

**FEASIBILITY OF RAT ERADICATION FROM AHND ATOLL,
FEDERATED STATES OF MICRONESIA
(PROJECT DESIGN DOCUMENT)**

Prepared by:

Gregg Howald¹

Alex Wegmann²

and

Holly Jones³

Prepared for:

CONSERVATION SOCIETY OF POHNPEI
Kolonia Pohnpei, Federated States of Micronesia

1. Island Conservation Canada, 680 — 220 Cambie St. Vancouver, BC V6B 2M9
Gregg.Howald@islandconservation.org
2. Island Conservation, 100 Shaffer Rd., Santa Cruz, California, 95060
3. Yale University, New Haven, Connecticut

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Feasibility of Rat Eradication from Ahnd Atoll, Federated States of Micronesia (PROJECT DESIGN DOCUMENT)

Executive Summary

Ahnd Atoll (also known as And or Ant Atoll), located 18.5 km Southwest of Kolonia, Pohnpei state, Federated States of Micronesia (FSM), has a significant lagoon area of approximately 74 km² and 12 separate islets totaling 1.86 km², with the largest two islets at 0.6 and 0.5 km². The atoll is home to 13 species of reptiles (including the hawksbill and green turtles), 25 bird species, 7 mammals (Buden, 1996), several species of land crabs, and hundreds of marine species. Privately owned by the Nanpei Family, Ahnd Atoll is one of the most biologically diverse and undisturbed atolls in the FSM. In the FSM National Biodiversity Strategic Action Plan (NBSAP) and the accompanying TNC-authored “A Blue Print for Conserving the Biodiversity of the Federated States of Micronesia,” Ahnd Atoll was determined to be a national Priority Action Area and Pohnpei’s top marine area of biological significance (ABS). The atoll has been prioritized in the Polynesia-Micronesia Biodiversity Hotspot Ecosystem Profile for CEPF investment as Key Biodiversity Area #6.

Ahnd Atoll’s terrestrial biodiversity is threatened by two invasive rat species, *Rattus rattus*, and *R. exulans*. This proposal seeks funding to eradicate rats from Ahnd Atoll, thus allowing natural recolonization of and augmentation seabird, forestbird, terrestrial reptile, terrestrial invertebrate and native mammal populations. Aside from restoring integrity to Ahnd Atoll’s terrestrial ecosystem, this project will provide safe habitat for many species that are threatened or nearly threatened on nearby Pohnpei. It is proposed to 1) conduct a trial eradication involving hand-baiting brodifacoum on several (≥ 5) small islands adjacent to Pohnpei to test and perfect monitoring methods and non-target species mitigation practices; 2) eradicate rats from Ahnd Atoll involving helicopter aerial bating brodifacoum. The proposed project offers significant learning opportunities for local and regional conservation entities, as well as economic, social, and environmental benefit to the local inhabitants of Pohnpei. Through this project, knowledge gained by local and regional conservation groups can be used to eradicate rats from other islands in the Polynesian/Micronesian region, and increase the biosecurity of critical habitat for many species at risk.

The following table summarizes the proposed eradication of rats from several small islands adjacent to Pohnpei, and ultimately from Ahnd Atoll.

Table 1: Ahnd Atoll Rat Eradication Project Summary

Location	Federated States of Micronesia, Pohnpei State, Ahnd Atoll and small islands adjacent to Pohnpei: Ahnd Atoll = 1.86 km ² emergent land
Primary target pest species	Pacific Rat (<i>Rattus exulans</i>) and Black Rat (<i>Rattus rattus</i>)
Secondary target species	Feral Dogs, Pigs, Cats, and Fowl on Ahnd Atoll
Timing	Trial Eradication on small islands adjacent to Pohnpei: January-February 2007. Ahnd Atoll Eradication: 2008
Target benefit species	<p><u>Birds</u>: Micronesian Pigeon <i>Ducula oceanica</i>; Micronesian Starling; <i>Aplonis opaca</i>; Pohnpei Lory <i>Trichoglossus rubiginosus</i>; Caroline Is. Reed Warbler; <i>Acrocephalus syrx</i>; Micronesian Kingfisher <i>Halcyon cinnamomina</i>; Micronesian Honeyeater; <i>Myzomela rubratra</i>; seabirds.</p> <p><u>Mammals</u>: Micronesian Fruit Bat <i>Pteropus molossinus</i>; Sheath Tailed Bat <i>Emballonura sulcata</i></p> <p><u>Terrestrial Invertebrates</u>: Coconut Crab <i>Birgus latro</i>; Hermit Crab <i>Coenopita perlatus</i>, <i>C. brevimanus</i>; Land Crab <i>Geocarcoidea sp.</i></p> <p><u>Plants</u>: <i>Allophylus ternatus</i>; <i>Cordia subcordata</i>, <i>Ficus spp.</i>; <i>Guetterda speciosa</i>; <i>Hernandia sonora</i>; <i>Neisosperma oppositifolia</i>; <i>Pisonia grandis</i>, <i>Terminalia litoralis</i></p>
Vegetation type	Broadleaf forest, coconut plantation
Climate characteristics	Aseasonal, ITCZ
Community interests	Uninhabited, Islands owned by local families
Historic sites	None known
Project Coordinator	Patterson Shed, Conservation Society of Pohnpei
Operational Manager	Gregg Howald, Island Conservation
Start and end date	Trial Eradication : Start January – End February 2007; Ahnd Atoll Eradication commence in 2008
Methods	Trial Eradication: Hand broadcasting brodifacoum bait; Ahnd Atoll Eradication: Aerial broadcast brodifacoum bait
Biodiversity/conservation outcomes	Recovery of threatened bird populations, plus enhancement of native lizard, invertebrate and plant communities
Socio-economic benefits	Providing employment (eradication operation and subsequent surveillance and biosecurity)
Capacity development	<ul style="list-style-type: none"> • Training and skills-sharing • Develop quarantine and contingency procedures • New partnerships and initiatives in island invasives management
Management history	No previous management attempted at project locations

Justification

In 1992, the Federated States of Micronesia signed the Convention on Biological Diversity and followed it with ratification by the FSM congress in 1994. In 2002, the FSM produced a National Biodiversity Strategic Action Plan (NBSAP) that has acted as a guideline for biodiversity conservation in the country. In 2004, Pohnpei State formulated and adopted its own biodiversity strategic action plan (BSAP). Both these documents list conversion and degradation of habitat and ecosystems, over exploitation and unsustainable harvesting methods and practices, and invasive organisms and pests as major threats and constraints to biodiversity conservation. This project addresses these three major threats.

The Conservation Society of Pohnpei (CSP) has a long and successful history of projects aimed at applied biodiversity conservation. Eradicating rats from Ahnd Atoll will carry on CSP's agenda by restoring and maintain an ecological balance and promote habitat diversity. Other projects that CSP has implemented successfully include a campaign to get farmers to plant sakau (*Piper methysticum*) in the lowlands and a network of community-based marine protected areas, and a mangrove ecosystem conservation public awareness campaign. The Ahnd Atoll rat eradication project, along with CSP's other initiatives, will further the strategic goal of empowering communities to manage their own resources.

The Pohnpei State Government and the Nanpei Family (owners of Ahnd Atoll) all support the eradication of rats from Ahnd Atoll. Recently, the Conservation Society of Pohnpei, the Pohnpei State Government and the Nanpei Family began putting together an application to UNESCO to gain biosphere status for the atoll. The Nanpei Family has agreed to provide access to the atoll and human resources to assist with the eradication work and the subsequent monitoring.

Context

The FSM Eco-regional Plan provides a shared blueprint of FSM's biological resources – a clear picture of the places in the nation where those resources reside and prioritization of conservation needs, and what is required in order to set and achieve conservation objectives. The planning process identified fifty-three conservation targets (12 systems, 6 communities, 4 special ecological features and 29 species) and 130 Areas of Biodiversity Significance (ABS), which are habitats for the fifty-three conservation targets. These areas constitute 19% of the nation's entire terrestrial and inshore areas, excluding its territorial waters, which consist of mostly open ocean. Out of the 130 ABS, 24 "Priority Action Areas" were selected to focus conservation action in the next three to five years (A Blueprint for Conserving the Biodiversity of the FSM). Ahnd Atoll is one of these.

Importance of Island Ecosystems

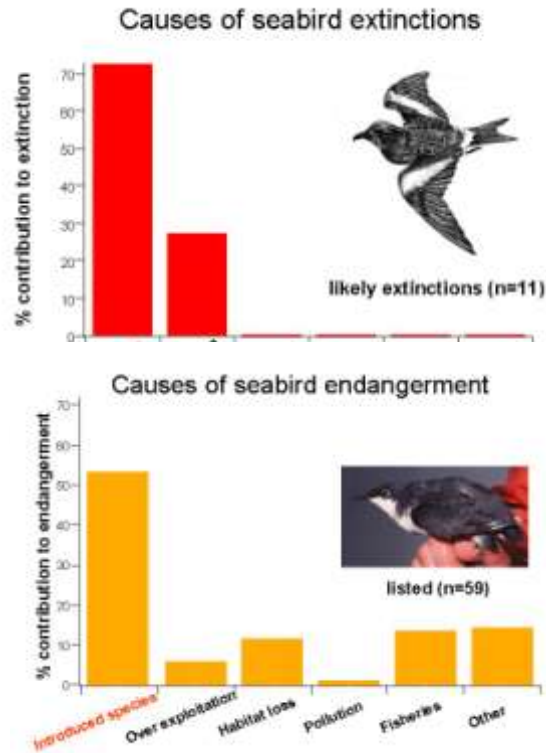
Island ecosystems, like Ahnd Atoll near the island of Pohnpei, Federated States of Micronesia, are key areas for conservation of biodiversity because they are critical habitat for seabirds and sea turtles that spend most of their lives in the open ocean, but depend on islands for resting and breeding. Islands are rich with endemic species, are home to 20% of all plant, reptile and bird species, but represent only 3% of the earth's surface (Whittaker 2001).

Unfortunately, islands have been disproportionately impacted by humans. Overall, 70% of recorded animal extinctions (90% of birds, 90% of reptiles, 65% of mammals) have occurred on islands, and most of these extinctions, including more than half of all seabird extinctions, were caused by invasive species (Fig.1a). Today, more than half of all IUCN red listed birds are threatened by introduced species (Fig. 1b). Feral cats and rodents are the most damaging introduced species to island ecosystems, where they frequently impact native species through direct predation, competition or changes in the food web.

Introduced Rats on Islands

There are three species of commensal rats in the genus *Rattus* that have been introduced to islands throughout the world. In order of decreasing body size they are: the Norway or Brown Rat (*R. norvegicus*), the Ship or Black Rat (*R. rattus*), and the Polynesian Rat (*R. exulans*). They have different dietary preferences, distributions and histories of introduction, but all three species are omnivorous, behaviorally plastic, have high reproductive rates, and can survive in a variety of habitats (Atkinson 1985; Moors *et al.* 1992). These traits make them ideally suited to survive on a variety of predator-free islands. One or more of these species occurs on an estimated 82% of all island groups worldwide (Atkinson 1985).

Figure 1: Causes of seabird extinctions and endangerment



The most pronounced impact of introduced rodents on island ecosystems is the extinction of endemic species. Rats alone are responsible for an estimated 40-60% of all bird and reptile extinctions (Island Conservation analysis of World Conservation Monitoring Centre data; Atkinson 1985). They have caused the extinction of endemic mammals, birds and invertebrates on islands throughout the world's oceans (Andrews 1909; Daniel and Williams 1984; Meads *et al.* 1984; Atkinson 1985; Hindwood 1940; Tomich 1986).

Even if extinctions do not occur, rats can have ecosystem-wide effects on the distribution and abundance of native species through direct and indirect effects. For example, comparisons of rat-infested and rat-free islands, and pre- and post-rat eradication experiments, have shown that rats depressed the population size and recruitment of birds (Thibault 1995; Campbell 1991; Jouventin *et al.* 2003; Jones *et al.* 2005), reptiles (Bullock 1986; Cree *et al.* 1992; Whitaker 1973; Towns 1991), plants and terrestrial invertebrates. Rats are known to cause disturbance to sensitive breeding seabirds, causing failed breeding attempts and higher susceptibility to predation by other species (Jouventin *et al.* 2003; Tomkins 1985). Rats have also been shown to affect the abundance and age structure of intertidal invertebrates (Navarrete and Castilla 1993). Where rats occur together with other predators (such as cats or predatory birds) the direct impact of the rats and other predators on seabirds is greater than the sum of the individual impacts because the rats, themselves a food source, artificially support a greater population of the predators when the seabirds are absent (Atkinson 1985; Moors and Atkinson 1984).

In addition to preying on local seabird colonies, introduced rats feed opportunistically on plants, and alter the floral communities of ecosystems into which they are introduced (Campbell and Atkinson 2002), in some cases degrading the quality of nesting habitat for birds that depend on the vegetation. On Tiritiri Matangi Island, New Zealand, ripe fruits and seeds and understory vegetation cover increased significantly after rats were eradicated from the island, indicating their previous impacts on the vegetation (Graham and Veitch 2002).

Each of the three species of introduced *Rattus* has been implicated in extinctions and changes in prey population structure. Although all rat species are damaging to insular biota, due to their different natural histories each species has slightly different impacts. For example, of the three introduced rat species, *R. norvegicus* tends to have the greatest impact on burrow-nesting seabirds, *R. rattus* tends to prefer preying on tree-nesting birds, and *R. exulans* appears to impact both types of nesters (Atkinson 1985). Consequently, the introduction of new *Rattus* species should be avoided, even to islands that already have introduced rats (Moors *et al.* 1992).

Overview of Global Rat Eradications

Rodents have been eradicated from at least 206 islands worldwide (Island Conservation unpub. data). Most rodent eradications have taken place in Australasia, with 120

successful eradications taking place in New Zealand. The majority of rodent eradications (75%) have been on islands less than 100 ha. Rats have been removed from eleven islands over 500 ha, with the largest rat eradication taking place on Campbell Island, New Zealand (11,300 ha, McClelland 2002; Towns & Broome 2003).

The fundamental approach that all but one of these eradications utilized involved:

1. Delivering bait containing a rodenticide into every potential rat territory on the island,
2. Timing the eradication to maximize probability that every rat will eat the bait or be exposed to the rodenticide,
3. Preventing rats from migrating back onto the island, either naturally from other islands, or responding to an accidental/deliberate introduction.

Bait is typically delivered during the time of year when rats were approaching the low point of their annual food dependent population decline.

Rodenticide

With the exception of one island, rodenticides were used in all eradication campaigns. Of the total land area treated, 94% was treated with second generation anticoagulants, primarily brodifacoum. A relatively minor number (32) of eradications used first generation anticoagulants, and 8 used acute toxins (e.g. 1080 and strychnine), most of which were supplemented with second generation anticoagulants (Island Conservation unpub. data). Approximately 32% of eradication campaigns supplemented the rodenticide application with an alternative rodenticide and/or trapping.

The choice of bait must have a high likelihood of achieving eradication, but must be evaluated against potential negative consequences, such as non-target poisoning. Strictly from an eradication perspective, the choice of bait used must:

- contain an active ingredient that is known to be highly efficacious to rats,
- be palatable and demonstrate low or no bait shyness by rats,
- delivered into the territory of each rat on the island,
- be consumed in sufficient amounts by every single rat to receive a lethal dose.

From an efficacy standpoint, the bait must contain a rodenticide that has the ability to kill rats and prevent the possibility of incurring bait shyness (individuals that will intentionally avoid the bait). There are three classes of rodenticides available on the market internationally. They are the acute rodenticides, the subacute rodenticides, and the anticoagulants.

Acute Rodenticides

Zinc Phosphide, Bromethalin

Acute rodenticides kill rats quickly after a single feeding. The major benefit of acute rodenticides is that rats die quickly before they build up high levels of rodenticide in their tissue. This reduces the incidence of secondary poisoning. However, there are two drawbacks to the use of acute rodenticides. First, they are often extremely toxic to humans and there are not always effective antidotes. Second, they can induce bait avoidance if animals consume a sub-lethal dose. For these reasons acute rodenticides have not, to our knowledge, been used exclusively to eradicate rats from islands.

The acute rodenticides, such as zinc phosphide, are known to induce some degree of bait shyness due to the rapid onset of poisoning symptoms. Studies with zinc phosphide have demonstrated that rats associate the toxic symptoms with toxic bait if the onset of symptoms occurs within 6-7 hours of consumption (see Lund 1988). Thus, any individual surviving that round of exposure is likely to avoid the bait in the future (Record and Marsh 1988). To overcome this potential, it is recommended to pre-bait, where unarmed bait (i.e., bait without the toxic ingredient) is delivered into the environment and the target animal is allowed to consume the bait. After a period of time, the armed product is delivered and bait take is believed to be higher than with no pre-baiting, thus increasing efficacy. In island restoration projects, there is no guarantee that pre-baiting will increase efficacy to 100% and thus is not recommended. To improve acceptance and reduce potential of bait shyness, bait should contain an active ingredient that has a delayed onset of toxicosis.

Subacute Rodenticides

Cholecalciferol

Subacute rodenticides have similar properties to acute rodenticides; however, death may be delayed beyond 24 hours. Cholecalciferol disrupts the calcium homeostasis mechanism, resulting in the resorption of calcium from bone, and is the only subacute rodenticide registered with the US EPA. Death results from hypercalcemia causing kidney failure and heart arrhythmias. A benefit of cholecalciferol is that the symptoms are somewhat delayed between 24 hours to several days after ingestion. However, symptoms of toxicosis can be felt after ingestion of a sub-lethal dose that could result in development of bait shyness on recovery (Prescott et al. 1992). There is very little field data from the use of this product; however, it appears that it has potential as an island restoration rodenticide. Cholecalciferol was tested successfully to remove rats from a small offshore islet of San Jorge, Mexico (Donlan et al. 2002) It is not toxic to birds. (based on LD50 data) and preliminary data suggests it does not present a secondary poisoning hazard.

Anticoagulants

The most widely used rodenticides over the last 50 years have been anticoagulants, primarily warfarin and brodifacoum. They are incredibly effective compared to other rodenticides and about a dozen varieties have been developed, of which only 6 are available in the US market. Other anticoagulants such as flocoumafen and difenacoum are available internationally. All anticoagulant rodenticides act by blocking the vitamin K1 dependent oxidation-reduction cycle in the liver. They also cause capillary damage. As a result, death is due to massive internal hemorrhaging (Taylor 1993). Because illness is delayed, rats generally do not develop bait avoidance behavior and will continue consuming bait when ill. Thus, there is no social transmission of bait avoidance and no pre-baiting is needed.

There are three first-generation anticoagulants (warfarin, chlorophacinone, and diphacinone) and second-generation anticoagulants (brodifacoum, difethialone, bromadiolone). First generation anticoagulants require rats to feed on the bait over a period of days, decreasing the probability that all rats will receive a lethal dose. The second-generation anticoagulants are able to induce mortality after a single-feed, dramatically increasing the probability that all house mice will receive a lethal dose.

First Generation Anticoagulants

The most widely used first generation anticoagulant is warfarin. The main benefit of warfarin is its low toxicity to birds (Kaukeinen 1993). However, house mice must feed over several days exclusively on warfarin bait in order to consume a toxic dose. The control of rats can be a strong selection agent, increasing the frequency of house mice that cannot be killed via the control method used. Where populations of house mice have been previously exposed to rodenticides, some house mice demonstrate bait avoidance behavior and others may be biochemically “resistant” to the anticoagulant used. Most importantly, there has been no successful eradication of house mice with a first generation anticoagulant that we are aware of. In Australia, mice were removed from islands using pindone, a first generation anticoagulant in conjunction with a second generation anticoagulant.

Second Generation Anticoagulants

The second-generation anticoagulants will kill warfarin-resistant rats and, if in sufficient concentration, kill house mice after a single feeding, thus dramatically increasing the probability of successful eradication. Only brodifacoum has been used successfully and repeatedly to eradicate rats from islands worldwide. Currently, it is the primary rodenticide used repeatedly to eradicate rats from islands.

Brodifacoum, like warfarin, is a coumarin-based anticoagulant (Chemical formula (3-[3-4'-bromo (1-1'-biphenyl)-4-y-1]-1, 2, 3, 4-tetrahydro-1-naphthalenyl]-4-hydroxy-2H-1-benzopyran-2-one)). Coumarin is a common substance in green plants that was discovered when moist and molded clover hay caused internal bleeding and mortality in cattle (Lund 1988a, in Taylor 1993). It is also found in high concentrations in *Gliricida*

sepium, a Central American plant widely used as a natural form of rodent control (Hochman 1966, in Taylor 1993).

Detailed descriptions of brodifacoum and its effects on non-target species can be found in Taylor (1993) and Kaukeinen (1993). The following discussion comes primarily from Taylor (1993) unless otherwise cited.

Absorption & Degradation in Soil:

The half-life of brodifacoum in soil is from 84-170 days and it is less stable in alkaline soils. Degradation of brodifacoum by soil microbes results in non-toxic metabolites in microorganisms, and eventual reduction to its base components of CO₂ and H₂O.

Half Life in Living Organisms:

The half-life of brodifacoum in the tissue of living organisms is about the same as that in soil 150-200 days. However, there is some evidence that it may be somewhat longer. In house mice, and perhaps other mammals, 75% of a lethal dose is maintained in the liver, the rest is absorbed into other tissue at a variable rate.

Soil Mobility of Brodifacoum:

Brodifacoum is not soluble in water, and will not migrate from the land to the water supply or ocean. Because brodifacoum remains absorbed to soil, only erosion of the soil will result in it reaching the water. However, it would remain absorbed to organic material and settle out into the sediment, which would be widely dispersed and diluted by waves and currents.

Effects on Humans:

Brodifacoum is potentially toxic to all mammals including humans. Although there may be some skin irritation caused by contact with bait, poisoning is only likely if ingested. The lethal dose of brodifacoum for a human is likely between 0.28 – 25 mg/kg (based on the range of toxic doses in five species of mammals). Assuming the bait used on Ahnd Atoll would be 5 g pellets with 25 ppm brodifacoum, spread at 10 kg/ha, a 70 kg adult would have to find and consume a minimum of 140 pellets, which would be spread over a 700 square meter area to consume a lethal dose.

Even if a person did consume a lethal dose of bait, death is extremely unlikely because brodifacoum is slow acting and the symptoms are treated with the antidote vitamin K1. In fact, there are no recorded cases of accidental poisonings of humans caused by brodifacoum, even though brodifacoum is the most widely used second-generation anticoagulant rodenticide in the world (Taylor 1993).

Effects on Marine and Terrestrial Invertebrates:

Anticoagulant rodenticides are not known to affect invertebrates, likely because of their different blood clotting systems. Extensive field and lab trials have shown that tinibronid beetles (Tershy et al. 1992), land crabs (Pain et al. 2000), snails, slugs (Howald 1997), and ants (B. Tershy, unpubl. data) can survive on a diet of 20-50 ppm brodifacoum. In addition, invertebrates do not appear to accumulate residues, minimizing the transport of brodifacoum into the ecosystem.

Effects on Reptiles:

There are, to our knowledge, no published studies on the toxicity of brodifacoum to amphibians or reptiles. Unpublished data suggests that snakes fed brodifacoum killed house mice (R. Marsh pers. comm.), and lizards force fed 50ppm brodifacoum survived for at least several weeks (Tershy unpubl. data). Eason and Spurr (1995) reported brodifacoum poisoned skinks, testing positive for brodifacoum residues and apparent hemorrhaging. However, neither study tested the ability of these individuals to breed. More conclusive is empirical experience from large-scale rabbit and rat eradication campaigns using brodifacoum. None of these have resulted in detectable mortality to endemic and native lizards, or declines in populations (Merton 1987). In fact, lizard and amphibian populations typically increased after house mice were eradicated using brodifacoum (e.g. Towns 1991, Cree et al. 1992, T. Comendant, pers. comm.), indicating that no extensive mitigation is necessary.

Effects on Native Birds:

Brodifacoum is toxic to birds. However, the toxicity is highly variable among species. The bird species using the island that are most likely to directly consume bait or poisoned rats are granivorous Micronesian Starlings and the Micronesian Kingfisher. There are no published LD50's for non-target birds found on Ahnd Atoll, but published LD50's for several different Passerine birds range from 3.0-6.0 mg/kg. For an untested bird species there is a 95% probability that its LD50 will be above 0.56mg/kg (Howald et al. 1999).

Bait Delivery Techniques

There are three methods typically used to deliver bait: in bait stations, broadcast by hand, or broadcast by helicopter.

Helicopter broadcast has been typically used on large or rugged islands that preclude the use of delivering bait by hand. Aerial broadcast usually requires the bait be dispensed from a hopper suspended under a helicopter. The broadcast is guided by an onboard differential global positioning system (DGPS) to ensure even and accurate bait coverage. The main advantages of this method are that it is quick, it delivers bait to all rats at the same time, and bait reaches hard to access areas like steep and rugged cliffs and tree canopies in the case of arboreal rats.

Bait stations are usually used on smaller islands with relatively flat terrain where most or all of the island is accessible on foot. Stations are laid out on a grid pattern (e.g. 50 m x 50 m spacing) to ensure one or more stations exist in each rat territory. Stations are loaded with bait blocks and bait is refreshed as needed. Stations are checked daily, for up to 6 weeks, then monthly, for up to one to two years. On tropical islands with coconut palm, *Rattus rattus* move regularly between the tree canopy and the forest floor (Howald et al. 2004) but the subsequent *planar* ranging area is much smaller than in more temperate areas. Thus, bait station spacing in tropical areas may need to be 25 x 25 m (16 stations per hectare) or smaller to ensure delivery of bait to each rat.

Hand broadcast is similar to the helicopter broadcast in that bait is delivered to all rats at the same time. Typically bait is spread along set transect lines that are flagged, or monitored with a GPS to ensure even lines. The limitation of hand broadcast is the rate at which bait can be spread on the island - ideally bait spread will be complete on the island within 1 to 2 days, but this is dictated by the quality of the people spreading the bait. Further, steep terrain and cliffs inaccessible on foot become difficult to spread bait accurately when using hand broadcast techniques. On tropical islands, with coconut palm, bait may need to be delivered to rats living in the canopy which can add significant time and effort to the eradication attempt (Buckelew et al. 2005). Hand broadcast on tropical islands is thus limited to relatively smaller islands with relatively few trees that require supplemental baiting.

We believe that bait, containing 20 to 50 ppm brodifacoum, broadcast from a hopper suspended under a helicopter offers the highest probability of successfully removing both species of rats from Ahnd Atoll. The toxicological risks to non-target species and people using the Atoll are limited to a short timeframe. Once the bait is applied to the Atoll, and the rats are removed, there will not be a need for further application of the rodenticide. Thus, any risks can be mitigated with specific mitigation measures which can reduce the risk of exposure of individual animals to the bait.

Bait Application

The presence of two species of rat at Ahnd Atoll, the smaller *R. exulans* and larger, partially arboreal *R. rattus*, poses complications and limits the options of method of bait application. *R. rattus* is competitively dominant and will dominate bait stations, likely excluding *R. exulans* from gaining access to bait stations (Swift 1998; K. Swift, pers. comm. 2006). It has been hypothesized that stations used by *R. rattus*, may not be used by all individual *R. exulans* even after *R. rattus* have been removed from the system, suggesting avoidance of odor, neophobia, or station avoidance. When nontarget species are not in danger, broadcasting bait directly onto the ground removes the uncertainty of these complex social behaviors from a baiting program and increases the chances of success. Thus, we recommend against the use of bait stations.

The high density of coconut palms on Nikilap Aru, and along the coastal belt of the remaining islets, presents an abundance of high quality food, cover, and nesting sites for *R. rattus* (Strecker et al. 1962). Although evidence suggests that rats are not strictly arboreal (Howald et al. 2004), the high stem densities and crown connectivity to palms and other broadleaf trees presents a concern that some individual rats could:

1. Meet all their life needs (food, cover, and mates) in the canopy
2. Infrequently come down from the canopy
3. maintain a small ranging territory on the forest floor

Table 2: Comparison of Aerial Broadcast, Hand Broadcast, and Bait station bait delivery methodologies for the Ahnd Atoll rat eradication

	<u>Aerial Broadcast</u>		<u>Hand Broadcast</u>		<u>Bait Station</u>	
Safety	+	Reduces # of people involved and people/hours necessary to complete the eradication	+	Does not involve potentially dangerous equipment, such as helicopters and bait hoppers	+	Reduces # of people and does not involve potentially dangerous equipment, such as helicopters and bait hoppers
	-	involve potentially dangerous equipment, such as helicopters	-	Increases # of people involved to complete the eradication, increases potential for occupational injuries, and highly variable bait application	-	Increases # of people/hours necessary to complete the eradication, increases potential for occupational injuries
Efficacy	+	Reduces potential for application error by minimizing # of people directly involved with bait delivery adds canopy baiting as an "insurance" tactic that minimizes bait competition with non-target organisms	+		+	Minimizes non-target competition for bait.
	-		-	Increases potential for application error by maximizing # of people directly involved with bait delivery, limits bait delivery to a two-dimensional plane while rats forage in a three-dimensional environment	-	Increases potential for missing rats by increasing the spatial gap between delivered bait units, increases potential for human error by requiring unfailing maintenance of thousands of bait stations for a long period of many months and up to two years.
Knowledge Transfer	+	Introduces Aerial Broadcasting as a possible eradication method	+	Reinforces the Hand Broadcast methodologies learned during the trial eradication phase	+	Reinforces the Bait Station methodology learned during the trial eradication phase
	-		-	Does not enhance knowledge of eradication methodologies beyond those employed in the trial eradication.	-	Does not enhance knowledge of eradication methodologies beyond those employed in the trial eradication.
Logistics	+	Bait delivery is completed 1-2 days, minimal # of people involved in bait delivery	+	All material are either available on, or easily transported to Pohnpei, all personnel needed are available on Pohnpei	+	All material are either available on, or easily transported to Pohnpei, all personnel needed are available on Pohnpei

	-	Helicopter and trained pilot are not immediately available on Pohnpei	-	Maximizes # of people involved in eradication effort	-	Maximizes amount of time spent conducting eradication
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Broadcasting bait into the trees would overcome the risk of rats present in palm trees. Hand broadcast application on Ahnd Atoll would not be easily implemented. The high stem density of palms on the Atoll (we conservatively estimated at >9400 palms using distance to nearest neighbor methods) would require an estimated > 200 person days to hand apply bait in ideal conditions. Further, the dense broadleaf tree canopy blocks much of the taller upper coconut palm canopy which precludes broadcasting of bait into the palm canopy by hand from the forest floor.

Assessing all issues outlined above, we believe that the eradication of rats from Ahnd Atoll has the highest probability of succeeding if bait is distributed by aerial broadcast onto the atoll, including into the palm forest canopy. See **Table 2** for a comparison of the three bait delivery methodologies.

Bait Competition with Land crabs

It is essential that enough bait is applied for the rats, for long enough that every rat has access to and will consume a lethal dose. However, land crabs will be attracted to and consume, but will not be affected by the bait, applied to the Atoll, essentially competing with the rats. Thus, enough bait has to be applied to overcome competition by land crabs with the rats on the Atoll.

To calculate the appropriate bait application rate, one must consider the amounts of bait needed to eradicate the rats, but also to compensate for the loss of bait to other species such as land crabs. The total application rate must consider the total uptake of bait by both rats and crabs.

Bait Selection

The ideal bait for broadcast onto Ahnd Atoll should:

1. Withstand the warm, damp, maritime climate, long enough for all rats to gain access to and consume a lethal amount of bait,
2. Degrade rapidly, if not consumed by rats, to minimize the temporal risk of primary exposure to non target birds,
3. Be dyed green or blue to minimize attractiveness of the bait to non target landbirds,
4. Be in a large pellet formulation, large enough to provide a barrier to ingestion by non-target land birds,
5. Not contain bitrex, a bittering agent that is known to affect palatability of baits to rats.

There are no baits available locally in Micronesia that would meet the needs for an eradication of rats from Ahnd Atoll. The bait must be imported from either New Zealand

or the United States. We recommend a full review of bait availability from all suppliers and their applicability to the Micronesian environment. Once candidate bait has been identified, the bait should be confirmed palatable to rats, against alternative natural foods, and to withstand the wet, warm climate on Ahnd Atoll. Three potential suppliers have been identified, including:

- Animal Control Products, Wanganui, New Zealand supplies the majority of baits for conservation purposes in New Zealand and internationally (<http://www.pestoff.co.nz>).
- Bell Laboratories, Wisconsin, USA (www.belllabs.com) manufacturers and distributes bait internationally.
- Hacco, Inc., Wisconsin, USA (www.hacco.com), manufacturers a 6 gram broadcast pellet on behalf of the USDA.

Timing the Eradication

Most eradication programs time the delivery of bait to when there is the least competition between the bait and natural foods (winter season in temperate regions) to maximize the likelihood that all rats will be exposed to the rodenticide, and, when there is no breeding to minimize the chance that young, weanling rats will emerge from the nest after all the available bait has been consumed. In temperate climates, this window typically corresponds to a declining or low point in the annual food dependent population cycle; food availability declines in fall and winter with limited or no breeding by rats. In some cases, mortality may be as high as 90% of local native rodents.

Rat populations cycle in the tropics and are tied to the rainy season and the fruiting season. In the tropics with pronounced wet/dry seasons, rat abundance increases during the rainy season as food resources increase, and progressively decline in the dry season as resources become scarce (Madsen et al. 1999; Stenseth et al.). In the wet tropics, such as Ahnd Atoll, where rain falls almost daily, and without a clear dry season, the rat population cycle appears to be tied to food availability, or a fruiting season (E.Jones, pers. comm.). On the island of Pohnpei, rat population abundance appears to be correlated with the fruiting season, which starts in May/June. Our May 2006 reconnaissance trip to Ahnd Atoll was early in the development cycle of the breadfruit fruiting season and may explain the low trap success that we experienced.

We recommend that the timing of the eradication take place at the low or declining rat population cycle. Based on our observations in May 2006, and knowledge of rat population cycles in the tropics, we believe that the late winter, spring (March through June) may be the best time to eradicate rats from the Atoll. This timing likely also corresponds to the movement of migratory shorebirds that move into the northern hemisphere for breeding, thus, minimizing the number of individual shorebirds, such as the vagrant Bristle Thighed Curlew, at risk of exposure to the rodenticide.

Project Stakeholders

The Conservation Society of Pohnpei (CSP) is partnering with Island Conservation (IC), RARE, The Nature Conservancy, the Pacific Invasive Initiative (PII), Pohnpei State Government, the Micronesia Conservation Trust (MCT), the Pacific Invasives Learning Network (PILN), Micronesians in Island Conservation (MIC), and local landowners to eradicate all rats from Ahnd Atoll and to facilitate demonstration of and training in successful techniques for eradicating invasive animals in the Polynesia-Micronesia Biodiversity Hotspot.

CSP (support level: high) will acquire the experience and knowledge necessary to plan and conduct subsequent invasive species eradications within Pohnpei State and throughout FSM.

IC (support level: high) will assist CSP and regional partners by sharing technical expertise in planning and implementing invasive rodent eradications on small islands near Pohnpei during the trial eradication phase and the Ahnd Atoll rat eradication. The small-island eradications will serve as trials for the Ahnd Atoll eradication and demonstrations of eradication techniques that can be applied throughout the region. IC and CSP will also develop a complete eradication plan and budget for eradicating rats from Ahnd Atoll based on data collected during the trial eradication. IC will partner with CSP to conduct the Ahnd Atoll rat eradication.

PII (support level: high) will promote the application of best practice procedures and quality control through the facilitation of peer review of project plans and reports. The PII will promote the opportunity to participate in the demonstration and symposium to its partners, and disseminate information from it through its partner networks. The PII may also facilitate the participation of eradication experts from elsewhere in the Region.

RARE (support level: high), in conjunction with IC and the PII, is developing a rat eradication manual to be shared in whole or part with those who participate in the Ahnd Atoll eradication.

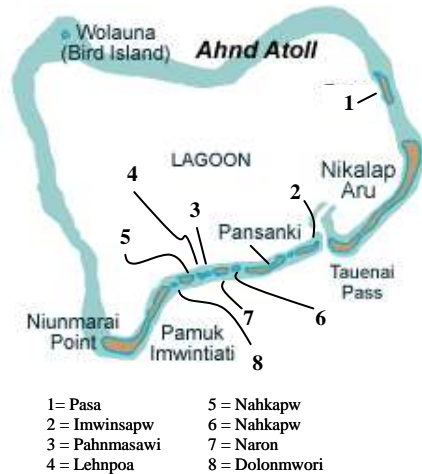
Feasibility

Location

Ahnd Atoll (6° 45' 00" N, 158° 00' 00" E) is 18.5 km southwest of Pohnpei State, Federated States of Micronesia - eastern Caroline Islands. The atoll is approximately

12.5 km long and 9 km wide, with 1.86 km² of emergent land broken into 12 islets of varying size. Two islets, Pamuk and Nikalap Aru account for more than half of the land area. All but one of the islands lie just inside of the south to east back reef. Except for Tauenai Pass between the islets Nikalap Aru and Imwinyap, channels between islets are shallow enough to wade across at low tide (**Figure 2**).

Figure 2: Map of Ahnd Atoll



Weather

Ahnd Atoll lies within the Inter-Tropical Convergence Zone (ITCZ), the band of low pressure along the equator formed by the upward convection of warm, moist air from the earth's surface. The climate of Ahnd Atoll is characterized by warm temperatures between 75 to 95 Fahrenheit, and almost daily copious rainfall events associated with thunderstorms. It is considered an ever-wet tropical climate; annual rainfall at Kolonia, Pohnpei is 4.75 m.

Island Size and Topography

The island is approximately 186 ha in size, among 12 islets. The island is well within the size range of successful eradications completed globally. All of the islets are easily accessed on foot or by boat in the inner lagoon. At low tide, the channels provide easy access to adjacent islets. The main deep water channel between Imwinyap and Nikalap Aru must be swum or crossing made by boat.

Individual islets are characteristically long and narrow, ranging from small (<1 ha) to large (>50 ha), and are between 100 and 300 m wide.

The island is a true coral atoll, with relatively flat topography, rising to a maximum elevation of about 2 m. The substrate is comprised of coral rubble, mostly covered with an organic layer of decaying plant matter, and thick mat of tree and shrub roots.

Walking across the island is deceptively difficult. The coral rubble is unstable and walking can be dangerous, requiring relatively slow traveling to prevent ankle sprains. The thick vegetation provides an impenetrable barrier to the interior of the islands without trail cutting.

Flora and Fauna

The most comprehensive summary of vertebrates and flora on Ahnd Atoll is found in Buden (1996).

Fauna

Ahnd Atoll hosts 25 bird species, 13 reptiles, and 6 mammals. Of the 25 birds, 9 are seabirds, 7 are land birds, and 9 are shorebirds. Except for the Red Jungle Fowl (*Gallus gallus*), all birds are considered native. Only 2 mammals, the common Micronesian Fruit Bat (*Pteropus molossinus*) and uncommon visitor sheath tailed bat (*Emballonura sulcata*), are native to Pohnpei and Ahnd Atoll. As Buden (1996) notes, the Micronesian Starling (*Aplonis opaca*) is the most common land bird at Ahnd Atoll.

Flora

The last comprehensive floral survey of Ahnd Atoll recorded 58 species of vascular plants (Buden 1996). Ahnd's forest extends inland from rocky or sandy beaches, and is occasionally bordered by thickets of *Tournefortia argentea*, *Scaevola serecia*, or *Pemphis acidula*. Except for portions of Nikalap Aru where a now-abandoned copra plantation created uniform stands of *Cocos nucifera* that span the entire island, *C. nucifera* is dominant only along a 50m wide strip on the lagoon side of each island, and is common to uncommon throughout the tropical broadleaf forest that covers about 60% of Ahnd's emergent land.

The atoll's tropical broad leaf forest has several co-dominant canopy trees that exhibit a moderate to high level of patchiness: *Allophylus ternatus*, *Artocarpus altilis*, *Barringtonia asiatica*, *Cordia subcordata*, *Ficus spp.* *Guetterda speciosa*, *Hernandia sonora*, *Neisosperma oppositifolia*, and *Pisonia grandis*. *P. grandis* is the dominant canopy tree on Wolauna islet, but is much less common throughout the rest of the atoll. *Morinda citrifoliai*, *Terminalia litoralis*, and *Pandanus tectorius* are common understory trees; *M. citrifolia* is most abundant around human encampments. A large (30m tall) tree in the family *Fabaceae* was observed on Pasa islet that was not mentioned by Buden (1996).

Introduced Mammals on Ahnd Atoll

Ahnd Atoll supports 5 introduced mammals, all brought to the atoll by humans, including:

1. Polynesian Rat (*Rattus exulans*)
2. Ship rat (*Rattus rattus*)
3. Feral cats (*Felis catus*)
4. Feral dogs (*Canis familiaris*)
5. Feral pigs (*Sus scrofa*)

Rats have been reported across all islands, except Wolouna (Bird Island) and Pasa, apparently the only rodent free islands (Buden 1996), though local fisherman have reported rats on Pasa in the past. Results from trapping and observations in May 2006 suggest that rats were in low density (8 ship rats and 1 Polynesian rat/144 trap nights), and unevenly distributed across the islets. Trap success across the islets ranged from undetectable (0 rats per 16 trap nights on Pasa, 25 trap nights on Panshanki, and 22 trap nights on Renipiua), low (1 rat/14 trap nights on Naron; 3 rats/ 54 trap nights on Panmuk) to moderately high densities (5 rats/12 trap nights on Nikilap Aru). The highest density was found in an abandoned copra plantation on Nikilap Aru, in a high-density stand of coconut palm (*Cocos nucifera*). The population cycle of the rats on Ahnd Atoll is unclear. There has been no systematic, repeated sampling over time. The results of the sampling in May 2006 was in contrast to Buden (1996) that regularly observed rats on the islands, and the anecdotal reports from the local fisherman that the islands were infested with rats that could be regularly observed on the beaches (we observed no activity or sign on the beaches). The contrasting results suggests that there may be either an intra annual or inter annual population cycle of rats on the island.

Cats have been reported on Nikilap Aru, Pamuk and Pasa (see Buden 1996). Cats were observed or heard on Naron (3 cats) and Panshanki (2 cats) in May 2006.

Buden (1996) noted dogs on Nikilap Aru and Pamuk. In May 2006, two dogs, likely the pets of the now deceased caretaker, were observed on Nikilap Aru.

Pigs have been reported on Nikilap Aru (Buden 1996). In May 2006, we observed evidence of pigs, including wallows and tracks on Panshanki (sighted 3 pigs), Shikaroi, Remba, Naron, and Iminyap. The shallow tidal channels between the islets are easily traversed by pigs, except for the deep water channel between Nikilap Aru and Iminyap. The pigs are owned and regularly hunted by members of the Nanpei family.

Impacts of Invasive Mammals on Ahnd Atoll

Introduced species on islands often have ecosystem wide impacts. However, once the distribution and abundance of native species have changed in response to competition or predation from the introduced species, negative interactions between native and introduced species may be rare. Consequently, there are four ways to estimate the impact of introduced species on island ecosystems:

- 1) comparisons from before and after the introduction or removal of an introduced species;
- 2) comparisons of enclosure plots, from which the introduced species is removed, with similar plots from which introduced species are not removed;
- 3) comparisons of similar islands with and without the introduced species;
- 4) logical inference based on the diet of the introduced species and its impact on other island ecosystems.

Unfortunately, no studies have been conducted on Ahnd Atoll prior to the introduction of the invasive mammals and invasive mammal enclosure plots are not technically feasible. Thus, to understand the likely impact of introduced species on Ahnd Atoll, one must make comparisons with other similar islands and use logical inference and models. Based on known impacts of rats, cats, dogs and pigs on other islands, we hypothesize that:

Plants

Hypothesis 1. Rats are limiting the productivity of plants through seed predation, especially of: *A. ternatus*, *A. altilis*, *C. subcordata*, *C. nucifera*, *Ficus spp.* *G. speciosa*, *H. sonora*, *N. oppositifolia*, *P. tectorious*, and *T. litoralis*.

Introduced rats are known to feed opportunistically on plants, and alter the floral communities of ecosystems they inhabit (Campbell and Atkinson 2002, A. Wegmann unpublished data). In Hawaii, rat granivory has been implicated in the reproductive failure of numerous rare endemic plant species on Mokapu Island (K. Wood unpublished data). On Tiritiri Matangi Island, New Zealand, ripe fruits and seeds and understory vegetation cover increased significantly after rats were eradicated from the island, indicating their previous impacts on the vegetation (Graham and Veitch 2002).

Avifauna

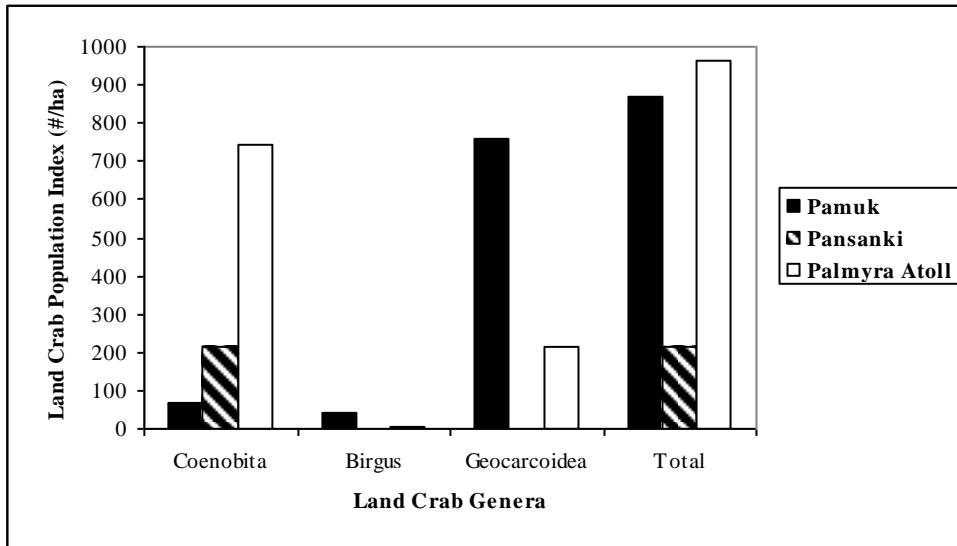
Hypothesis 2: Rats are limiting the nesting success of both seabirds and land birds together with cats. Rats prey on every life stage of both seabirds and land birds, while cats eat mainly adults. This direct predation by rats and cats has led to devastating effects to island avifauna worldwide (Atkinson 1985). Cat predation on adults led to the near extirpation of Black-vented Shearwaters (*Puffinus opisthomelas*) on Natividad Island in Mexico. Once cats were eradicated, breeding shearwater populations rebounded significantly (Keitt and Tershy 2003). Following rat eradication on Hardy Island in the French West Indies, Bridled Tern (*Sterna anaethetus*) breeding success increased from total breeding failure to as high as 75% reproductive success (Lorvelec and Pascal 2005). Rats have been the cause of many land bird extirpations, including wren (*Dendroscansor decurvirostris*), rails (*Capellirallus karamu*), nightjars (*Aegotheles novaezealandiae*), and many others (Townes et al. 2005).

Hypothesis 3: Cats and dogs are artificially supported by rats during non seabird breeding season. The probability of island extinctions increases with the number of invasive mammals presents (Blackburn et al. 2004). The combination multiple invasive predators on seabirds can sum to higher effects than just one of those species alone. This is because of the seasonality of nesting seabirds – there are seasons when seabirds are not there as a food source for cats, dogs, and rats. While this does not limit the food choice of generalist rats, dog and cat populations generally decrease during this time unless there is another prey item present. When rats, cats and dogs coexist on islands, cats and dogs can supplement their diets with rats when seabirds are absent, resulting in a steady or growing dog and cat population. This cat-dog-rat interaction has lead to the extinction of many island birds (Atkinson 1985).

Land Crabs

Hypothesis 4: Invasive pigs suppress land crab abundances through predation. We tested hypothesis 4 by conducting a small study in May 2006 by comparing land crab counts on pig free islands and islands with pigs. The relative abundance of three land crab genera, *Geocarcoidea* (land crab), *Birgus* (coconut crab), and *Coenobita* (hermit crab) was sampled on two islets at Ahnd Atoll: Pamuk, and Pansanki. Pamuk islet has rats, while Pansanki has rats, cats, and pigs. Relative abundance was measured as an index rather than a population estimate (Fig. 3). On each study islet, all crabs within randomly located 5m x 25m fixed-width transects were counted, and the number of crabs per 125 m² was applied to the atoll's total land area to generate a rough population index for each genera. We sampled 46 and 22 transects on Pamuk and Pansanki, respectively.

Figure 3: Ahnd Atoll Land Crab Population Index: May 2006. Population Index from Palmyra Atoll, Line Islands, included for comparison



No *Geocarcoidea* or *Birgus* were seen within transects on Pansanki during the population index survey, however a few (< 5) individuals were observed on the islet outside transects. The presence of pigs is likely a significant factor in the difference between *Geocarcoidea* and *Birgus* abundance on the two islets as pigs probably suppress the crab populations through predation (support for Hypothesis 4). Inversely, *Coenobitas* (both *C. perlatus* and *C. brevimanus*) are more numerous on Pansanki than Pamuk.

Terrestrial Invertebrates

Hypothesis 5: Removal of rats will result in an increase in the population size of terrestrial invertebrates.

Rats are known to prey on invertebrates. Removal of rats has led to significant increases in local invertebrate populations. It is expected native invertebrates will show similar increases after rat removal from Ahnd Atoll.

Project Design

Goal

The goal of this project is to restore natural function to and ensure the biosecurity of Ahnd Atoll's terrestrial ecosystem by removing invasive rodents from the atoll. Approximately three quarters of the globally threatened species scientifically identified in the hotspot are threatened by invasive species. Conservation International (CI), in the Polynesia-Micronesia ecosystem hotspot profile, listed all the islands of Micronesia (including Ahnd Atoll) in the roster of Key Biodiversity Areas in the FSM. To avoid the threat of extinction, it is necessary to safeguard the natural habitats of these islands. Ahnd Atoll is one of the most biologically diverse and undisturbed atolls in Pohnpei State. The atoll is home to 13 species of reptiles (including hawksbill and green turtles), 25 birds, 7 mammals, several species of land and coconut crabs, along with hundreds of other marine species. The atoll's terrestrial biodiversity is being threatened by rats, which are preying on birds, turtle eggs, coconut crabs and hundreds of other small land creatures that inhabit the atoll. Wolauna, one islet currently free from rats, is a significant seabird rookery; one of only three largely intact seabird colonies remaining in Micronesia. Eradicating the rats from the remaining islets of the atoll is likely to lead to the re-colonization and expansion of the seabird colony, dramatically increasing the available breeding habitat in the region.

Objective

The objective of this project is to:

- Protect the biodiversity of Ahnd Atoll from damaging invasive mammals including rats and create opportunities to enhance local livelihoods by reducing the socio-economic impacts of rodents.
- Develop techniques for eradicating rats from the Ahnd Atoll that can be transferred to subsequent, regional invasive species eradication programs
- Build the capacity of conservation practitioners in the Pacific in invasive mammal eradication techniques
- Strengthen key regional networks such as PILN, MIC, and the Pacific Invasives Initiative, and
- Raise awareness among key government decision makers of past successes and high feasibility of invasive species eradication from islands to ease regulatory hurdles, and increase the likelihood of support for subsequent eradications.

Outputs

Below is a list of the particular results that need to be achieved in order to realize the project objectives:

Output 1: Trial phase and planning for Ahnd Atoll eradication

- Identification of potential trial islands
- Confirmation of rat presence / absence
- Baseline Surveys Completed – non-target species, baseline ecosystem assessment, rat survey and bait palatability
- Partner Coordination for Demonstration and Symposium begun (announcements, agendas, meeting cost estimates)
- Potential participant list completed
- Process for gaining permits and permission to conduct trials on all islands begins
- Consultation with island owners begins
- Detailed planning for eradication demonstration completed using data from baseline surveys
- Logistics for project completed (bait ordered and shipped, supplies and equipment ordered and shipped, housing confirmed, transportation for project leaders confirmed)
- Set up and start trial/demonstration on ≥ 3 islands
- Radio collaring of rats occurs
- Indicator block monitoring occurs
- Pre-trapping occurs
- Bait application rate calibration occurs
- Bait dispersal occurs
- Determining fate of radio-collared rats occurs
- Post-trapping, indicator block monitoring begins
- Long-term monitoring plan is designed and implemented
- Ahnd Atoll site initial surveys occurs
- Process for securing a helicopter and trained pilot begins
- Symposium site visit occurs
- Symposium meeting occurs

Output 2: Ahnd Atoll Eradication

- Partner coordination for Ahnd Atoll eradication completed
- Process for gaining permits and permission to conduct trials on all islands completed
- Detailed planning for eradication completed using data from trial eradication and baseline surveys of Ahnd Atoll
- Education of the greater Pohnpei community on the Ahnd Atoll rat eradication project begins
- Process for securing a helicopter and trained pilot completed
- Logistics for base operations completed (bait ordered and shipped, supplies and equipment ordered and shipped, housing confirmed, transportation for project leaders confirmed)
- Eradication team assembled and organized
- Pre-implementation site monitoring conducted
- Bait is broadcast on Ahnd Atoll

- Post-implementation monitoring begins and continues bi-monthly for four years.

Activities

Trial Eradication

A key component of the rat eradication process is to conduct small scale trials to confirm that the broadcast techniques are appropriate and will succeed in eradicating rats yet not have a major negative impact on non-target species – both efficacy and risks will be evaluated using monitoring techniques. This further aids in the development of a successful eradication plan for Ahnd Atoll as it identifies potential problem areas that can be rectified prior to implementing the final phase. See **Appendix 2** for a brief discussion of the trial eradication.

Demonstration Eradication / Skills Building

We expect at least six conservation practitioners from within the Micronesia-Polynesia hotspot to conduct the demonstration project with us -- i.e. practitioners who would like to learn the techniques for their own eradication projects, this would be a three week commitment, including travel and 10 days on the ground.

Conservation Symposium in Pohnpei on Invasive Animal Eradications on Islands

As the eradication trial/demonstration project comes to a close, we will invite senior level conservation managers with policy / decision making authority in government agencies, NGOs, regional groups to participate in a symposium in Pohnpei. We expect 12 people from Micronesia and the wider Pacific region to participate in a 1-2 day seminar and demonstration site visit.

Ahnd Atoll Rat Eradication – Planning

Conservation Society of Pohnpei and Island Conservation will partner in the detailed planning of the Ahnd Atoll rat eradication including acquisition of needed equipment and supplies, pre-eradication monitoring, and eradication timing.

Ahnd Atoll Rat Eradication – Public Education Campaign

Conservation Society of Pohnpei launches a public awareness and education campaign to inform the general public about the goals, risks and risk mitigation, and benefits tied to eradicating rats from islands, and specifically eradicating rats from Ahnd Atoll. Special attention will be given to the risk of reintroduction and simple measures that can be taken to prevent transporting rats to rat-free islands.

Ahnd Atoll Rat eradication – Implementation

The Ahnd Atoll rat eradication will draw from the methodologies tested and knowledge gained during the trial eradication, and will add the practice and demonstration of helicopter based aerial bait delivery. Island Conservation will work closely with the Conservation Society of Pohnpei to stage and conduct the eradication

Post bait delivery monitoring and introduction prevention

This phase of the project will confirm the success of the eradication and the associated changes that may be detected in the environment. The efforts will be focused on searching for rats using at least three indicators – trapping, monitoring radio collared rats and wax chew blocks (rats leave incisor impression on blocks). Trap lines will be established in habitats that rats were detected in high density prior to the eradication. The introduction prevention program will be implemented in cooperation with the local caretakers, landowners, and visitors to the island.

The greater community of Pohnpei will be engaged in both the trial eradication and Ahnd Atoll eradication through hiring local people, working with the regulatory agencies and community leaders, conducting site visits, training conservation practitioners in eradication techniques and demonstrating impact of rats and benefits of eradication.

Risk and Risk Management

Table 3: Primary risks associated with the proposed Ahnd Atoll rat eradication project

#	Cause of Risk	Type of Risk	Effect on Project	Likelihood	Severity	Risk Management Strategy	Responsibility
1	Environmental Risk	Health and Biological	Detract from net, positive ecological gain of removing an invasive species	2	2	Identification of and mitigation for human health risks due to the unlikely exposure to toxicant, and mitigation of non-target species at risk from toxins used during the eradication effort.	Island Conservation.
2	Reinvasion by rats	Biological	Negate positive results from a Successful Eradication	2	5	Mitigated through education and sustained monitoring of Ahnd Atoll's terrestrial system	Conservation Society of Pohnpei
3	Logistical /	Operational	Delay	2-3	2-5	Mitigated by	Island

	Technical Failure		Project, Failure to remove all rats from Ahnd			working with experienced island invasive mammal eradication group	Conservation
4	Failure to obtain permission to run eradication	Regulatory	Delay Project	2	4	Mitigated by following proper regulatory pathways and full disclosure of project objectives and actions to involved land owners and regulating entities	Conservation Society of Pohnpei

Likelihood – Almost Certain: 5, Likely: 4, Possible: 3, Unlikely: 2, Rare: 1
Severity – Severe: 5, Major: 4, Moderate: 3, Minor: 2, Negligible: 1

Varied forms of risk are inherent to large scale ecological restoration projects; eradication rats from Ahnd Atoll will not be an exception to this rule. **Table 3** identifies major risks that could interfere with the successful implementation of Ahnd Atoll rat eradication, and the text after the table discusses several of the risks in greater detail.

Mitigation Needs

Human Health

The risk of human exposure to rodenticide is of concern and needs to be mitigated through a combination of eliminating the risk, education and awareness, and prohibiting harvesting of key species immediately after the eradication and for a short period of time afterwards.

Pigs, chickens and land crabs are harvested from Ahnd Atoll by the land owners (Nanpei family) and visitors. To mitigate the risk of human exposure to toxicant via consumption of non-target animals, the **non-native animals (pigs, chickens, cats, and dogs) will be removed from the atoll as part of the rat eradication process.** The Conservation Society of Pohnpei and Island Conservation will work with the Nanpei family to publicly announce and strictly enforce a no-tolerance policy on harvesting land-crabs until consistent monitoring shows that land crab brodifacoum residues are below detectable limits. Island Conservation research on Palmyra Atoll found land crabs in the genus *Cardisoma* contained less than 8 ppb brodifacoum 21 days after baiting. The same strategy will be used to stop non-target animal consumption from islands baited during the trial eradication. CSP will work with the land owners and local government to

establish who has the Authority to enforce said restrictions on harvesting food from the trial islands and Ahnd Atoll after implementation.

Water collection

The source of drinking and fresh wash water on the islands is collected rainwater. All water used on the island is collected from surface runoff during rainfall events. There is very low risk of human exposure to the rodenticide with basic precautions and protection from exposure. The small fisherman and copra plantation buildings use the rooftops to divert rainfall into large storage containers and are an important source of fresh water not otherwise readily available on the Atoll.

The risk of rodenticide entering into and contaminating the water supply is very low. The solubility of brodifacoum is very low, and will not enter into solution, unless attached to organic matter. There is no likelihood that brodifacoum of any measurable concentration or biological significance will enter into the water supply with very basic precautions:

- Protect the roofs from bait pellets by tarping the roofs of buildings used for water collection when bait is broadcast.
- Divert the runoff from the roof away from the cisterns onto the ground for 1 to 2 significant rainfall events.

Furthermore, Ahnd Atoll does not have any permanent residences. Approximately 15 temporary structures (sleeping platforms and cooking shelters) and 10 aboveground rainwater cisterns are spread throughout the atoll. Visitors (Ahnd Atoll does not have any permanent residents) to the atoll use the rainwater catchment for bathing and probably drinking. Prior to baiting, action will be taken to eliminate the probability of contaminating the water sources (including water catchment roofs) with bait: cisterns will be drained, sealed, or removed; roofs will be tarped before, and/or swept directly after baiting. The methods for preventing brodifacoum contamination of potable water during the Ahnd Atoll eradication will be applied to the trial eradication. Though, Only one of the three islands – Joy Island - identified as potential sites for the trial eradication (**Appendix 3**) has a rainwater catchment.

Non-target species

Pigs and Dogs

The pigs and Dogs on the Atoll are feral and are clearly having a negative impact on the flora and fauna of the island. Individual pigs, and possibly dogs, are periodically harvested and consumed by the owners of the island, the Nanpei family. Pigs are omnivorous and have an aggressive foraging strategy (turning over soil and destroying plants and consuming animals) that makes it a challenge to deliver bait to the rats without making it available to pigs. Pigs are known to have destroyed bait stations intended for rats in Hawaii (W. Pitt, pers. comm.) and pigs have been documented to forage on

aerially broadcast bait pellets intended for rats. Thus, the presence of pigs on the Atoll during any baiting campaign presents a risk of human exposure to the rodenticide. It is highly likely that some pigs would die from the rodenticide exposure, but some will likely survive and carry rodenticide in their tissues, primarily, in the liver where the highest concentration is typically found.

Dogs are carnivorous and are at high risk of secondary exposure to the rodenticide from feeding on poisoned rats and possibly pigs or other species. Dogs are highly sensitive to the rodenticides, and would likely not survive an eradication attempt, succumbing to secondary exposure to the rodenticide.

To prevent the risk of exposure to humans, pigs and dogs should be removed from the island prior to implementation of the rat eradication program. There are many benefits to removing dogs and pigs from the Atoll ecosystem, including increased recruitment and survivorship of plants and animals such as crabs, birds and green sea turtle eggs and hatchlings.

Jungle Fowl

Chickens are feral on the Atoll, actively foraging on the ground, consuming invertebrates, grains and fallen fruits. They are at a high risk of consuming any bait pellets they encounter on the forest floor. The exposure to the rodenticide will likely eliminate the majority if not eradicate chickens on the Atoll. However, there is the possibility that some individuals may survive the eradication attempt and repopulate the island. Two options for protection of people are to eradicate the chickens prior to the broadcast of bait, or to attempt to eliminate the chickens with the broadcast application of the bait. If eradication of chickens is not successful, as a precaution, the hunting of chickens for food consumption should be prohibited for one year to prevent the consumption of contaminated chickens. No organs, especially the liver should be consumed.

Land crabs

Land crabs of Ahnd Atoll are an important part of the diet of local fisherman and island visitors. The coconut crab population is skewed toward smaller, younger crabs indicating that there is pressure on the older, adult crabs, probably hunting pressure by humans. Land crabs will be attracted to and consume the bait that is presented to rats. However, the crabs will not be affected by the rodenticide. Land crabs consume the bait, digest it and pass the inert ingredients and the majority of the rodenticide. The rodenticide will not accumulate in the hepatopancreas or claw of the crabs (Buckelew *et al.* 2005). On Palmyra Atoll, 3 weeks after the hand broadcast application of a 25 ppm brodifacoum bait, land crab tissue residues hovered around the 8 to 12 ppb range, supporting that crabs do not accumulate rodenticide in their tissues. It is unclear how long after the broadcast that land crab residue data will be reduced further or eliminated. Further research is underway to assess the 56-day post broadcast brodifacoum residue level from land crabs on Palmyra Atoll and that data could be used to support the decision process.

As a precaution, the harvesting of land crabs should be prohibited until the residue levels fall below food tolerance limits set by a recognized regulatory agency.

Native Species

Mammals

Pteropus fruit bats are the only native mammal on the Atoll. *Pteropus* bats are considered frugivores, but in addition to fruit, consume flowers and leaf material from various trees (Bahnack 1998). Consumption of fruits by *Pteropus* bats involves the squeezing of juices out of the fruit against the palate and ejecting the pulp of the fruit in the form of a pellet. Bahnack (1998) notes that the seeds of the fruits are not consumed, and are ejected with the pulp. The bait used in the eradication will be a hard, compressed grain pellet that will not likely be attractive to the bats. Even if the bats were to inadvertently take pellets into their mouth, the dry, hard pellet could not be compressed against the palate and would likely be immediately rejected. Further, bats forage in the forest canopy where bait would be available in low density, and would not be available to bats where they forage near the outer edges of the crown of the tree where the majority of fruits develop. The bait pellets would be not available or of interest to *Pteropus* fruit bats.

Birds

There are six native species of birds found on Ahnd Atoll, none of which are endemic to Ahnd Atoll. Only one species, the abundant and ubiquitous Micronesian Starling, is at a high risk of exposure to the rodenticide (**Table 3**). The Micronesian Pigeon is believed to be at low to moderate risk of exposure to the rodenticide, primarily because of their diet. The diet of members of the genus *Ducula* indicate they are primarily frugivores, but do supplement their diet with grains, flowers, and insects (Blanvillain and Thorsen 2003; McConkey et al. 2004). We observed only three individual Micronesian Pigeons on Ahnd Atoll, but routinely heard the birds cooing from high up in the canopy, and never on the forest floor or under the canopy. Our observations are consistent with the literature indicating the species of the genus *Ducula* forage primarily in the forest canopy (Shanahan and Compton 2001; Green et al. 2002) strongly suggesting that, despite their diet, the Micronesian Pigeon would be at a low risk of exposure to the rodenticide.

Table 4. Landbird species of Ahnd Atoll, and their risk of exposure to the rodenticide

Species	Foraging Strategy/Diet	Risk of Exposure to the Rodenticide	Rationale	Mitigation Needed
Micronesian Pigeon <i>Ducula oceanica</i>	Frugivore/Granivore	Low to Medium	Diet/Forages primarily in the canopy	None
Micronesian Starling <i>Aplonis opaca</i>	Omnivorous diet	High	Diet/ behavior	Recolonization
Pohnpei Lory <i>Trichoglossus rubiginosus</i>	Nectarivore	Low	Forages primarily in forest canopy	None
Caroline Is. Reed Warbler <i>Acrocephalus syrinx</i>	Insectivore	Low	Diet and forages in shrub and canopy layer	None
Micronesian Kingfisher <i>Halcyon cinnamomina</i>	Carnivore/Insectivore	Medium	Diet	Recolonization
Micronesian Honeyeater <i>Myzomela rubratra</i>	Nectarivore	Low	Diet, Forages in shrub and canopy layer	None

The Micronesian Starling is at the greatest risk of exposure to the rodenticide on the Atoll. It is the most abundant land bird on the Atoll, considered a very common resident by Buden (1996), and is found in almost all habitats from coastal fringe and deep forest, forest floor to high in the canopy. Starlings are not endemic to the Atoll, and are abundant and ubiquitous on nearby Pohnpei. On several occasions we observed this bird flying to or from the ground and interfering with our rat indicator stations on Ahnd Atoll in May 2006. Their diet includes seeds and plant parts as well as insects. Further they appear to be extremely curious, routinely following people as they walk through the forest and investigating any materials left on the ground. Because of their diet and curious nature, the Micronesian Starling is at a greater risk than any other bird on the Atoll of non-target effects from a rodenticide application effort. It is difficult to quantify the risk to the local population, but we tentatively suggest that the vast majority of the population is at risk from rodenticide exposure.

The Pohnpei Lory (uncommon and presumed resident) and Micronesian Honeyeater (very common and presumed resident) (Buden 1996) are strict nectarivores, feeding in

flowers of trees in the forest understory and upper canopy. Thus, the Pohnpei Lory and Micronesian Honeyeaters are at low risk of being exposed to the rodenticide and will require no mitigation, with a high probability of surviving through any bait application on the Atoll.

The Caroline Islands Reed Warbler (a common resident) (Buden 1996) can be found throughout the Atoll in the forest and coastal scrub. Warblers are typically insectivorous, foraging on insects found in the shrub layer. We observed the CI Reed Warblers feeding on flying and crawling insects in the forest understory, never observing it to feed on the forest floor. Resident insectivorous Golden Crowned warblers and Bewick's Wrens survived the aerial application of brodifacoum in California and were breeding successfully within 6 months (Howald et al. 2005). Thus, we believe that the CI Reed Warbler is at a low risk of exposure to the rodenticide and no mitigation action is necessary.

The Micronesian Kingfisher, a fairly common and presumed resident (Buden 1996) was previously believed not to breed on the Atoll. We confirmed a nesting pair on Panshanki in the hollowed out core of a termite mound against a coconut palm in May 2006. This bird has a carnivorous and insectivorous diet including fish and reptiles, and likely would opportunistically take small rodents, especially during the latent period when poisoned rats will be slowing down making for easy prey. Therefore, kingfishers are at a moderate risk of secondary exposure to the rodenticide. Kingfishers are common on Pohnpei and would likely recolonize Ahnd Atoll. If need be, kingfishers could be translocated to the island after the eradication.

Preventing Reintroduction

A key component to the eradication is the development of a plan to prevent the re-introduction of rats, or other non native species. The effort and conservation gains made from the eradication could be negated with the re-introduction of rodents or other non-native species. Invasive species, including vertebrates, invertebrates, weeds and pathogens can all be transported to the island inadvertently and have detrimental impact on breeding seabirds. The rodent re-introduction prevention program will be one component of a comprehensive program designed to prevent many non-native species from being introduced onto the island.

Preventing non-native species from reaching the islands requires that the potential introduction pathways be closed, or the risk via those pathways be reduced. Reducing the risk of introductions to Ahnd Atoll will require a multi-faceted approach including:

- controlling invasive species at departure points,
- implementing specific guidelines for boats and fisherman,
- educating the general public about reinvasion prevention measures, and

- prohibiting certain high risk activities and materials destined for the islands that could carry invasive species to the islands.

The prevention plan should be incorporated into a larger management strategy for non-native species. An effective management strategy should include plans for:

1. Preventing introductions
2. Early detection, responding, and eradicating if feasible,
3. Controlling if not feasible to eradicate,
4. Continuous, ongoing monitoring to evaluate progress towards goals or make necessary adjustments, and
5. Education for all stakeholders.

The successful implementation of this plan, and overall management strategy, will be dependent on a strong policy and compliance by all stakeholders including the Nanpei family, cooperators, contractors and all visitors.

Project Implementation

The existing CSP management structure will be used for this project and all work will be based entirely within Pohnpei State in the FSM. No Australian-based offices will be used for the project. All project administration and management will be from existing staff with technical and expert guidance from Island Conservation. All work will be overseen by the Terrestrial Division manager Mr. Wendolin Marquez with input from the Executive Director Mr. Patterson K. Shed in close expert consultation with Gregg Howald from Island Conservation on all technical implementation. Existing administrative and office staff will handle fiscal paperwork.

In-Country Government Cooperation and/or Involvement in Project Delivery:

1. Pohnpei State Department of Land and Natural Resources. Supporter of the Ahnd Biosphere Reserve application.
2. Pohnpei State Department of Marine Development. Responsible for marine fisheries and concerned about reef and fishery deterioration.
3. Pohnpei State Environmental Protection Agency. Responsible for drinking and inshore water quality. Supporter of a reduction in organic pollution from poorly placed pig pens and outhouses with mandate to authorize, issue, and oversee permitting process. EPA also provide funding support to our Innovative and interactive Green Road Show within our Education Program
4. Secretariat of the Pacific Community, Plant Protection Micronesia Unit who will provide support and training for the invasive species eradication program.
5. Pohnpei Resource Management Committee, which comprises all state, sponsored, NGO and traditional leadership resource management personnel.

6. Pohnpei state municipal governments (5 in total) who are responsible for policing and enforcing designated Pohnpei State Marine Protected Areas (MPA) and reserves in each municipality jurisdictions.
7. FSM National Government department of biodiversity conservation under the Department of Economic Affairs.
8. Pohnpei State department of education who will assist with the education and awareness program.
9. The Nature Conservancy who will provide technical support where necessary.
10. Island Conservation who will provide technical consultation and implementation of the project

Sustainability

CSP, assisted as needed by the primary stakeholders, will initiate a multi-faceted invasive species program that will:

- Develop and instigate a plan to measure ecosystem response to invasive species removal at Ahnd Atoll. This monitoring plan will be applied to subsequent eradications in the region
- Facilitate the sharing of knowledge gained during the trial eradication and the Ahnd Atoll eradication with conservation practitioners throughout the Pacific
- Start a local and regional education campaign to increase awareness of the ecological and socio-economic costs associated with island invasives, and the benefits of eradication programs
- Work with local and regional government entities to facilitate subsequent eradication efforts

Community Participation

As proposed above, the project will serve as a demonstration for other islands in the FSM and the wider Pacific. The project will include eradication training for at least one person from each of the four FSM states, and a meeting to discuss general vertebrate eradication in the FSM and the funding opportunities from MCT for such work.

With island communities in particular so highly dependent on biological resources for survival, protecting against invasive species is critical not only for the maintenance of essential ecosystem function, but also for sustaining human livelihoods. Furthermore, while only 0.1 percent of the hotspot is land, islands are extremely important for not only

sustaining terrestrial biodiversity but also providing critical breeding and resting habitat for seabirds, cetaceans, and sea turtles.

Over the past seven years CSP has implemented some of the most innovative and effective environmental education and awareness programs in FSM. These include the Green-Road Show, the Youth-to-Youth in Environmental Education Program, the Pohnpei Youth Club and the Community Outreach and Project Implementation Program. Building on these successful programs, CSP and its local partners will develop an education and public outreach program to increase awareness on the rat eradication and general invasive alien species work around the island of Pohnpei. Again, the education and outreach program that is developed to complement this project will be used as a demonstration for other islands in the FSM and the region.

Training

During the trial rat eradication and the actual Ahnd Atoll rat eradication the Island Conservation eradication team lead by Gregg Howald (Rat Eradication Expert) and Alex Wegmann (Tropical Ecosystem Specialist) will train Conservation Society of Pohnpei personnel and attending regional conservation representatives on pre and post eradication ecosystem monitoring, bait selection, bait delivery methodologies, non-target species mitigation, and reinvasion prevention. The Island Conservation team will also include Conservation Society of Pohnpei personnel in the detailed eradication planning process so as to transfer knowledge on all aspects of running a successful invasive species eradication project.

Project management

CSP will manage both the trial eradication and invasive species symposium, and the Ahnd Atoll eradication. IC will assume responsibility for transferring eradication knowledge to CSP and regional conservation partners, and will serve as the principle advisor during trial eradication and the Ahnd Atoll eradication. IC will supervise the report writing for both the trial eradication and the Ahnd Atoll eradication. IC will also serve as the principal advisor during post-eradication monitoring and development of the regional invasive species program. CSP will be responsible for resolving conflicts during the planning, implementation, and post eradication monitoring and regional capacity building phases of this project

Timeframe

We conservatively estimate that the project will take approximately 4 years to complete. The first year will be dedicated to planning and conducting necessary pre-eradication research and trial eradication. The remaining three years will focus on planning the eradication based on knowledge gained during the trial eradication, implementing the eradication on Ahnd Atoll, and conducting post-baiting monitoring such as ensuring that the rats have been removed, and the environmental effects are as predicted. If no rats are detected, after an extensive, systematic survey, at two years post bait application, the island can be declared rat free. A detailed project timeline is presented in **Table 5**.

Table 5: Ahnd Atoll eradication project timeline

Date	Activity	Participants
May 2006	Ahnd Atoll site visit and feasibility assessment, partnership building, and initial stages of project planning	CSP, IC
June-August 2006	Ahnd Atoll Project Design Document drafting and submission	CSP, IC, PII
September-January 2006	Detailed planning for the trial rat eradication, eradication skills demonstration workshop, and conservation symposium in Pohnpei on invasive animal eradications on islands	CSP, IC
January-February 2007	Implementation of the trial eradication, eradication skills workshop, and invasive animal eradications symposium	CSP, IC, PII, TNC, RARE, MIC, PILN, MCT, Pohnpei State Gov., Local Land Owners.
March 2007-February 2008	Detailed planning for Ahnd Atoll rat eradication	CSP, IC
February – June 2008	Implementation of Ahnd Atoll rat eradication (precise timing subject to specified parameters of rat and non-target species demographics – see Context/Timing The Eradication section for explanation).	CSP, IC
2008-2012	Post-baiting monitoring	CSP, IC

Monitoring and Evaluation

While Conservation Society of Pohnpei personnel will be responsible for monitoring and evaluating the Ahnd Atoll rat eradication project in its entirety, the Island Conservation team will provide support on biological, operational, and logistical matters. Refer to **Appendix 3** for a detailed description of information gathered during this project will be collected, analyzed, and reported.

Estimated Expenditure

The proposed project contains two discernable segments: 1) the trial rat eradication which includes the demonstration eradication and invasive species symposium, and 2) the Ahnd

Atoll rat eradication. A general breakdown of the estimated costs (\$NZ) for segment 1 are presented in **Table 6**.

Table 6: Estimated expenditures for the trial eradication, eradication demonstration, and invasive species symposium components of the Ahnd Atoll eradication project

Detailed Planning and Baseline Surveys	\$27,500
Trial Eradication	\$103,000
Eradication Demonstration	\$28,500
Invasive Species Symposium	\$44,500
Total Cost	\$203,500

The budget for the Ahnd Atoll eradication segment will be based on the actual expense of the trial eradication and thus an estimated expenditure for this segment is not currently available.

Glossary

Activities are the number of different activities that contribute to achievement of outputs. They describe what is done with the resources available, such as people, money, equipment, technology.

Baseline data are facts and figures collected at the initial stages of a project and providing a basis for measuring progress in achieving project goal, objectives and outputs.

Communities are the men, women and youth with an interest in the area where a Demonstration Project are being implemented.

Goal is a single statement of the overall long term aim of the project. Key characteristics of a project goal are that; it provides a reason for the project, there is only one goal, it is reasonably focused and achievable.

Implementing agency is the organization with the main responsibility in the Demonstration Project.

Indicator is something that can be measured or clearly described that provides a simple and reliable basis for assessing achievement, change or performance. A unit of information measured over time that can help show changes in a specific condition. A goal or objective can have multiple indicators.

Objectives are the specific results expected from the project by its completion. There may be a number but if there are too many the project becomes very complex and difficult to implement. One way to distinguish an objective from an output or activity is to think of it as usually indicating some distinct change. Words like improve, reduce, develop are often found in objective statements.

Outputs are the identifiable results of project activities. There may be one or more for each objective, they denote actions that should have occurred by the end of the project, and often are what you can see (e.g. wells dug, a schoolroom built, a small business established). But this is not always the case, for example in a project involving training, outputs may be the number of men and women trained but could also be the skills learned.

Risks and Constraints are **1)** negative external factors, i.e. events, conditions or decisions, which are expected to seriously delay or prevent the achievement of the project objectives and outputs (and which are normally largely or completely beyond the control of the project management) and **2)** internal risks and constraints that the project seeks to manage through various activities in the design (e.g. training, management systems, monitoring, etc.).

Risk Management refers to the measures to be put in place to manage the risks.

Stakeholders are the individuals, groups, agencies or organizations that have a direct or indirect interest in the project, or that affect or are affected, positively or negatively, by the implementation of it.

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Appendix 1: General Project Design Components

	Summary	Indicators of change	How change is measured
Goal	Restore natural function to and ensure biosecurity of Ahnd Atoll's terrestrial biota through rat eradication	Restoration or enrichment of native ecosystem components: avifauna, mammals, invertebrates, plants	Comparison between baseline and post-eradication Ahnd Atoll ecosystem monitoring data
Objective	<ol style="list-style-type: none"> 1. Protect biodiversity of Ahnd Atoll 2. Develop rat eradication techniques that are transferable to regional invasive species programs 3. Build capacity of regional conservation practitioners 4. Strengthen key regional conservation networks 5. Raise awareness among key government decision makers of success and feasibility of invasive species eradications from islands 	<ol style="list-style-type: none"> 1. Positive ecosystem response to rat removal 2. Subsequent successful regional invasive species eradication campaigns 3. Increased regional conservation activity 4. Same as 3. 5. Progressive ease of regulatory hurdles and increase in government support for subsequent eradications 	<ol style="list-style-type: none"> 1. See above 2. Recognition of subsequent regional eradication projects 3. Recognition of subsequent regional conservation activity 4. Increased initiative and collaboration by regional conservation entities 5. Greater government facilitation of subsequent invasive species projects
Output 1	TRIAL RAT ERADICATION ON ISLANDS ADJACENT TO POHNPEI		
Activity 1.1	Detailed planning for trial eradication	High level of preparedness for trial eradication	Successful implementation of eradication project
Activity 1.2	Trial rat eradication	Repeated failure to detect <i>Rattus</i> sp. on islands after bait delivery	Trap lines, chew-blocks, and natural indicators are monitored regularly for rat activity
Activity 1.3	Demonstration Eradication / Skills Building	Transfer of eradication knowledge from Island Conservation to local and regional conservation groups	Local and regional capacity to lead subsequent invasive species eradications increases
Activity 1.4	Conservation Symposium on Invasive Animal Eradications on Islands	Representative attendance by representatives from local and regional conservation groups	Enhanced local and regional conservation activity and cooperation between attending groups
Output 2	AHND ATOLL RAT ERADICATION		
Activity 2.1	Detailed planning for Ahnd Atoll rat eradication	Application of knowledge gained during the trial eradication, high level of preparedness for the eradication	Successful implementation of Ahnd Atoll rat eradication project
Activity 2.2	Public education campaign on Ahnd Atoll rat eradication	Recognition by the general public of the small human health risk and large ecological and socioeconomic benefit of invasive species eradication programs.	Uniform local support of this and subsequent invasive species eradication projects.
Activity 2.3	Ahnd Atoll rat eradication	Repeated failure to detect <i>Rattus</i> sp. on Ahnd Atoll after bait delivery	Trap lines, chew-blocks, and natural indicators are monitored regularly for rat activity
Activity 2.4	Post bait delivery monitoring and reintroduction prevention	Consistent, accurate monitoring of Ahnd Atoll's terrestrial biota and prevention of a <i>Rattus</i> reinvasion through public outreach and expeditious response to post-eradication rat presence on the atoll	Continued and consistent post-eradication monitoring of Ahnd Atoll's terrestrial ecosystem coupled with a continued public awareness campaign about reinvasion prevention

Appendix 2: Trial Eradication Summary

Based on an initial survey and assessment conducted in a recent feasibility study conducted by Island Conservation expert Gregg Howald, we identified several near shore islands South East of Pohnpei -off the coast of Madolenihmw and less than a mile boat ride from the Nan Madol Ruins (refer to Pohnpei Map above) on which a trial rat eradication can be performed. These islands will allow the eradication team an opportunity to field test and perfect methods of delivery, implementation, and monitoring while working within the limits of the resources available. The removal of rats from small islands near Pohnpei will serve as a test for the larger Ahnd Atoll eradication project. The trials and the eradication of rats from Ahnd Atoll together will serve to demonstrate to the regional communities and regulatory agencies that restoration of habitat through rat eradication is an achievable goal. Using a cooperative approach, we will train local conservation practitioners in the strategies, planning, and techniques that are necessary to successfully implement a rat eradication.

Potential Trial Eradication Islands

Several small islands within Pohnpei's protective barrier reef offer an excellent opportunity to trial and demonstrate the eradication methods intended for the Ahnd Atoll eradication while creating rat-free habitat for numerous forestbird, seabird, and shorebird species. On 11 May, we surveyed Joy Island, Small Island, and West Island as potential trial eradication sites; details for each island are listed below:

Joy Island

- Area: 1 ha
- Distance from Pohnpei: 0.5 km
- Distance to nearest land (Small Island): 200 m – shallow water
- Rats: None observed, but local knowledge assures rat presence
- Cats, Dogs, Pigs: Cat tracks on the beach
- Human habitation: No permanent residents; small-scale guest facility is in early stages of development
- Non-target species observed: Several forestbirds observed: Micronesian honeyeater, Micronesian Lori
- Vegetation: Coconut Palm dominated forest (50-100 trees) with interspersed Breadfruit, Papaya, Banana, Terminalia, and Noni trees; approximately 500 m² of Mangrove forest on the northeast shoreline
- Land Crabs: no crabs observed; evidence of coconut crabs

Small Island

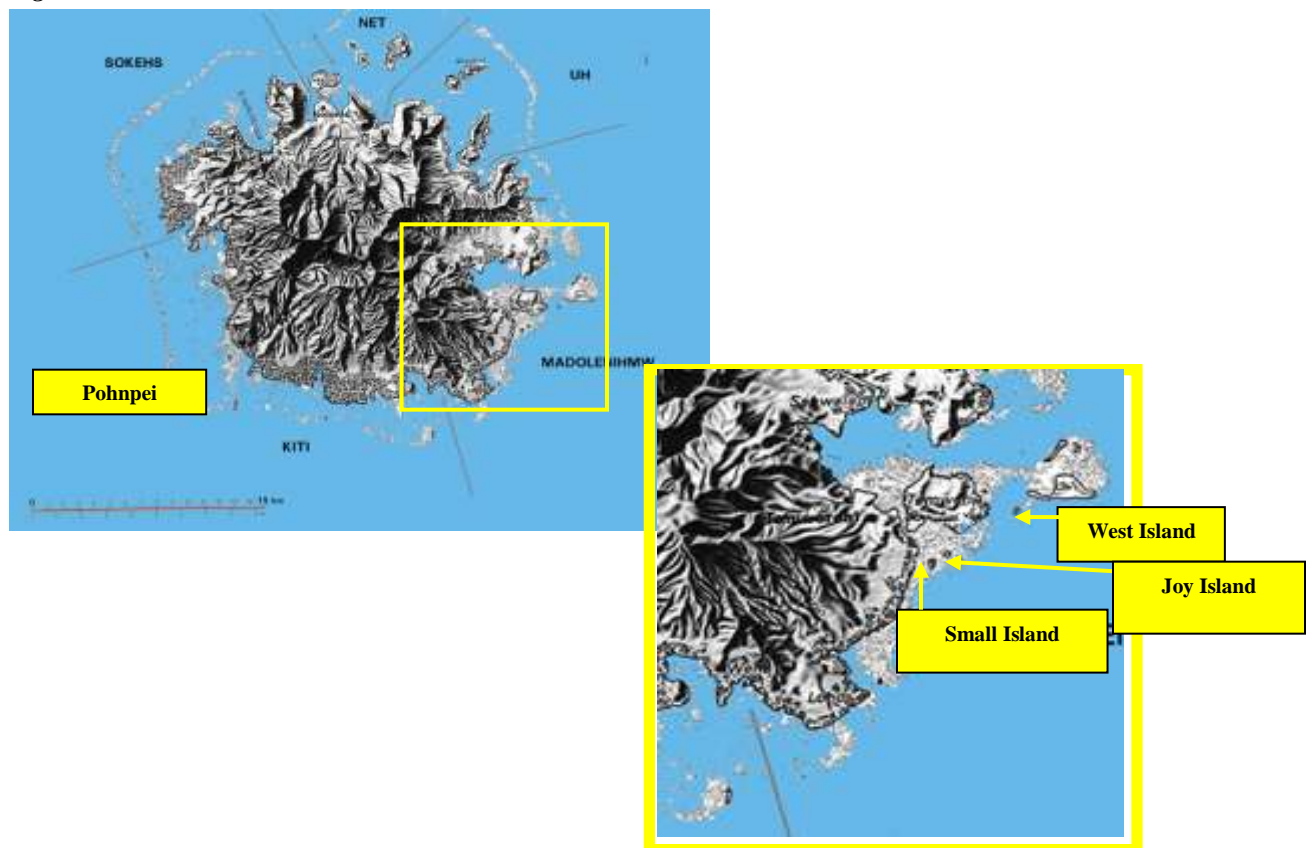
- Area: 1.2 ha
- Distance from Pohnpei: 0.5 km
- Distance to nearest land (Joy Island): 200 m – shallow water
- Rats: *Rattus rattus* observed
- Cats, Dogs, Pigs: None observed

- Human habitation: No permanent residents; a family was temporarily camped on the island at the time of our survey
- Non-target species observed: Several forestbirds observed – Micronesian Lori, Micronesian Kingfisher, Micronesian Honeyeater, Brown Noddy, Reef Heron.
- Vegetation: Coconut Palm dominated forest (150-200 trees) with interspersed Breadfruit, Pandanus, and Terminalia catappa; 2/3 of island surrounded by a 20 m wide Mangrove swath.
- Land Crabs: *Geocardoidea* burrows and *Coenobita* observed

West Island

- Area: 1 ha
- Distance from Pohnpei: 0.5 km
- Distance from nearest land (Na Island): 250 m – deep water
- Rats: *Rattus* sign observed
- Cats, Dogs, Pigs: None observed
- Human habitation: No permanent residents; evidence of recent copra harvesting
- Non-target species observed: Micronesian Honeyeater
- Vegetation: Coconut Palm dominated forest (100 trees) with interspersed Hernandia, Breadfruit, and Terminalia trees.
- Land Crabs: *Geocardoidea* and *Coenobita* observed

Figure 3: Potential Trial Eradication Sites



Appendix 3: Monitoring and Evaluation Plan

Project Considerations	Indicators	Baseline Situation	Data Needed	Method of Collecting Data	Timing	Responsibility	Data Storage and analysis
1. Biological parameters	Native and introduced species presence and status at eradication site	Two species of <i>Rattus</i> present; Native species (avifauna, mammals, invertebrates, reptiles, plants) present but compromised by introduced rats	Population index for each native and non-native species present at the eradication site	Ecological assessment of terrestrial ecosystem including abundance, distribution and basic life history information gathered for the following communities: avifauna, mammals, invertebrates, reptiles, plants) present but compromised by introduced rats	Ecological assessment will occur tangentially with the trial rat eradication in Jan-Feb 2006, and again just prior to the Ahnd Atoll rat eradication in 2008	CSP and Island Conservation will perform the ecological assessments	CSP & IC, both paper and electronic copies archived by project leaders
2. Socio-economic benefits	Estimated health and economic risk due to presence of introduced species (rats)	Current rat infestation on islands adjacent to Pohnpei and Ahnd Atoll does not pose a serious health risk. Loss of economic potential from ecotourism due to rat related degradation of natural environment.	Documentation of health risk pathogens hosted by rats on Pohnpei, estimate of potential economic loss through rat related damage to native species and crops	Consult with regional health experts about rat born disease on Pohnpei. Consult with USDA and regional tourism board about potential economic gain resulting from rat eradication projects	During the detailed planning process for the Ahnd Atoll rat eradication	CSP	CSP, both paper and electronic copies archived by project leaders
3. Community awareness	Public recognition and understanding of rat eradication goals, objectives, and risk	Little to no local knowledge of rat eradications.	Survey for pre and post eradication understanding of rat eradication goals, objectives, and risks	Survey members of local community	Before and after trial rat eradication, and before and after Ahnd Atoll rat eradication	CSP	Same as above
4. Implementing Agency awareness	Internal understanding of rat eradication goals, objectives, and risks	Understanding varies between participating organizations, and individuals within the organizations	Survey for pre and post eradication understanding of rat eradication goals, objectives, and risks	Survey personnel within participating agencies	Before and after trial rat eradication, and before and after Ahnd Atoll rat eradication	CSP	Same as above
5. Community capacity	Ability to execute eradications that are well received understood and supported by the local community	Little to no practical experience with eradications, moderate to strong support for eradications.	Evidence of community support for and participation in eradications	Conducting trial eradication on island adjacent to Pohnpei	January – February 2007	CSP and IC	Same as above
6. Implementing Agency capacity	Ability to execute eradications that are well received understood and supported by conservation practitioners, and local and regional governing bodies.	Little to moderate practical experience with eradications, strong support for eradications	Evidence of agency support for and participation in eradications	Conducting trial eradication on islands adjacent to Pohnpei	January – February 2007	CSP and IC	Same as above
7. Achievement of project goal and objectives	Successful eradication of rats from trial islands and Ahnd Atoll, community involvement, agency support, transfer of knowledge to regional conservation groups	CSP and IC are planning accordingly	Internal and external review of the Ahnd Atoll eradication project	End of the project evaluation	After the Ahnd Atoll eradication	CSP	Same as above

