Feasibility Assessment for the Removal of Pacific Rats (*Rattus exulans)* from Late Island

Prepared for the
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Late Island, Photo by David Butler

EXECUTIVE SUMMARY

Late is an isolated and uninhabited island located about 55 km WSW of the island of Vava'u, in the Kingdom of Tonga. Late supports a tropical broad-leaf forest ecosystem, one of the most threatened ecosystem types in the world and one of the best remaining tracts of diverse native forest in Tonga. Owing to its relatively unmodified forest communities, Late is also a global stronghold for two IUCN listed species of bird, one native mammal, and six species of reptile.

However, the biological integrity of Late is threatened by invasive Pacific rats that were historically introduced to the island. The direct and indirect impacts of this invasive species include habitat degradation; soil nutrient depletion, loss of floral diversity, seed predation, species extinctions and extirpations, predation of bird eggs, and chicks, and reduced bird, reptile, and invertebrate diversity and abundance. In addition, invasive rats are responsible for altering ecosystem processes such as pollination, seed dispersal, and nutrient flow to islands via seabird guano.

This report assesses the feasibility of restoring Late through the removal of invasive rats, and describes options, recommendations, and challenges to realizing a successful project. We believe the proposed conservation action to be both socially and politically feasible from the consultation completed with project stakeholders. Although invasive species removal will require a significant investment of resources, we conclude that this conservation action is technically feasible using techniques that have been proven around the world, and is likely sustainable with recommended improvements to biosecurity measures. However, any decision to proceed with this project will require further investigation of the challenges identified in this report. The most significant challenges identified are potential non-target species impacts, preventing reinvasion, and the availability of adequate funding. While all three of these issues have the potential to influence the feasibility and operational details of the proposed project, none are deemed insurmountable.

This feasibility study was based on information gathered remotely, consultation with Tongan government agencies, community representatives and researchers familiar with the island. The authors did not visit Late and thus the recommendations presented herein do not reflect direct knowledge of the island. The decision to proceed or not with an invasive rat eradication lies with the land managers and the government of Tonga. It is important that the decision makers fully understand the options and risks associated with those options before making a decision. This document is intended to provide the background to assist in making such a decision. However, it is recommended that additional meetings be held and additional expert opinion solicited before a decision to proceed is made.

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Malo 'aupito

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1. INTRODUCTION

Late Island is a stronghold of native forest diversity in Tonga. The diversity of its plant and animal communities, the absence of human settlement, and the potential to support populations of endangered species, make Late a unique conservation opportunity. The goals of the Ministry of Lands, Environment, Climate Change and Natural Resources (MLECCNR) of the Government of the Kingdom of Tonga for the management of Late Island are to protect and recover the island's endemic flora and fauna. To support this aim, eradication of invasive rats has been proposed.

This assessment evaluates the rationale and feasibility for the removal of rats from Late and recommends strategies that would enhance the likely success and sustainability of such an action. The assessment was conducted by Island Conservation, an international non-profit conservation organization whose mission is preventing extinctions by removing invasive species from islands, at the request of the MLECCNR. Funding for this assessment was provided through the GEF-PAS Invasive Species Project. This feasibility study was based on information sourced from a literature search, consultation with officers of the MLECCNR, other Tongan government agencies, community representatives and researchers familiar with the island.

2. OBJECTIVES

The objectives of this feasibility assessment are:

- To set out and evaluate the costs and benefits of removing invasive rats from Late.
- Assess the feasibility of removing invasive rats from Late and preventing their reintroduction.
- Propose a suitable eradication strategy or strategies for the removal of invasive rats from Late.
- Provide an indicative cost estimate for the planning and implementation of the recommended eradication strategy.

3. THE SITE

Late Island is an isolated and uninhabited island located about 55 km WSW of the island of Vava'u, in the Kingdom of Tonga. The 6-km wide circular island has historically been reported as having an area of 1, 500 ha (e.g. Sykes 1981); however utilizing GPS points collected on island and digital aerial imagery, we recalculate the area to be about 1,731 ha, with a high point of 565 m. The island is characterized by a central crater, with the terrain sloping gradually away to the sea (Sykes 1981). Cliffs rising to approximately 20 m dominate the coastline (Sykes 1981). Late is volcanic in origin, with volcanic activity reported as late as 1854 (Bryan, Stice & Ewart 1972).

The climate of Late is tropical, with a distinct wet and dry season. The nearest measured average annual rainfall is in Vava'u, with a total of 2,147 mm (Tonga Meteorological Service 2006). The wet season occurs between November and April, within which 60-70% of the annual precipitation falls (Tonga Meteorological Service 2013). Tropical cyclones occur during the wet season, with February having the highest frequency of occurrence (Tonga Meteorological Service 2013). The wettest month is typically March, and the driest varying between June, July, and August (Tonga Meteorological Service 2013). Climate information recorded at the Lupepau'u Airport in Vava'u suggests that August has a low mean number of days without measurable precipitation (n=14) combined with the lowest mean total rainfall (100 mm) (Tonga Meteorological Service 2006). Mean annual temperature ranges from 23-28 degrees Celsius, with a mean humidity of 75%. The southeast trade winds predominate year-round, with the strongest wind period occurring May to October; normal wind speed is 12 to 15 knots from east to southeast (Tonga Meteorological Service 2013). Tonga's climate can vary considerably from year to year due to the El Niño-Southern Oscillation (Tonga Meteorological Service 2013).

Late stands out as one of the best and least disturbed tracts of native forest remaining in Tonga. The plant communities of Late include coastal scrub and forest, *Casuarina* forest, broad-leaved forest, and fern dominated understory (Sykes 1981). *Casuarina equisetifolia*, toa, forest is the most widespread and common plant community (Sykes 1981). (Sykes 1981) also reported a relatively intact natural plant community and noted that areas covered by introduced plant species were very limited in extent on Late, with most of the serious weeds of the main Tongan islands being absent. However, (Sykes 1981) did note the presence of three introduced weed species that could potentially pose a threat to the plant communities of Late.

Due in large part to its relatively intact forest communities, Late provides a global stronghold for two species listed by the IUCN , the vulnerable Friendly Ground-dove (*Gallicolumba stairi)* and the near threatened Tongan whistler (*Pachycephala jacquinoti)*. An attempted translocation of the IUCN Endangered Tongan Megapode (Malau) (*Megapodius pritchardii)* was made to Late in 1992. Sixty eggs were buried at volcanically heated sites (Watling 2003). However, the translocation was considered unsuccessful after searches at the translocation site in 2004 and 2013 failed to detect Malau (Watling 2003; Butler 2013). Late is also home to seven central Polynesian Restricted Range Species, as well as eleven species of seabird which are currently believed to breed on the island (Butler 2013).

One native mammal, the Pacific flying-fox (*Pteropus tonganus*), and six species of reptile (*Emoia cyanura*, *Emoia impar*, *Cryptoblepharus boutonii*, *Lipinia noctua*, *Nactus pelagicus*, and *Gehyra oceanica)* have also been documented on Late (Rinke 1991; Butler 2013).

Late is managed by the Kingdom of Tonga's Ministry of Lands, Environment, Climate Change, and Natural Resources and is designated as a protected area. Late is also designated as an Important Bird Area by BirdLife International (BirdLife International 2014). In addition, Late falls within the Critically Endangered South Pacific Island Forests Ecoregion as designated by the World Wildlife Fund.

Historically, human use of the island has been limited and sporadic. During the 1970's and 1980's the island was settled by a small group of people who tried to farm on the island (V. Hakaumotu, MLECCNR personal communication, January 2014). However, there is currently no known human habitation, nor evidence of farming occurring on Late (V. Hakaumotu, MLECCNR, personal communication, January 2014; D. Butler, personal communication, January 2014).

5. THE TARGET SPECIES, IMPACTS AND BENEFITS OF ERADICATION

5.1 Target Species

Several species of rats have been transported around the world by voyaging people. The Pacific rat (*Rattus exulans*) originated in the Indo-Malayan region but became widely distributed throughout the Pacific during the period of Polynesian expansion (Atkinson 1985). Both the Pacific rat and the ship rat (*Rattus rattus)* have historically been reported on Late (Global Invasive Species Database 2011), but recent surveys detected only Pacific rats (Butler 2013) and for the purposes of this feasibility assessment they are assumed to be the only rodent species present. It is unknown when Pacific rats arrived on Late.

Pacific rats are expected to inhabit all areas of Late. Current densities are unknown, but were reported as low by (Butler 2013) who completed a site visit in September 2013. Seasonal patterns of abundance and the reproductive cycle are also unknown for Late. However, experience from other tropical islands suggests that a proportion of the rat population is likely to be breeding at any time of the year and peaks in breeding activity are likely to coincide with periods of increased rainfall. (Butler 2013) conducted two nights of trapping in September 2013. Of the nine rats captured none were found to be in breeding condition, though a juvenile was captured.

Feral pigs and cats have been reported as being present on Late in the past (Douglas 1969 as cited in Sherley 2000). However no other references to pigs or cats were found in the literature and recent surveys found no evidence of either species being present on island (D. Butler, personal communication, January 2014). For the purpose of this feasibility assessment, no other invasive mammal was considered to be present on Late.

5.2 Anticipated Impacts of Rats on Late

Rodents have been introduced to more than 80% of islands worldwide, causing ecosystem-wide impacts (Atkinson 1985; Jones *et al.* 2008; Kurle, Croll & Tershy 2008; Towns *et al.* 2009; Varnham 2010). The most pronounced impact has been the extinction of endemic species; it is estimated that introduced rats (*Rattus* sp.) are responsible for between 40% and 60% of all bird and reptile extinctions (Atkinson 1985; Island Conservation 2010) . Rodents have also caused the extinction of many island endemic mammals and invertebrates (Andrews 1909; Hindwood 1940; Daniel & Williams 1984; Meads, Walker & Elliot 1984; Atkinson 1985; Tomich 1986). Comparisons between islands with and without introduced rodents, and pre and post rat eradication experiments, found that rodents suppress population size, species diversity, and recruitment of birds (Campbell 1991; Thibault 1995; Jouventin, Bried & Micol 2003), reptiles (Whitaker 1973; Bullock 1986; Towns 1991), terrestrial invertebrates (Kurle, Croll & Tershy 2008; Towns *et al.* 2009), plants (Campbell & Atkinson 2002; Graham & Veitch 2002) and are known to cause significant nest failure in breeding seabirds (Tomkins 1985; Jouventin, Bried & Micol 2003; Jones *et al.* 2005).

The effects of Pacific rats on ecosystems of the tropical Pacific remain relatively unstudied. However, in Tongan forests, rats are a known seed predator (McConkey *et al.* 2003). In New Zealand and throughout the Pacific, Pacific rats have been implicated in the decline and local extinction of numerous forest trees and shrubs, palm and climber; species of invertebrates, frogs, reptiles; seabirds and forest birds (D.R. Towns, unpub. data as cited in Brooke & Towns 2008; Meyer & Butaud 2009). Based on the evidence of the effects of Pacific rats in New Zealand and on other islands of the Pacific, it is likely that on Late, Pacific rats have and continue to influence the plant community, and are likely having significant impacts on invertebrates and the reptile species found there. Pacific rats are also likely having a negative impact on the seabirds that breed on Late, especially smaller ground-nesting species. It is also probable that populations of landbirds are lower than they would be in the absence of rats because of predation and competition.

Though other environmental factors could be implicated, it is possible that the failed translocation of Malau on Late was wholly or partially a result of the presence of Pacific rats. (Butler 2013) recommends that Late remains a suitable site for Malau but any future attempt to establish Malau on Late should be undertaken after rats are removed from the island.

5.3 Benefits of eradication

As evidenced by other island restoration projects, removal and exclusion of Pacific rats from Late would result in long-term species and ecosystem recovery. The absence of invasive species would eliminate threats posed by browsing, predation and competition leading to changes in forest composition and recovery of Late's floral communities and of the island's fauna. Removal of invasive species from Late would elevate the importance of the island as critical habitat for many unique and rare species, providing a safe harbor for native and endemic species to thrive. As suitable habitat continues to decline across these species' ranges, protecting breeding habitats becomes increasingly important.

Pacific rat eradications in New Zealand have resulted in positive responses from populations of at least 14 native species of forest plants, large invertebrates, skinks, geckos, lizards, and at least five species of seabirds (Brooke & Towns 2008).

Based on results from similar restoration efforts around the world, it is likely that the eradication of Pacific rats from Late would result in:

- Enhanced seabird breeding success and growth of ground-nesting bird populations.

Population growth has been the experience on New Zealand's islands following rat eradication. For example, fledging success of Cook's petrel (*Pterodroma cookii*) increased from as little as 5% in the presence of Pacific rats to at least 60% after their removal from Little Barrier Island (Imber, West & Cooper 2003; Rayner *et al.* 2007).

- Regeneration of those species of plants susceptible to suppression by rat predation. As an example, remarkable regeneration by the plant community was recorded on Palmyra Atoll after rats were removed (Wolf & Newton 2012).

- Recovery of frugivorous and nectivorous bird species populations because of increased availability of fruit and flowers. Benefits to insectivorous species are also possible from decreased competition and an increase in invertebrate abundance.

- Re-colonization or reintroduction of locally extirpated species of birds. For example the globally Endangered Phoenix petrel (*Pterodroma alba*) is a possible (re)-colonist.

- Late would be considered a better prospect for translocation of the Polynesian megapode and a second reintroduction attempt could be made.

- Recovery of invertebrate and reptile populations susceptible to rat predation and competition.

- Increased population sizes would convey greater resilience to Late's native species populations improving their ability to withstand environmental changes such as climate change.

- Removing rats from Late would improve biosecurity for nearby Fonualei Island by removing the risk of rats being transported from Late.

- A successful eradication of rats from Late that engages the community could bring attention to the threats to Tonga's biodiversity and strengthen public support for future island restoration and biosecurity work in Tonga.

Potentially negative effects could include:

- Short term impacts to non-target species due to direct or indirect poisoning from the use of a rodenticide.

- Short-term fluctuations in the abundance of resident species, for example the removal of rats could lead to an increase in some invertebrates that could in turn lead to short term impacts to some native plants.

- Increased presence of invasive plant species that had previously been suppressed by rat predation (e.g. *Sorghum bicolor*).

- Public perceptions of risk, both real and perceived, if not properly addressed in advance of an eradication, could lead to negativity over the use of rodenticides in Tonga.

- There is a small chance that the operation could fail. If this were to occur then confidence in the methodology and invasive species removal could be lost.

6. PROJECT FEASIBILITY

To date, successful rodent eradications have been achieved on 444 islands in over 40 countries and territories (Island Conservation 2012). Pacific rats have been eradicated from at least 92 islands across the world, ranging in size from small offshore rock stacks to islands the size of Little Barrier Island (Hauturu) in New Zealand 3,083 ha (Island Conservation 2012). These eradications include islands with similar characteristics to Late, such as tall forest and massive cliffs. Three of the islands, (Mayor (Tuhua)-NZ, Hauturu-NZ, and Codfish-NZ) are of similar size or larger than Late and possess similar or more extreme topography. All of these eradications were achieved using aerial spread of cereal-based baits containing the rodenticide brodifacoum (Towns & Broome 2003). Several successful eradications have been completed on islands of similar latitude to Late including Mabualau, Fiji; Nuutele, Samoa; and Oeno, Pitcairn.

Of the successful eradications, the closest to Late in size and latitude is Raoul Island, NZ (2,941 ha). Raoul is in the humid subtropics, is a high island reaching over 500 m above sea level and has deep ravines and massive and steep cliffs on caldera walls. In addition, much like Late, overland movement on the surface of parts of Raoul Island is extremely difficult due to dense vegetation cover over rock falls and fallen trees because of eruptions and cyclones.

While there have been many successful eradications of rats from islands, there is still a risk that an operation may fail. Eradication projects undertaken in lower latitudes have a higher rate of failure (Holmes *et al.* In prep), as highlighted by the failure of several recent well planned and carefully executed projects attempted on larger tropical islands (Keitt *et al.* In prep). Specifically the failed attempts to eradicate rats from Wake (USA), Henderson (Pitcairn), and Enderbury (Kiribati) highlight the more challenging conditions presented by tropical islands.

It is not fully known why rodent eradications in tropical climates have a higher rate of failure than those in temperate zones, but several key factors have been identified as potential causes:

- Bait is available for a shorter period of time because of consumption by non-target species such as land crabs and more rapid degradation rates.
- Natural food is generally readily available.
- Rodent populations are often at higher densities.
- Breeding can occur at any time of the year and its occurrence cannot be predicted with certainty.

Lessons learned from the most recent failures have been taken into consideration by the authors of this document and should be applied in an effort to maximize the potential success of any future eradication attempt on Late. Given the general history of success on large and difficult islands, and on an island with similar climate and latitude, the eradication of Pacific rats from Late is considered technically feasible.

6.1 Technical approach

Of the successful rodent eradications to date, in all but a handful of cases project success relied on the use of bait containing a rodenticide. If bait is distributed consistently across the island and during a time of year when rodents are relatively food deprived then based on the extensive eradication record a rodent eradication has a high chance of success.

Method of Bait Broadcast

Due to the size of Late, the rugged terrain, dense vegetation and inaccessible areas, the recommended strategy for the proposed rat eradication is to apply rodent bait aerially using a spreader bucket below a helicopter. It is our opinion that aerial broadcast of rodenticide provides the highest probability of success, while minimizing risk to personnel and disturbance to the island. Although hand spreading and bait station campaigns have successfully removed rats, they require that field staff access 100% of an island, something that is not possible on Late based on analysis of topo maps, photos of the island, and first-hand accounts from people familiar with the island. Areas with steep topography, loose substrate, caves, dense vegetation, and/or cliff faces are difficult to access, can often pose serious risk to personnel, and would exclude personnel on foot from reaching every rat territory on the island. They also require personnel to spend significantly more time on an island which can have its own set of impacts on the island's biodiversity.

Recommended Rodenticide

The rodenticide selected for the Late project should present a low probability of bait shyness, and the target species should be highly susceptible. The only class of rodenticides that meet these criteria is the first and second generation anticoagulants, which have proven the most effective of for rodent eradication. First-generation anticoagulants must be consumed in greater quantities and over a longer time period to be effective and a proven methodology for their aerial application is currently unavailable. The largest island where rats have been removed using a first generation anticoagulant that was aerially applied was Mokapu at 4 ha in size (Parkes, Fisher & Forrester 2011) and more research is required to evaluate their efficacy on larger islands. Consequently, the use of a first generation anticoagulant on Late is not recommended.

It should be noted that first-generation anticoagulants are less toxic and persist for a shorter period than second-generation compounds, resulting in a lower risk to non-target species. Thus, when island conditions allow for alternative means of applying bait (e.g. bait stations); there can be advantages to using these toxins.

Of the second generation rodenticides, the most commonly used has been brodifacoum (Howald *et al.* 2007) and all rat eradications of the scale of Late or larger have relied on the use of bait containing this rodenticide (Howald *et al.* 2007; Island Conservation 2012). On this basis we recommend brodifacoum as the preferred rodenticide to achieve success on Late. Brodifacoum is a second-generation anticoagulant that is used throughout the world for conservation use. Brodifacoum is an anticoagulant which affects the clotting ability of vertebrate blood. The effects of the toxin are not experienced for several days, thereby increasing the effectiveness of the toxin in eradication operations, because rodents that are more cautious about eating new food are unlikely to associate the bait with symptoms of poisoning.

Bait Type

Available bait products containing brodifacoum are typically formulated as a bait block or pellet that comprises the rodenticide locked within a grain-based matrix; the grain matrix is typically highly palatable to rats. When in pellet form, bait can be distributed from a mechanical spreader bucket which can be calibrated for specific application rates. The bait pellet formulation is designed to persist on the ground long enough for all rats to be exposed but to degrade quickly to minimize the risk of exposure to non-target species. To reduce the impact of brodifacoum to non-target species, the bait product can be formulated to be less attractive; typically bait blocks or bait pellets are dyed green or blue – colors which birds tend to avoid (Buckle 1994; Tershy & Breese 1994; Howald *et al.* 2005). Cereal bait pellets are the recommended bait formulation for the Late rat eradication. It is also recommended to utilize a formulation whose performance has been demonstrated as being effective as an eradication tool under tropical conditions.

6.2 Operational Timing

Eradications are likely to have a higher probability of success when target animals are food-stressed, at lower densities, are non-reproductive, and experience periods of high population mortality. In the tropics, rainfall is a key driver of ecosystem productivity and rodent population cycles are generally aligned with these changes in resource availability (Madsen & Shine 1996). No information is available on population fluctuations of rats on Late, but based on other successful tropical projects (Samaniego-Herrera *et al.* 2013) it is recommended that the eradication be conducted during the drier months. Fruit was found to be relatively abundant on Late during a September site visit (Butler 2013), but without comparison to wetter months it is impossible to determine its relative availability at other times of the year.

The months of lowest rainfall for Late are likely to be June and July based on mainland weather records (Tonga Meteorological Service 2013). Consequently, it is recommended that the rodent eradication be implemented between May and August, coinciding with the dry season and avoiding the cyclone season (November to April). Greater confidence could be gained by deploying a remote weather station on the island to measure rainfall and temperature as a means to better determine the best time for project implementation (Keitt *et al.* In prep). In addition, these data would provide project managers with a baseline to compare conditions during the implementation year.

In order to ensure the entire rodent population is targeted, including juveniles, it is recommended that two bait applications are completed approximately 21 days apart. Juveniles emerging after bait is no longer readily available may explain why several recent projects undertaken on tropical islands failed e.g. Wake, Enderbury (Keitt *et al.* In prep). A worst case scenario (based on a breeding female surviving for 21 days; the maximum period of time documented for mortality of a laboratory rat after ingestion of a lethal dose of brodifacoum (Howald et al. 2004) could allow juveniles to emerge as late as 3-4 weeks after bait is first applied.

6.3 Monitoring to Confirm the Project's Outcome

Confirming the success of the project should be undertaken after two rat breeding seasons or at least 12 months have elapsed since bait application. If no rats are detected, confirmation of eradication can be declared. A range of tools are available to detect rats during field surveys including: traps, tracking tunnels, chew sticks and chew blocks, hair traps, trained dogs and remote trail cameras. Ideally the methods utilized for baseline monitoring would be also used for confirmation. Traps can include live traps and snap-traps that kill rodents; however kill traps are only recommended if they can be modified to prevent mortality risk to native and endemic reptiles and birds.

6.4 Sustainability

Ensuring the sustainability of rat removal from Late will require protocols and activities to prevent their reintroduction after operations are completed. Further research is required to fully quantify the risk of reinvasion but an initial assessment indicates that the risk is likely to be medium under current conditions, primarily due to the infrequency of landings on island (Table 1).

Rats (*Rattus spp.)* are currently found on the 45 inhabited islands of Tonga (Pagad 2013), all of which pose a threat as source populations for reinvasion of Late. Both *Rattus exulans* and *R. rattus* are widespread in forest habitats in Tonga (Steadman *et al.* 1999); while *R. norvegicus* is usually found only in the vicinity of villages (Twibell 1973). All three species of rat are found on the closest island group to Late, Vava'u. However *R. exulans* was historically found to be the most abundant (Twibell 1973). Late is located about 55 km WSW of the island group of Vava'u, a sufficient distance to prevent natural reinvasion by rats. However, the ongoing use of Late by government agencies, tourists, and fisherman present a significant risk of unintentional reintroduction/introduction of pests. Equipment and supplies brought by boats, to support the various people working, and visiting the island, poses a real risk of rat reintroduction, as well as other unwanted pests. Currently, biosecurity protocols for Late are not available. The development of a biosecurity plan and the proper implementation and management of that plan is crucial to the long-term success of this project.

Table 1 Invasion Pathways, Risk, and Prevention

Species	Source	Pathway	Risk	Prevention Strategy
Species Name	*Where will be invasive species come from*	*How will it travel to the island?*	*How severe is the risk: Critical/High/ Medium/ Low*	*How will you prevent the species using the pathway to re-invade*
Rodents	Other islands of Tonga, especially Vava'u	Accidental introduction, e.g. in cargo, stowaway aboard boat approaching or moored at/close to Late	MEDIUM	Rodent control at key mainland departure points; screening and control on boats; on-island monitoring; prevention at main landing areas; rapid response to detection; rat spill response plan; awareness of risk among frequent island users; protocols for visitors, tourists, and tour operators; cargo quarantine and screening procedures.
Invertebrates	Other islands of Tonga, especially Vava'u	Accidental introduction, e.g. in cargo, stowaway aboard boat approaching or moored at/close to Late	MEDIUM	Screening and control on boats; on-island monitoring; prevention at main landing areas; rapid response to detection; awareness of risk among frequent island users; protocols for visitors, tourists, and tour operators; cargo quarantine and screening procedures.

6.5 Social acceptability

Projects that protect the biodiversity of Tonga generally receive public support (A. Palaki, MLECCNR, personal communication, January 2014). A previous rodent eradication was conducted in the Vava'u group, using the application of a rodenticide bait to treat three small islands (Houston 2002). The project did not report any challenges getting acceptance from stakeholders, or opposition to the project. It is anticipated that a similar social response would be received with regards to a rat eradication on Late.

It is felt that with proper communication, advocacy, and education there will be public support for the project (L. Matoto, MLECCNR, personal communication, January 2014). The Tonga Civil Society feels that the public will have little concern because the project will be seen to benefit Late (Pelenatita Kara, personal communication, January 2014). The project is expected to have benefits for local communities through training opportunities, education, and ecotourism. Therefore, the removal of rats from Late is expected to be socially acceptable. However, the use of a rodenticide in a protected area and the potential environmental impact that may arise may be a controversial social issue within both local and international communities. Demonstration of the long-term benefits to fauna and flora will be critical to addressing these concerns.

To maintain social acceptability, advocacy and education should be conducted through local news, radio, and newspapers. In addition, community groups such as the Tonga Civil Society and the Vava'u Environmental Protection Association (VEPA) should be engaged early in the planning process to aid in advocacy and education activities. See Appendix 2 for a list of the stakeholders consulted as part of this assessment.

6.6 Political & legal acceptability

The MLECCNR is mandated with the management of threatened species and ecosystems, in order to sustain the integrity of the ecosystems of Tonga. Invasive species are a direct threat to the integrity of Tongan ecosystems, suggesting that the removal of rats from Late aligns with the objectives of the MLECCNR. The GEF-PAS Invasive Species Project is also currently implemented in Tonga by MLECCNR. The main objective of the project is to reduce the environmental, economic, and human health impacts of invasive alien species in both terrestrial and marine habitats in the Pacific region. The removal of rats from Late aligns with the GEF-PAS project goals and directly supports *Component 3: Management Action* by eliminating the impacts of an established invasive species by eradication.

The registration, manufacture, import, sale, storage, distribution, use and disposal of pesticides in Tonga are regulated by the Pesticides Act (2002). The Ministry of Agriculture, Food, Forest, and Fisheries (MAFFF) is responsible for enforcing this Act and the regulations regarding pesticide use in Tonga and will need to be consulted on the project details. A detailed environmental impact statement will be required that accounts for the full range of terrestrial and marine species that may be affected, either directly or indirectly, over the short and long term (V. Manu, MAFFF, personal communication, February 2014). Rodent bait products containing brodifacoum are already registered in Tonga (S. Tupou, MAFFF, personal communication, February 2014) and the previous rat eradication attempt utilized Pestoff 20R rodent bait containing brodifacoum a bait product produced in New Zealand (Houston 2002). This suggests that the use of this or similar bait products is likely to be approved for Late.

In addition, the Ministry of Infrastructure-Civil Aviation Division will need to be informed and consulted regarding the use of helicopters and the flight plans surrounding the project. There is no reason to suspect that this approval for the operation will not be given. Given the information provided by the respective Ministries, the likelihood of this project receiving all required legal permits and permissions is high.

6.7 Impacts to the Environment

As part of the feasibility assessment we completed a desk-top non-target risk assessment to determine which native and endemic species present on Late are likely to be vulnerable to the proposed eradication technique. Before proceeding with an operation on Late, we recommend this assessment be reviewed by other agencies and preferably tested via a site based trial. Due to the proposed use of cereal bait, our risk assessment focused on granivorous, omnivorous, and predatory bird species, reptiles, and crabs. We highlight the likely mitigation actions that would be required to reduce any significant non-target impacts. These should be included in an operational plan. An eradication operation poses a variety and number of risks, such as the risk of a helicopter accident. However for the purposes of this assessment we focused on the potential impacts from the rodenticide as we consider these to be the most significant. The key risks to non-target species associated with an eradication operation on Late can be divided into three categories.

1. **Toxicant risks -** During rodent eradication operations there is the potential for native and endemic species to be at risk of unintentional poisoning through the consumption of rodent bait (primary poisoning) or the consumption of other animals that have ingested the bait (secondary poisoning).
2. **Physical disturbance -** Specific measures should be taken to minimize impacts such as disturbance to nesting seabirds, soil compaction (e.g. if setting up a camp on island), erosion from increased foot traffic, and physical disturbance associated with operating a helicopter.
3. **Biosecurity** - Risk of introducing another invasive species that could impact native species.

While the unintentional mortality of individuals has been documented during invasive species eradication operations, species populations typically show rapid population growth and increased breeding success following the removal of invasive species (Whitworth *et al.* 2005; Daltry *et al.* 2012). No non-target native species population has been extirpated as a result of rodent eradication using the techniques proposed.

Water and Soil Quality

To ensure that bait is available to all rats in the population it will be necessary to apply the bait along the islands' coastlines. This will mean that a small percentage of baits will fall into the surrounding sea and inland lake. Brodifacoum is highly insoluble in water and has been shown to have no impact on the water quality of the sea nor inland bodies of water (Primus, Wright & Fisher 2005; Fisher *et al.* 2011).

No impacts on the marine flora and fauna are expected from the use of brodifacoum on Late. In a field trial conducted off Kapiti Island (NZ) cereal baits disintegrated within 15 minutes and few species of fish were observed eating them (Empson & Miskelly 1999). In the same study, surveys conducted before and after an aerial brodifacoum operation found no evidence that fish densities were affected and no changes in marine assemblages resulted (Empson & Miskelly 1999). No mortality of marine life was observed following the accidental spillage of 18 tons of Pestoff 20R brodifacoum baits into the sea at a single point at Kaikoura, (NZ) in 2001 (Primus, Wright & Fisher 2005). Given the insolubility of brodifacoum and the small number of baits that are anticipated to fall into the sea, the proposed operation poses little risk to marine species, including fish.

Brodifacoum is not readily soluble. When baits disintegrate, brodifacoum remains in the soil where it binds strongly to soil particles, it is then broken down by microbial activity over 1 to 6 months (Ogilvie *et al.* 1997; Fisher *et al.* 2011). Soil contamination is likely to be localized and limited to soil directly under decaying baits. Microbiological breakdown of brodifacoum is dependent on the climate, particularly temperature and the presence of microbial species. Late's warm, humid climate will ensure that the breakdown of brodifacoum is rapid.

Land Birds

The risk to land birds on Late depends on each species' susceptibility to brodifacoum, the probability they will encounter baits and their diet. Generally speaking, they fall into three categories:

1) Not affected by the operation.
2) At risk of primary poisoning from directly eating baits.
3) At risk of secondary poisoning from eating other animals that have eaten baits.

Birds that forage on the ground, are omnivorous, eat seeds and grains and/or are inquisitive will be at greatest risk from primary poisoning. Those birds that feed on ground dwelling animals that eat baits (i.e. invertebrates, crabs, reptiles, rats) or scavenge poisoned carcasses are at the greatest risk of secondary poisoning. A simple risk assessment, based upon a similar assessment conducted in Samoa (Hooson 2006), was undertaken examining the risk to the land birds on Late and the consequence of potential impacts (Appendix 1).

Friendly ground-dove

The Friendly ground-dove is at high risk, as it forages extensively on the ground and its diet suggests there is a high chance it will eat brodifacoum baits. A species with a similar ecology, the Barred ground-dove (*Geopelia striata*) had an estimated mortality of between 40 and 80 % on four different islands in the Seychelles following aerial brodifacoum baiting (Merton et al. 2002), suggesting that ground doves as a group are vulnerable. Due to its international conservation status (IUCN-VU), efforts should be made to mitigate any potential impacts. A similar rat eradication project conducted in Samoa implemented a captive holding program for the Friendly ground-dove to safeguard against potential impacts (Butler et al. 2011). The project successfully captured, held, and released over 20 individuals (Collen et al. 2011). A similar mitigation effort is recommended for Late (see Section 6.7).

Tongan whistler

Insectivorous birds are more likely to be exposed to brodifacoum by eating invertebrates that have fed on baits vs. directly consuming bait. On Late the Tongan whistler (*Pachycephala jacquinoti*) likely has a moderate risk of secondary poisoning, as they obtain insects from the subcanopy or ground. Overall, we consider the risk to the Tongan whistler to be moderate based on a combination of its international conservation status (IUCN-NT), feeding behavior, and diet. We anticipate mortality of individuals; however, population level impacts are not expected, thus we do not recommend mitigation. Research has shown that brodifacoum does not persist for a long period in some arthropods (Fisher & Fairweather 2006) so the period of risk may be relatively short lived for insectivorous species.

Buff-banded rail

The buff-banded rail (*Gallirallus phillippensis)* eats insects, crustaceans, snails and fruits and is at medium risk from eating baits, contaminated crabs and insects and probably from scavenging dead rat carcasses. Eradication projects in New Zealand and elsewhere have led to sharp reductions of some rail populations (Eason & Wickstrom 2001), although in all cases where long-term populations were desired, they recovered and in many cases have expanded beyond pre-eradication population levels within a few years.

Spotless crake

Spotless crakes (*Porzana tabuensis*) are at medium risk due to their diet and foraging behavior. Spotless crakes have been present at a number of island eradications where brodifacoum, the proposed toxin, has been used. A single fatality has been documented (Veitch 2002), although more birds are likely to have died and not been recovered. The Spotless crake is common and widespread, and population level impacts are not expected.

Barn owl

The barn owl (*Tyto alba*) is at risk of secondary poisoning due to its diet of rodents and insects. Barn owls have died after being fed rats that had eaten brodifacoum and significant declines in their populations have been observed in field trials (Eason *et al.* 2002). The proposed project is a one-time event and brodifacoum will not be present in the environment for long, so the risk of secondary poisoning is reduced. Barn owls are regionally and globally widespread and locally common, so if birds on the islands are killed, others will likely recolonize Late.

Pacific black duck

The Pacific black duck (*Anas superciliosa*) has been anecdotally reported to be present on Late's inland lake and is not likely a year-round resident. Previous eradications have been conducted with Pacific black duck present and no significant impacts have occurred (Dowding, Murphy & Veitch 1999; Griffiths 2004; Lovegrove & Ritchie 2005).

Purple swamphen

Several rodent eradication projects in New Zealand have documented population level impacts on Purple swamphen (Dowding, Murphy & Veitch 1999; Lovegrove & Ritchie 2005), with the highest loss being over 90% of the population (Veitch 2002). However even in the most extreme case the population recovered either by breeding or immigration from surrounding populations, and was increasing within a year of the removal of rats (Dowding, Murphy & Veitch 1999). A temporary reduction in the local population of Purple swamphen on Late is expected. However, natural recovery and a return to previous population levels are also expected to occur.

Other Birds

Seabird species breeding on Late feed entirely at sea and will not be affected by bait onshore on the island. The possible exceptions are the greater (*Fregata minor*) and lesser frigatebird (*Fregata ariel*) that could possibly take moribund rats from littoral areas and be exposed to the risk of secondary poisoning. However, these frigatebird species are globally widespread and not threatened, and the risk to the species is considered low. Frigate bird populations have not been affected in past rodent eradications e.g. Palmyra Atoll.

Several shorebird species, including the globally vulnerable bristle-thighed curlew, are reported to visit Late during the northern winter (Rinke 1991). All forage from the ground and are likely to pick up bait. However, the number of birds present on Late during the potential project is expected to be low, with only non-migrants present. While a handful of birds might be exposed and some of those would likely die, observations on Palmyra Atoll suggest the problem is not acute (Buckelew *et al.* 2005) and the impact on the species' global populations would likely be negligible and outweighed by the potential long-term positive effects on other globally threatened bird species. To reduce potential impacts, timing of the rodent eradication should occur when shorebird numbers are at their lowest; which is thought to be June-August, when only non-migratory individuals would be present.

Invertebrates

A range of invertebrates have been recorded feeding on or near brodifacoum cereal baits and brodifacoum residues have been found in a number of insect species (e.g., Booth, Eason & Spurr 2001; Craddock 2003; Bowie & Ross 2006). However, invertebrates are generally not considered to be at risk from brodifacoum poisoning and species exposed to brodifacoum were unaffected (Booth *et al.* 2003; Fisher & Fairweather 2006).

Terrestrial crabs (*Birgus latro*) are present on Late and are likely non-target consumers of rat bait. Only one species of crab has been reported and densities on Late have been anecdotally reported as very low (Butler 2013). However because crabs are significant bait consumers and can have a large impact on bait availability, crab densities and confirmation of the species present will be required prior to project implementation. Crabs like most other invertebrates are not susceptible to brodifacoum (Pain *et al.* 2000; Buckelew *et al.* 2005; Primus, Wright & Fisher 2005).

Reptiles

Reptiles are susceptible to brodifacoum poisoning and are known to feed on brodifacoum cereal pellets (e.g. Merton *et al.* 2002) and are likely to eat insects that have eaten brodifacoum baits. However, based on the results of other rodent eradications, none of the species present on Late are expected to be affected at the population level and the benefits of eradicating Pacific rats and releasing lizards from rat predation are likely to outweigh any short term losses as a result of the project. Studies have shown that lizard populations increase notably following the removal of rats (Towns 1991; Brown 1997; Thorsen *et al.* 2000).

Bats

The Pacific flying-fox has been historically documented on Late (Rinke 1991), though no densities or population estimate was made. However, flying fox were not detected on a recent site visit (Butler 2013). The Pacific flying-fox is frugivorous and thus the likelihood of these bats being impacted directly or indirectly by the rodenticide is considered very low.

6.8 Mitigation of non-target impacts

A successful rat eradication project on Late is also dependent on mitigating potential impacts to non-target species. The following mitigation measures are recommended to prevent or mitigate the potential impacts on non-target species:

- As a general precaution, brodifacoum baits should be dyed green. Baits dyed this color have been shown to be less attractive to birds (Caithness & Williams 1971).
- Baits should be handled in a manner that, as far as is practicable, minimizes the fragmentation of the bait pellets.
- Prior to the operation, the spreading bucket should be calibrated to ensure accurate bait coverage.

As identified in this assessment, additional mitigation is recommended for the Friendly-ground dove. Mitigation measures recommended include capturing and maintaining a healthy population of Friendly-ground dove in order to provide a source population in the event of widespread mortality of the wild population of doves following bait application. This could be done on or off Late. The success of this operation depends upon the following factors:

- Capturing sufficient numbers of Friendly-ground dove
- Maintaining a live and healthy captive population of birds for the required period of captivity
- Monitoring the wild population of dove to determine levels of mortality that have occurred on the island prior to the release of the captive population back in to the wild

Friendly ground doves would be captured before the baiting operation and held in captivity in a temporary aviary until their release on Late is deemed safe. Protocols utilized by the Nu'tele island (Samoa) rat eradication project (Collen *et al.* 2011) to capture and transport doves, as well as general husbandry, should be used for Late.

6.9 Capacity

Further development of the project including operational planning and field implementation should be in collaboration with project stakeholders. Individuals skilled and experienced in invasive species eradication will be required to lead any required field studies and the implementation of field operations. Additional personnel will be needed for field surveys, logistical support, boat crews, first aid and safety, helicopter support crew, rodent baiting, and GIS. Personnel in key roles may be sourced internationally or from within the Pacific region, while many support personnel can be recruited locally and be provided with the appropriate training. Personnel capacity as described is therefore determined to be feasible. A complete list of personnel, their roles, and skills needed should be provided in the Operational Plan.

In addition to personnel, large specialized equipment will be needed to conduct an aerial baiting operation on Late. Two helicopters with adequate performance capabilities and rigging will be needed, as well as a ship with deck space capable of serving as a loading platform for the baiting operation. Much of this equipment could be sourced within New Zealand or Fiji where companies experienced in this type of operation are present.

Table 2 Primary roles required to develop and implement the Late restoration project

ROLE/POSITION	PURPOSE
Project Lead	Oversees project processes; facilitates legal compliance and authorizations; acquires funding.
Project Manager	Manages overall project; collaborates with Technical Project Manager on development of Operational Plan; supports compliance planning, field trials, logistics, and implementation.
Technical Project Manager	Designs, plans, implements, and supervises fieldwork; manages compliance planning; develops Operational Plan; leads field implementation; supervises operational staff; provides reporting.
Communications Manager	Develops communications materials, manages media, public education and advocacy.
Eradication Specialists, Field team	Implements field trials, eradication operation, manages logistics, and provides reporting.
Biological field staff	Implements biological monitoring before, during, and after operations to monitor species and ecosystem changes; implements operational monitoring.

6.10 Affordability

A preliminary estimate for the total cost of the operation is **$2.7M (USD)**. This is an indicative estimate of costs for the project based on eradication projects of similar scale and complexity, and includes 20% contingency to cover the risk of encountering unexpected costs during the operation. The costs of the project may be able to be reduced if the operation could be staged from the island (insufficient information is currently available to consider this approach) or if cost sharing with other rodent eradication projects in the SW pacific could be coordinated.

More accurate estimates will be able to be calculated once a preferred project approach has been selected and a decision to proceed with the project made. The summary below highlights the key activities requiring funding. Because of the uncertainty in the amount of time and effort that may be required to remove rats, conservative estimates have been made.

The feasibility of securing adequate funding is considered moderate. Similar sums have been raised for other eradication projects in the region and multi-lateral funds are potentially available. However, it is likely that funding from an external funder, outside the Pacific region, and from non-governmental sources would need to be secured in order to fully fund the project.

Planning Costs

Projected costs for the planning stage are approximately $195K (USD). This will support operational planning required to implement the eradication. Planning costs will need to incorporate a site visit to complete field trials, non-target risk assessments, environmental compliance, as well as agency and public consultation, and the development of communications and other social advocacy and education.

Operational Costs

The total cost of implementing the operation is projected at about $2.4M (USD). Operational costs include but are not limited to implementation, biodiversity recovery monitoring, and eradication confirmation. These costs also include purchase of equipment and supplies, personnel costs, and helicopter and boat charters. These implementation costs are independent of any approved operational strategy, and implementation costs could vary depending on the strategy chosen.

Non-Target Mitigation Costs

The total cost for non-target mitigation actions is projected at about $87K (USD). These costs are for actions that may be needed to reduce any potential impact of the eradication to native, endemic, and other species, as a result of the operation. For example, captive holding of the Friendly Ground-dove or other mitigation measures may be required. The actual cost for non-target species mitigation will be dependent on the outcome of further non-target risk evaluations carried out as part of the operational planning.

6. CONCLUSION

Our assessment of the feasibility of the Late project provides confidence that the removal of invasive rats from the island is possible. However, several enabling conditions will need to be met prior to the eradication project moving forward. These include sourcing adequate funding, establishing an island specific biosecurity plan, completing environmental compliance, and pre-implementation field trials.

The aerial application of rodent bait containing brodifacoum is proposed as the preferred method for eradicating Pacific rats from Late and is the method most likely to lead to the project's success based on an examination of past eradication projects. Research on other islands also demonstrates the likely benefits that may be seen on Late once Pacific rats are removed. The purpose of the project is to restore ecosystem processes on the island, allow for the recovery of existing invertebrate, lizard, and bird populations, provide for the reintroduction of species that may have been extirpated and to increase the islands potential as a site for the recovery of other threatened species. The project is also expected to have benefits for the local communities through training opportunities, education and possibly ecotourism.

For this feasibility assessment, consultation was undertaken with numerous interest groups (Appendix 2). All parties spoken to were very supportive of the project and did not raise concerns that might have suggested there would be serious impediments to project completion. Nevertheless, further consultation with local communities will need to be undertaken to ensure the project remains socially acceptable. The assessment concludes that the operation is in accordance with the requirements of relevant legislation, will be beneficial to the species and ecosystems of Late and that the proposed mitigation measures will prevent, mitigate or remedy all significant adverse environmental effects.

This assessment examined the potential impacts that an aerial application of rodent bait containing brodifacoum could have on the quality of water and soil; native species, and introduced animal species, and the ecosystem of Late. Some areas of concern were identified and appropriate mitigation measures will be required to prevent, mitigate or remedy all of the significant actual or potential, environmental impacts of the project. For those issues we identified where mitigation measures were not available, the long-term benefits of the project are considered to outweigh the anticipated short term impacts.

7. RECOMMENDED COURSE OF ACTION

The next phase in developing this project is to draft an Operational Plan. However, further information is needed in the following areas before this feasibility assessment can be finalized and an operational plan completed.

7.1. Environmental Compliance

A detailed assessment that considers the impacts on the environment (both terrestrial and marine) of aerial baiting to eradicate Pacific rats from Late is required by MAFFF. The assessment should evaluate the potential impacts, both in the short and long term, and recommend specific mitigation measures needed to reduce or eliminate any impacts considered unacceptable by project partners.

It is recommended that a food web be developed for the island as part of the environmental assessment, and the pathways for rodenticide bait be incorporated in the food web. If possible, different potential climatic scenarios at the time of implementation should be considered. A food web model can help identify possible bait competitors and risk to non-target species (Keitt et al. In prep).

7.2. Pre-Implementation Field Trials

On-island research will be needed to inform the operational plan. Field trials to determine the most effective methods of detecting rodents on Late will be required for post-eradication monitoring. Pre-eradication trials should include trail cameras, chew sticks/blocks, trapping, sign searching, and tracking boards. Trials will also be necessary to determine an appropriate bait application rate (kg/ha) for the eradication of rats on Late. This is typically determined through field trials that monitor the consumption of placebo (non-toxic) bait at the same time of year and climatic conditions as the proposed eradication. In addition, the impact of environmental conditions on bait longevity must be determined on Late. Typically, the quality and physical form of placebo bait is monitored over time to determine bait pellet persistence under the environmental conditions on Late. This data also helps to inform non-target risk assessments.

A rodent eradication could fail because not all individuals were eradicated (and the population re-establishes) or because Late was re-invaded by rodents from a boat, in cargo, etc. A comparison of rodent DNA collected before and after a failed rodent eradication can indicate the cause of failure. Prior to eradication, a baseline DNA profile of the rodent population on Late should be established according to standardized protocols.

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APPENDICES

Appendix 1

Common Name	Scientific Name	Diet	Feeding Stratum	Risk*	Consequence+	Mitigation Recommended
Buff-banded rail	*Gallirallus phillippensis*	Insects, snails, crustaceans, fruit	Ground	High	Medium	No
Barn owl	*Tyto alba*	Exclusively rats, insects	Ground	High	Medium	No
Blue-crowned lorikeet	*Vini australis*	Nectar, pollen, fruit	Sub-/canopy	Low	Low	No
Crimson-crowned fruit dove	*Ptilinopus poriphyraceus*	Frugivorous	Sub canopy	Low	Low	No
Pacific black duck	*Anas superciliosa*	Aquatic snails and insects, leaves and seeds of aquatic plants	Aquatic/ground	High	Medium	No
Long-tailed koel	*Eudynamys taitensis*	Insects, lizards, other small vertebrates	Incl. ground	Medium	Low	No
Many-colored fruit dove	*Ptilinopus perousii*	Frugivorous	Canopy	Low	Low	No
Pacific pigeon	*Ducula pacifica*	Frugivorous	Occ. Ground	Low	Low	No
Polynesian starling	*Aplonis tabuensis*	Fruit, berries, insects	Sub-/canopy	Low	Low	No
Polynesian triller	*Lalaga maculosa*	Insects, caterpillars, fruit	Incl. ground	Medium	Low	No
Purple swamphen	*Porphyrio porphyrio*	Vegetation, invertebrates, berries and grains	Ground	High	Medium	No
Shining parrot spp.	*Prosopeia spp.*	Fruit, berries, some plant material	Canopy	Low	Low	No
Friendly ground-dove	*Gallicolumba stairi*	Seeds, fruit, buds, leaves	Ground/ sub canopy	High	High	Yes
Spotless crake	*Porzana tabuensis*	Mollusks, insects and aquatic plants	Ground	High	Medium	No
Tongan whistler	*Pachycephala jacquinoti*	Berries, insects, spiders, and other small arthropods	Any level	Medium	High	No
Wattled honeyeater	*Foulehalo carunculata*	Nectivorous, fruit, insects, lizards	Sub-/canopy	Low	Low	No
White-collard kingfisher	*Todiramphus chloris*	Fish, large insects, crabs, lizards	Aquatic/ground	Medium	Low	No
White-rumped swiftlet	*Aeroramphus spodiopygius*	Exclusively insectivorous	Aerial	Low	Low	No

*Risk score: based on diet and feeding behavior as related to risk of primary or secondary poisoning.

+Consequence: based on international threat ranking and potential for population level impacts

Appendix 2

Table 3 Stakeholder Consultations

Name	Organization	Date Contacted	Topics Discussed
Asipeli Palaki	Ministry of Lands, Environment, Climate Change, and Natural Resources	Jan 28, 2014	Island status, roles of other Ministries, permissions needed, use by public and MLECCNR, social acceptability, biosecurity
Viliami Hakaumotu	Ministry of Lands, Environment, Climate Change, and Natural Resources	Jan – Feb, 2014	All topics
Lupe Matoto	Ministry of Lands, Environment, Climate Change, and Natural Resources	Jan 23, 2014	Island status, use by public, social acceptability
Dr. Viliami Manu	Ministry of Agriculture, Food, Forestry, and Fisheries	Feb 22, 2014	Project description and purpose, permissions needed for pesticide import and use.
Siutoni Tupou	Ministry of Agriculture, Food, Forestry, and Fisheries	Feb 20, 2014	Project description and purpose, permissions needed for pesticide import and use.
Pelenatita Kara	Tonga Civil Society	Jan 21, 2014	Island use by public, social acceptability, biosecurity, potential concerns
Karen Stone	Vava'u Environmental Protection Association	Feb 12, 2014	Project description and purpose, social acceptability.
Ana Fekau	Integrated Island Biodiversity Project	Jan 30, 2014	Late island as location for Tongan megapode translocation
David Butler	International Consultant	Jan 24, 2014	Biosecurity, logistics, island conditions, public support

Appendix 3

Potential Project Progression

1. Draft operational plan
2. Undertake further consultation with stakeholders.
3. Conduct bait application trials on Late to inform the baiting strategy at the time of year proposed for project implementation.
4. Collect rodent DNA samples.
5. Confirm rodent body condition and breeding status.
6. Collect baseline data on rodent abundance with detection tools/methods to be used for confirmation.
7. Complete an environmental impact assessment and develop mitigation plans for species of concern.
8. Secure permissions from Tongan regulatory agencies.
9. Undertake consultation with other stakeholders.
10. Create and implement a biosecurity plan for Late.
11. Conduct audits to assess biosecurity.
12. Commence captive management program for those species identified as requiring this mitigation action in the non-target risk assessment and mitigation plans
13. 1st bait application
14. Assess uptake and bait persistence
15. 2nd bait application
16. Assess uptake and bait persistence
17. Once the risk is considered low, release species held in captivity.
18. Confirm eradication after at least 12 months have passed without detection