemic species and the endemic bat (*Pteropus samoensis*) (Collar et al 1994, Stattersfield et al 1998). The islands are a very important nesting site for seabirds, probably the most important in the country. Six to eight species breed there but they are especially important for red footed and brown boob (*Sula sula and S. leucogaster*), greater frigatebird (*Fregata minor*) and brown noddy (*Anous stolidus*)" (Brian.D.Bell 2000). The islands also host many other animal species such as one species of snake, lizards, butterflies, coconut crabs (becoming threatened) and a diversity of native plants.

3.2. International, Regional and National Concern.

Islands are extremely vulnerable to disturbance from human activities and from introduced plants. animals and diseases (G.H.Sherley, 2000:pers comm). This has led the International Union for Conserving Nature (IUCN) strengthened and enhanced programs and activities with regard to protecting and conserving islands biodiversity. These series of programs include the production of action plans and strategies for islands conservations and also promoting researches and studies in reviewing conservation status of islands around the world. Currently a IUCN Task Force on Island Conservation is now established by the Internation Union of Conserving Nature in cooperation with the United Nation Environment Program. This Task Forces principal role is to compile an Islands Database and Directory. This annonated listing of all significant islands provides a definite review of the conservation status of the worlds islands, and is the basis for deciding priorities for conservation actions around the world. Under this process the island of Nuutele was given a recognition by the IUCN to be incorporated in the IUCN Marine Protected Area Project (Foua, 2001:pers comm.). However, the idea of restoring the Nuutele island biodiversity was initiated by the South Pacific Regional Environment Program under the Invasive Species Management Program. It was highly supported by the Government of Samoa, the local community and the AusAid who has made funds available for this eradication project (S.Miller 2001:pers comm.).

3. 0 MATERIALS, EQUIPMENT AND FACILITIES.

3.1. For Studying the Area.

- Topographic / Contour Maps (Scale 1:5000 / 1:10000).
- GPS / Calculator / Scale Ruler.
- Note Book / Pencil / Rubber.
- Binoculars / Digital Cameras / Video Cameras.

3.2. Determining Rodent Abundance.

- Tracking tunnel set ((500mm long x 75mm high x 55mm wide paper box, painted cardboard cover, two tracking brown papers each end with moist food dye saturated foam and a pad in the middle).
- Plastic ear tags / wire / GBS / Note Book / Pencil.

3.3. Determining Rodent Food Sources / Identification of Rats.

- Plastic bag / Alcohol / Cooler & Ice / Sharp knife / Identification Book./ Note book / Pencil.

3.4. Monitoring of Invertebrates.

- Insect pitfall trap set (100 mm plastic cup, antifreeze (use by motor cars), dinner plate sized cover).
- storage containers / alcohol / plastic ear tag / wire / GBS / Note book / Pencil / Nuutele Islands` invertebrates Checklist.

3.5. Monitoring Lizards in the Area.

- Lizard Pitfall trap set (tapered plastic paint pails of 4litres volume, cat food bait, Plywood (300mm x 300mm), fresh plant leaves, peanut butter.
- spade / plastic ear tags / wire / pencil / note book / GBS / Nuutele Islands lizards checklist.

3.6. Monitoring Birds.

- Nuutele Island Birds Checklist / Note book / pencil.
- Binoculars / video cameras / Digital Cameras / GPS / Tape Recorder
- Plastic ear tags / wire.

3.7. Monitoring coconut crabs.

- radio transmitter / monitoring screen / antenna / sticky clue / GPS.
- Note book / pencil.

3.8. Determining preferred bait.

- peanut butter / roast coconut / rat snap trap / tracking tunnel set.
- Pencil / notebook

3.9. Investigating rodents ecological impact.

- binocular / video camera / note book / pencil

4.0. METHODOLOGY.

A line of 17 sample stations was set up from the base of the hill on the eastern side of Nu'utele the northern beach (old lepers village camp) following the existing track. Samples site were established about 50m apart along this. They were marked with white numbered plastic ear tags that were wired to trees. The samples taken from each site are given on table 1 below.

The positions of most sites were taken with GPS. No positions were obtained with the GPS at site 10 and 14, because they were covered with a thick canopy and were in valleys. The position obtained for site 9 is also inaccurate for the same reason. After the setting up of stations, the following trapping mechanisms as outlined below were established at each station. The trapping mechanisms for rats (kill snap traps and the tracking tunnels) and insects (insect pitfall traps) were set at every stations. In addition, the lizard pitfall traps and the 5minutes bird count were conducted at a different interval along the same established line of stations. The lizard pitfall traps were conducted at three locations only along the transect line (one set of 10traps at the beginning of the transect line, one set of 10traps at the center and one set at the end). Additional sets of 10s were also carried out along the beaches at both sides of the island. For the birds monitoring, the 5minutes bird counts were performed along the transect line at an interval of 150m (every 3rd stations). Other additional monitoring and study with regard to the area itself, the coconut crabs and other non-target species were generally carried out throughout the area. The reason for establishing traps along the stations of fixed distance is to find out a general and fair representative of the target and non-target species presence throughout the area.

Table 1. STATIONS POSITIONS (RATS TRACKING TUNNELS / RAT SNAP TRAPS/ INSECTS PITFALL TRAPS, LIZARD PITFALL TRAPS & BIRD COUNTS).

Site	South	West	North
Beach at Vini	14º03' 39.1"	171º25'37.7"	Start of 10 lizard pitfall traps; 20m to start of tracking tunnels and insect and insect pitfall trap sites A, B, C and D.
1	14º03'45.2"	171º25'34.9"	Insect pitfall, tracking tunnel, snap traps
2	14º03'46.8"	171º25'39.3"	Insect pitfall, tracking tunnel, snap traps
3	14º03'47.3"	171º25'37.3"	Insect pitfall, tracking tunnel, snap traps
4	14º03'47.5"	171º25'36.2"	Insect pitfall, tracking tunnel, snap traps
5	14º03'50.5"	171º25'34.8"	Insect pitfall, tracking tunnel, snap traps
6	14º03'50.6"	171º25'32.0"	Insect pitfall, tracking tunnel, snap traps, 10 lizard pitfall traps
7	14º03'52.4"	171º25'32.5"	Insect pitfall, tracking tunnel, snap traps
8	14º03'54.1"	171º25'32.6"	Insect pitfall, tracking tunnel, snap traps
9	(14º04'20.7")	(171º25'53.7")	Insect pitfall, tracking tunnel: Inaccurate GPS reading: too few satellites.
10	-	-	Insect pitfall, tracking tunnel no GPS reading

11	14º03'56.8"	171º25'27.9"	Insect pitfall, tracking tunnel, snap traps
12	14º03'55.9"	171º25'26.4"	Insect pitfall, tracking tunnel, snap traps
13	14º03'56.1"	171º25'24.2"	Insect pitfall, tracking tunnel, snap traps
14	-	-	Insect pitfall, tracking tunnel, snap traps. No GPS reading.
15	14º03'56.0"	171º25'21.3"	-
16	14`03'55.6"	171`25'18.0"	Insect pitfall, tracking tunnel, snap traps, 10 lizard pitfall traps.
17	14º03'55.2"	171º25'14.3"	Insect pitfall, tracking tunnel, snap traps
North Beach	14º03'54.0"	171º25'11.1"	10 lizard pitfall traps

Monitoring of the non target species such as birds, lizards and insects is very important, since they are the potential indicators that will be used to determine the achievement of this operation expected results, and the long term expected conservation outcomes of this mission. On the other hand, these species are regarded as the potential beneficial species that will be benefit from the outcome of this operation. The need to monitor the target species (rat) and its aspects is vital for the planning process of this operation and as check up of the operational success and failure in the future.

OUTLINE AND PROCEDURES OF DIFFERENT MONITORING MECHANISM APPLIED.

A. AREA ACCESSIBILITY / IMPORTANT CONSERVATION SITES.

3.1. Studying the Target Area.

We used topographic and contour maps (scales 1:10000 / 1:5000) to ground truth and locate some important sites and areas of special interest particularly with the planning of stations to be established on the island during the ground based operation, or spreading patterns bait by aerial operation. We carefully ground truth the accuracy of information on maps for better operational design in the office. In addition we performed sites observation by riding around the island and observed from the boat using binoculars areas where normal access is impossible and sites where heavily occupied by sea birds. Notes and images were taken with cameras and geographical positions were taken with GPS.

B. TARGET SPECIES - RAT.

3.2. Determining the Rodent Species, Distribution and Abundance.

We used the rodent tracking tunnel (500mm long x 75mm high x 55mm wide paper box, painted cardboard cover, two tracking brown papers each end with moist food dye saturated foam and a pad in the middle). The system works by tracking every rat that goes through the tunnel. This method is commonly used by scientists to determine the relative or absolute abundance of rat species and mouse in an area. It involves the setting up of a small tunnel with an inkpad in the middle and paper at each end so that the animal leaves its prints. Each end of the tunnel is baited usually with peanut butter. Species are identified by their tracks and their tracking frequency is then calculated from the percentage of tunnels tracked by different species.

Knowing the rodent species present and their abundance will help design more effective ways of successfully eradicating the rats from the island. These traps were checked regularly everyday during the four days study, replaced the tracking tunnel paper and re-baited its ends with peanut butter. There were 17 tracking tunnels set at every station. These were checked and re-set on daily basis. During our first monitoring in July 2000, we used the peanut butter baits for our tracking tunnels and substituted with roasted coconuts during our second monitoring in June 2001 in an attempt to determine the preferred bait.

3.3. Determining the Rodent Food Sources / Species Identification.

A very simple trap used to catch rats by using peanut butter bait to attract rats to the set trap spring. The spring quickly releases the tension it has once the rats disturb the bait setting the steel on the rat. The rats that will be trapped will be taken for identification purposes and other relevant biological studies. These studies include researches on important issues such as rat's diet and behavioural aspects as they assist a lot with the operation planning and designing for effective eradication of rats. The traps were checked regularly, re-baited with peanut butter and re-set the springs. There were 17 rat snap traps set at every station. These were checked and re-set on daily basis. We used the peanut butter standard baits for our first monitoring operations in July 2000 and then substituted with roasted coconut during our second monitoring in June 2001 for the same reason as mentioned earlier.

3.4. Determining the preferred baits by rats.

We used peanut butter for our first monitoring (July 2000) operation for both the tracking tunnels and the rat snap traps. During the second monitoring operation in June 2001 we roasted some coconuts on fire (half cook). These were split into small pieces and then mounted to rat snap traps. We also placed some coconuts inside both sides of the rat tracking tunnels.

3.5. Assessing and determining the ecological impacts of rodents on the island.

We did not performed any scientific based study to determine the ecological impact of rats on the islands flora and fauna because of limited time and resources available. However, field observations were made by looking at field signs of potential rodents feeding on plants, seeds and flora. These were noted and images were taken by cameras.

C. NON TARGET SPECIES / BENEFICIAL SPECIES - INDICATORS.

3.6. Monitoring the Inverterbrates in the area.

We provided every 17 stations in the area with a insect pitfall trap. A very special technique designed to trap the invertebrates or insects for monitoring purposes. A hole is dug in the ground that is enough for the brim of the cup to level with the ground surface in order to prevent insect shyness. The cup contains antifreeze coolant that is intended to kill the insects while keeping them fresh for identification purposes later. A dinner plate is placed above as an umbrella to prevent rainwater from entering. Insect pitfall traps are cleared daily and any trapped insects are counted and taken away.

3.7 Monitoring the Lizards in the Area.

A similar technique with the same principle of trapping specially designed for trapping lizards. The tapered plastics do not have antifreeze coolant as used for insect traps but have cat food on fresh leaves as bait and then a ply sheets 300mm x 300mm is placed on the top as cover to prevent it from rainwater and other disturbances.

The lizards will find it hard to escape once they get inside the tapered plastic paint pails since they find the plastics slippery. Lizard pitfall traps (51 tapered plastic paint pails) were set in groups of ten consisting of five pairs. One was set above high water near the camp, one at the crest of the cross-island track, one on the flat about 200m off the steep slope on the other side of the cross-island track and one set above the high water mark near the leper village site where the cross-island track meets the beach. These traps were checked and re-set on daily basis.

3.8. Monitoring Birds in the Area.

A general scientific method of determining birds abundance in an area. The method involves four people watching, listening and facing the four quarters of the compass calling every bird heard and seen which is verified by the others before being recorded. The scoring goes on for five minutes. The intention was to repeat these observations at every station, which have been permanently labeled to facilitate this. These observations were to be repeated once in the morning and again in the afternoon. However, these data have yet to be collected to complete the monitoring of the beneficiary species. Also included are general observations of birds seen around the area but not within the 5minutes count. This is important in just noting the presence of birds species on the island. This was only done at once for only one day.

D. NON TARGET SPECIES AT HIGH RISK

Monitoring Coconut crabs in the Area..

We roughly noted down every coconut crabs seen and their locations. We trapped and mounted one coconut trap with a radio transmitter. The main intention is to investigate its home range and coverage which is important in designing plans to prevent it from exposing to higher risk during the implementation phase of this operation.

5. RESULT.

A. TARGET SPECIES - RAT.

- RAT SPECIES / CONFIRMATION OF PRESENCE.

During our first monitoring operation in July 2000 a single male kiore rat (*Rattus exulan*) was caught in the snap traps (at site 3) together with 7 land crabs during 36.5 corrected trap nights. All of the rat traps were set up on trees either vertically or horizontally on suitable branches in order to reduce the chances of crabs reaching them. No rodent tracks were found in any of the tracking tunnels during 44 tunnel-nights, but 52% of the tracking tunnels had land crab tracks through them. One rat was seen during the day at site 15 but there was never any evidence of rat tracks at this site. However during the second monitoring operation in June 2001, 2 rats were trapped at station 3 and 7 with 8 land crabs during a 51 corrected trap nights. Other traps were sprung with baits still remaining because of fallen twigs from trees. From 8 additional stations set around the plantation area each with a rat snap trap and tracking tunnel, 17 rats were trapped out of 21 corrected trap nights. Other traps had land crabs. More than 50% of the tracking tunnels received rodent tracks. Furthermore, other snap traps set randomly around the camping site caught 11rats out of 19 trap nights.

Other undisturbed traps were baited with peanut butter and about 10 rats were also sighted around the area at night and daytime. At the end of the monitoring week, more than 30 rats of the *Rattus exulan* species were trapped and killed. There was no *Rattus rattus* caught during this study.

Table 2. Results of rat snap trap catches on two different monitoring

	July 2000	June 2001
Rats Trapped / Killed	2	33
Land crabs Trapped.	7	3
Hermit crabs	8	8
Coconut crabs	8	8
No. of traps set per night	17	17
No. Of traps sprung but empty	24	25

- ABUNDANCE AND DISTRIBUTION.

The number of rats caught shows that the population of rats on the island is very high in line with the outcome of these studies. The information obtained from the study cannot really determine the actual distribution of rats because of poor result obtained from other sides of the island. This poor results could happen as consequences of great disturbances from fallen twigs and hermit crabs but undermining the actual situation. Rats could also be present at other areas but cannot be determined because of the highlighted problem. However, the obtained results show that more rats are concentrated around the plantation area. This is because of the available food sources.

- ECOLOGICAL IMPACTS..

  No sign of ecological impacts were noticed on fauna and native flora. However, the taro plants and pumpkin as observed were heavily affected by rats. Rats were actually seen around these crops during day-time.

- BAITS.

  The outcome of the two monitoring in July 2000 and June 2001 focussing on testing the NZ standard bait for monitoring (peanut butter) and the local bait (roasted coconut) clearly shows a big difference. Only 2 rats were caught from the peanut baited traps while the coconut baited traps trapped about 33 rats. Therefore shows that the tropical rats prefer the local bait which is a special issue to be considered prior to the implementation of this operation.

B. NON TARGET SPECIES.

- LIZARDS.

The lizard pitfall traps (July 2000 monitoring) caught only two skinks during 160 trap nights on Nu'utele Island (one *Emoia cyanaura* on the north beach and one *Emoia nigra* on the flats in the bush behind this beach: both were caught in unbaited traps).
The second monitoring on June 2001 caught nothing at this time during 160 trap nights on Nuutele Island. Many lizards were caught by hands and the species are listed below with the lizards found during the first monitoring.

Table 3. Lizards Species on Nu'utele Island.

Species	Sites were found
Emoia nigra	All sites
Emoia samoensis	All sites
Emoia cyanaura	Beach front
Emoia murphyii	Cliffs south of Vini
Gehyra mutilans	Beach and fale
Gehyra oceanica	Site 17

- INSECTS /INVERTEBRATES.

A total of 406 invertebrates were caught but few were likely to have been eaten by rats (i.e. 5 mm or larger). These are listed in Table 4. The other invertebrates collected were all less than 3 mm long and most were less than 2 mm long. They comprised, in order of abundance, tiny flies (Diptera: 42.6%), small ants (Formicidae: 20.2%), small spiders ((4.9%), springtails (Collemola: 3.7%), small crickets (Gryllidae: 3.4%), rove beetles and sucking bugs (Coleoptera: Staphylinidae and Hemiptera, both 2.0%), landsnails and leaf litter mites (Gastropoda and Acarina: both 1.7%), and minute parasitic wasps (Hymenoptera, 0.7%).

Table 4. Invertebrates 5mm long or larger caught in pitfall traps on Nu'utele Island

Invertebrate	No. Caught	Body length (mm)	Sites where caught
Earthworms (Oligochaeta)	2	34, 15	17, 4
Earwig (Dermaptera)	1	6	A
Hermit crab (Anomura)	1	15	A
Caterpillar (Lepidoptera)	1	10	22
Large ants (Ponerinae: Odontomachus sp.)	44	Ca 7-11	1, 3, 6, 7, 8, 11, 12, 13, 14, 15, 16, A
Land snails (Gastropoda)	3	7, 7, 9	11, 22

- BIRDS

Table 5. Land birds abundance based on the 5 minutes Count Method

Fuafua forest ----→-------Maota forest --→----------Nonu Vao Forest :

Bird Species	5m asl 1	26m asl 2	100m asl 3	130m asl 4	150m asl 5	175m asl 6	Total	Abundance
Iao (Wattle Honeyeater)	7	3	4	6	7	5	32	**1.06**
Fuia (Samoan Starling) **	3	1	1	3	1	2	11	**0.36**
Vasavasa (Whistler) *	-	-	3	4	1	1	9	**0.30**
Lupe (Pacifica pigeon)	-	-	1	1	2	1	5	**0.16**
Pea (Flying fox)	1	2	-	-	2	-	5	**0.16**
Miti (Polynesian thriller)	1	3	-	-	-	-	4	**0.13**
Sega (Cardinal honeyeater)	-	-	1	1	1	1	4	**0.13**
Manutagi (Crimson crowned fruit dove)	-	1	-	-	-	1	2	**0.06**
Tolai fatu (Samoan Broadbill) *	-	1	-	-	-	-	1	**0.03**
Unidentified birds	2	2	2	1	1	1	1	**0.33**

Asl – Altitude above sealevel * - Endemic sppto Samoa ** - Endemic spp to Samoa/American Samoa.

The above table shows the abundance of the different birds as listed per minute basis. The most common bird according to the above table was the Wattled Honeyeater followed by the Samoan Starling, Whistler and the Pacific Pigeon. There were also a number of birds that could not be identified. Three of these unidentified birds could be the Manumea or Ground Dove birds. No special evidence was identified with relation to any potential rat predation on birds. However, with the nature of the *Rattus exulan* there is potential threat on ground based bird species like the ground dove and sea birds that normally nest on the rocks around the island.

- Sea Birds

More number of seabirds (Red footed boobie, Brown boobie, Reef heron and others) were seen on site on the ground and rocks at most coastal regions of the island with difficult access. The other side of the island that impossible to access with the normal walk is largely occupied with hundreds and hundreds of sea birds of these species. Their eggs and juvenile ones can be easily located and seen from a distance, nesting on rocks and thus become a major concern for their safety from rats predation.

- COCONUT / HERMIT / LAND CRABS.

The coconut crab home range and area coverage appears to be very wide according to the result obtained from this investigation. It moved from area to area and most of the time the transmitter cannot locate it properly and sometime did not appear on the monitoring screen at all. This happened when the coconut crab went down very deep under the rocks. One of the things encountered during these series of studies was the disturbance form hermit crabs. More of the snap traps were disturbed by hermit crabs because they were attracted easily to the peanut and roasted coconut baits.

- OTHER NON TARGET SPECIES.

No mouse was trapped, tracked or seen during this operation. About 3 snakes were seen and caught during these two series of monitoring in the area.

6. DISCUSSION.

Management Decision

With the outcome of this study on the island, it is now confirmed that there are many rats on the island, probably one species of rat (*Rattus exulan*). This satisfies the requirement to carry out an eradication operation. It is also very fortunate that the *Rattus rattus* in line with the findings of these two monitoring operations is not present. It is generally believed that *Rattus rattus* is more destructive than *Rattus exulan*, because of its capacity to climb tall trees where most bird nests are located. What could be very challenging as far as rat eradication concerns is the further confirmation of the destruction that these rats caused to the island by some means of detailed and scientific based studies. This is not to question the findings and experiences from the temperate countries like New Zealand with well established information but to have some second opinion and thought on this by considering the islands situation. It could make a big difference if taken into account the stable availability of variety of food sources for rats on the island such as ripe banana, pumpkins and many more. The big question is why rats go for birds, eggs, lizards and insects if these agricultural crops are already available on site.

The main issue here is that why decide to go for a very expensive and risky operation if the island rats are not responsible. There is a need to have evidences on this impact of rats on the islands flora and fauna. This will strengthen our belief of the ecological consequences rats have on our indigenous ecosystems and its unique life forms. If such understanding is not highly supported here practically, then why we need to poison our environment with toxins for the purpose of just following the usual strategies of wildlife management.

Area Accessibilty.

As observed during our investigations and assessments of the entire area, it appears that more than 60% of the area is impossible for normal access by human. it is very hard to access many parts of the islands with very steep to vertical topography. To enable the operation to cover these areas, a group of specialized climbers must be hired to effectively distribute toxin baits to these parts of the island. As far as rat eradication is concerned, all the rats must be killed. The entire area should be all covered with baits no matter if the area is too steep or very rugged. Therefore, special people with such skill will enable operation to achieve its objectives.

Disturbance

The problem with hermit crabs being attracted easily at high numbers and appeared to consume more baits during the operation requires the use of special techniques to protect this from happening.

Non Target Species.

The bird species as identified to be at high risk during this operation are the shy ground doves and the sea birds that likely to consume the baits on ground whereas the barn owl is under threat with feeding on dead rats already affected with the poison. Special techniques have to be developed to protect these birds. The coconut crab is also a big worry particularly with potential affect to poachers from the mainland who may consume any affected coconut crabs during the operation period. Therefore, the local community requires to be informed and educated about this.

Baits / Food sources.

The peanut butter as the standard New Zealand bait appears to be ineffective on the island in contrast to the outcome of the coconut baited traps. This was proved during the second monitoring when roasted coconuts were used as baits. The improvement from the last time almost around 80%, thus the bait issue should also be well taken into account during this eradication planning process. Another important move to enhance understanding and knowledge of the rats sources of food is to study the rodents diet. If the main diet is know then it may be effective to try such an identified source of food as potential baits in whatever combination with the toxin to produce an effective bait for this schedule operation.

Potential Predators

It is now confirmed from these series of studies that wild cats as another potential predators on island is not present. However, with the discovery of snakes, it could be important to further investigate whether this is more a primary predator than rats. This is very important because rats have a stable food supply available on the island such as ripe bananas, coconut, pumpkin seeds, taro and many more.

On the other hand, snakes have very limited sources of food so there is more chances that snakes is the major problem here. Therefore, this must be taken into account so that these snakes can be also eliminated during this operation, probably through second poisoning when they consume poisoned rats.

Rats Abundance and Distribution

The distribution of rats is clearly concentrated in the area around the plantation, where sources of food is available. The first and second monitoring found nothing from stations located away from this zone. More rats were found around the plantation. This could clearly present a message for decision making to consider. However, the unsatisfactory performance from other stations away from the plantation area could have been caused from intense interference from crabs and fallen twigs from trees.

Monitoring Suggestion

One thing that is completely lacked here is about the rat home range.. This is important as far as wild life management concerns so that the entire area (rats home range) is completely covered with toxin baits. This should be determined before the operation so that baits cover the entire home range of rats.

Management Decision.

Further investigation is required to determine the ecological impacts of rats to the island fauna and flora. The impact on agricultural crops and stored food is understandable but it is interesting to know whether rats have been responsible for destruction to the island wildlife. If rats are not responsible then a control method using the normal trapping approach must be carried out to control the population of rats to an acceptable number.

7. CONCLUSIONS.

A. Main findings as Planning Concerns.

a) The species of rat currently invading the island is the *Rattus exulan.*

b) The density of rats on the island is very high particularly at the plantation area but very low at other areas.

c) The non target fauna species that are likely to be at high risk during the poisoning stage of this operation is the ground dove bird, the owl, the puppies and the coconut crabs.

d) More intense works will be required in the implementation phase of this eradication project and more resources must be committed (funds, human and etc).

e) The islands topography and landscape is very complicated in terms of access and thus required skillful mountain climbers

f) The eradication of rats using the second generation toxin (broadifacoum) in special designed stations is suitable for the island situation.

g) The ground based operation will prevent any adverse impact to the surrounding environment and other non target species and thus requires commitment of resources to implement it.

Eradication importance.

a) The eradication of rats has some potential benefits as highly expected as outcome of this operation.

b) The terrestrial birds and some of the seabirds should increase their populations because of the absence of rat predation on eggs and chicks, and also because of less competition for food. The fruit bats may also benefit from less competition.

c) provide a possible translocation site for two threatened island species or subspecies - the Island thrush (Turdus poliocephalus samoensis) and Samoan white eye (Zosterops samoensis)

d) It will be a conservation focal point for the Aleipata District Community and for Samoa, and will be an example to other Pacific Island nations.

e) It will eventually become a very important eco-tourist destination that will bring associated benefits to the local community and Samoa.

f) Globally it will demonstrate what can be achieved by international agencies working closely with the local community, and how specialist management personnel can work with and train local managers in specific programs.

g) Also from a global perspective it will provide a secure habitat for a good percentage of the Samoan endemic fauna, The invertebrates should benefit and this will in turn help the insectivorous birds.

h) The improvement in the regeneration of some trees and other plants, as seeds will not be destroyed by rats.

i) A noticeable increase in lizard numbers will be experienced..

j) Fruit and vegetables will receive no longer rat damages.

Significance For Samoa.

1. It will be important as it will establish the only protected predator free area for the shy ground dove in the Pacific, let alone Samoa, and also provide a further site for the tooth billed pigeon and Samoan flycatcher.

2. The island if rat free will serves as nursery to restore the population of birds in the country with special focus on the endemic and endangered bird species.

3. The capacity building and skills of the local people will be enhanced with regard to pest and invasive animal species management.

8. RECOMMENDATION.

1) To incorporate the traditional knowledge of people with their local baits such as the roasted coconut, ripe banana and others in the formation of toxin bait to be used in the implementation phase of this project.

2) More fieldwork studies should be done in the future prior to the eradication operation to determine the rodent's distribution and abundance. This can be accomplished by setting up stations throughout the entire islands to ascertain how far the rats move around (home range) and what locations the rats are at high density. This will assist in providing better information for the successful eradication of rats once the eradication operation is implemented.

3) Further researches is needed to confirm that the *Rattus rattus* is not present on the island and further investigate whether the island snake is responsible for any ecological impact on the island.

4) The ground-based operation is recommended despite of its high cost and labour intensive in line with the findings of this study - safer for the environment and more effective.

5) Seek the support and participation of the local community right from the decision making process until the implementation phase.

6) Enhance awareness of the local community with regard to important issues concerning measures taken as post activities and effort to island protection from rats re-invasion.

7) Seek public understanding and cooperation among the NGOs, communities and the government with island prevention measures.

8) To establish policies and other legal means of enforcing islands protection from rats re-invasion.

9) Have a Rodent Contingency and Management Plans.

9. REFERENCES CITED.

1. Amituanai.F. 2000. Local Marine Consultant, Marine Protected Area Government of Samoa. Personal Communication.

2. Brian.D.Bell, 2000. Feasibility Study Of Removal of Rats From Nuutele Island, Report to the Department of Lands, Surveys and Environment., Apia, Samoa.

3. Brian.D.Bell. Director. Wildlife Management Consultancy, NZ. Personal Communication.

4. Brown, D.A. 1997. Chetwode Island Kiore and Weka Eradication Project. Ecological Management 5. New Zealand.

5. Department of Conservation. 2000. Pest Animal Management Guidelines Handbook. Wellington. NZ.

6 . Greg.Sherley. Project Officer. Invasive Species Management Program. SPREP. Apia. Samoa. Personal Communication.

7. Holloway and Floyd, 1974. The National Park System of Samoa, Department of Agriculture, Forestry, Fishery and Meteorology, Western Samoa.

8. Isaia.F. 2000. Nafanua Horticulture Former Manager. Government of Samoa, Apia. Personal Communication.

9. Liu.S.F.2001. Assistant Director of Environment and Conservation Division. Government of Samoa, Apia. Personal Communication.

10. Lovegrove.T.Bell and Hay, R. 1992, The Indigenous Wildlife Of Western Samoa, Impacts of Cyclone Val and Recovery And Management Strategy, W. Samoa.

11. Murphy, E, and Dowding, J. 1994. Ecology of Ship Rats (Rattus rattus) in a Kauri (Agathis australis) forest in Northland, New Zealand. NZ Journal Of Ecology 18.

12. Ollier, C, W.A. Whistler, and B.Amerson Jr.1979. O le Pupu Pue National Park. U.N.Develop.Adv.Team for the So.Pac,. Vols. 1 and 11.

13. P.J.Moors, I.A.E.Atkinson, G.H.Sherley. 1989. Prohibited Imigrants: The Rat Threat to Island Conservation. World Wide Fund, NZ.

14. Sue.Miller. Project Manager. IUCN Marine Protected Area. Samoa. Personal Communication.

15. Taylor, G.A. 1986. The Ecology of Norway Rats on Campell Island. Ecology Division, DSIR, Nelsoln.

APPENDIX 1. - ISLAND SCENARIO