Threatened Species Recovery Plan

Polynesian Megapode (*Megapodius pritchardii)*

2014-2024

Ministry of Environment, Energy, Climate Change,
Disaster Management, Meteorology,
Information and Communications (MEECCDMMIC),
Kingdom of Tonga.

December 2014

INTRODUCTION

Figure 1: Polynesian megapode male calling. (D. Butler photo)

This recovery plan covers one of the most threatened species within the Megapode family – the Polynesian Megapode (Tongan Scrubfowl)[1] *Megapodius pritchardii* (Gray 1864). The species is considered to be globally threatened and as Endangered (BirdLife International 2014) due to its confinement to two small islands and apparently declining population size. This plan builds on the previous Conservation Strategy developed by the World Pheasant Association (WPA) and Tonga Community Development Trust (TCDT) in 2011 (Lloyd *et al.* , 2011), updating knowledge of the species and its conservation status based on more recent surveys conducted since 2011 and including a revised series of objectives and actions, developed under the leadership of the Department of Environment, Ministry of Environment, Energy, Climate Change, Disaster Management, Meteorology, Information and Communications (MEECCDMMIC).

This updated strategy is based on an internationally recognised format, as used in New Zealand, including an introductory section providing details on the species ecology and options for its recovery followed by a strategy to achieve recovery to a certain target. The strategy presents a concise work plan with a minimal number of achievable actions for the Kingdom of Tonga to implement with its relatively limited resources and expertise. It covers a 10-year period with

1The common name of this species has recently been changed to the Tongan Scrubfowl. However the previous name is retained in this plan as the Tongan people, who have the key responsibility for its implementation, are familiar with ‘megapode’. Using its translation ‘big feet’ also offers an opportunity to introduce the bird to school children.

a review expected to be undertaken after five years of implementation, with additional revised actions produced at that time if deemed necessary by stakeholders. The MEECCDMMIC will take responsibility to annually assess progress towards the recovery of the species.

This recovery plan will be distributed to all those who are in a position to play a role in the conservation of the species over the next ten years: Government staff, non-governmental organisations, community leaders for the islands on which it is found, politicians and other decision makers, scientists, teachers, and funding organisations.

The recovery plan was developed as part of the regional GEF-PAS Integrated Island Biodiversity Project executed by the Secretariat for the Pacific Regional Environment Programme (SPREP), and implemented by United Nations Environment Programme (UNEP) with funding from the Global Environment Facility (GEF).

1 SPECIES DESCRIPTION AND ECOLOGY

1.1. Introduction to the species

The Polynesian Megapode (*Megapodius pritchardii)* (Gray 1864) is a medium-sized megapode species endemic to the Kingdom of Tonga and confined for many years to the small volcanic island of Niuafo'ou (GPS 15˚36'S, 175˚38'W), the northernmost island in the country (Figure 1). A second population has been established on Fonualei Island in the Vava'u Group by a translocation in 1993. A further transfer to Late Island in 1992 (Göth & Vogel 1993) appears to have failed (Watling 2003, Butler 2013).

The species is the only extant megapode species in Polynesia though Steadman (1999) identified from sub-fossil bones that in the past there were several other species found in Tonga, Fiji, New Caledonia and American Samoa and Niue. Bones of the Polynesian Megapode itself were also found on Foa Island in the Ha'apai Group and on Eua Island, so it may have been widespread across the country before the arrival of people (Steadman op. cit.). Niuafo'ou was the only island where it was able to survive. An alternative explanation is that Niuafo'ou

was the only island where a breeding population thrived, and that these other records represent dispersing birds as a recent review has concluded that megapodes have historically dispersed over long distances by flying (Harris et al. 2014).

On Niuafo'ou the species is locally known as the *Malau* and is largely confined to the forested inner slopes of the volcanic caldera and three islands in the crater lake. On Fonualei it occupies at least two areas of forest in a patchwork of rock and scrub formed as a result of more recent volcanic activity. As with other members of the Megapodiidae, the Polynesian Megapode does not use body heat to incubate its eggs. On Niuafo'ou the *Malau* buries its eggs in burrows up to 1.5m deep in volcanically heated loose soil within the caldera. Typically several burrows, which are used repeatedly by more than one female, are grouped together within a single 'nesting ground'.

If the Polynesian Megapode did breed on the limestone islands of Eua and Foa in the past it must have used alternative methods such as organic decomposition or solar radiation (Steadman 1999). [2]

Historically *Malau* eggs have been harvested by the people of Niuafo'ou, a scenario similar for many other megapodes throughout South-east Asia and the Australasian region (Jones et al. 1995). This continues today though apparently not to the extent reported in previous peer-reviewed studies in the 1990's..

The key threat to the species was considered to be the harvesting of eggs by collectors on Niuafo'ou where historically all nesting sites have been exploited with at least >50% of all eggs found in each nest taken (Göth & Vogel 1995). Predation by feral cats was also an issue there and some adult birds are also occasionally reported to be hunted. A recently established population on the uninhabited island of Fonualei is free of such threats.

The most comprehensive research on the species ecology, conducted during 1991-93 estimated the population on Niuafo'ou ranging from 188-235 pairs occupying 641 ha of 719 ha of suitable habitat (Göth & Vogel 1995). The authors

2For the purposes of future Polynesian Megapode management it is safest to assume that, even if the species was able to use different nesting strategies in the past, it has lost that ability (as indicated by a failed transfer to Tafahi Island – see later). It thus probably requires volcanically-heated soil which limits the islands on which it may survive.

suggested that this represented 52-65% of the possible carrying capacity of the island, assuming an average of 0.5 pairs per ha (Göth & Vogel 1995). This compares with an earlier population estimate of 820 adults from a study area of 500 ha (Todd 1983). Three brief surveys have been undertaken recently in 2010 (Lloyd et al. 2011), 2012 (MLECCNR 2012) and 2014 (Butler 2014) that indicate that the population has declined further since 1991-93.

Three attempts have been made to translocate birds to establish populations on other islands. The first was made in the 1960s when six adults and three juveniles were moved by H. Bregulla to Tafahi Island. This was at a time that little was known about the species' requirements, and it failed since this island has no geothermal areas for nesting (Todd 1983). In 1993 D. Rinke transferred birds and eggs to Fonualei[3] though details are not available. Follow-up surveys were conducted in 2003 and 2013 and showed that a population has become established. 63 eggs were transferred to Late Island in September and October 1992 and buried near the edge of a water-filled secondary crater where soil temperatures of 34ºC were recorded (Göth & Vogel 1993). Three subsequent surveys were conducted on Late in 2003 (Watling 2003), 2004 (Watling pers. comm.), and 2013 (Butler 2013) but no evidence of megapodes was recorded.

The species is legally protected in Tonga which means that egg collection is illegal but this is not enforced on Niuafo'ou.

1.2 Taxonomy

The Polynesian megapode was described by Gray (1864) based on two specimens (skins) received in London, and named after William Pritchard, British Council in Tonga, who provided the first of these.

1.3 Morphology

The Polynesian Megapode is one of the smallest living megapodes (373 g, SD=52 g, n = 22) (Göth & Vogel 1993), it's overall length reported as 28 cm (Jones et al. 1995) or ranging from 30-35 cm (Elliot 1994). The following description from the 2011 Conservation Strategy (WPA & TCDT 2011) follows Elliot (1994) and Jones et al. (1995).

3Details have not been located. Various subsequent reports have included a number of 35 individuals and mention eggs, juveniles and adults.

PLUMAGE: Both sexes have similar plumage. Adult birds are dark slate grey, with a dark ash-grey forehead and crown with slight brownish tinge. The feathers of the nape and back of head are lighter slate-grey and slightly elongated, forming an indistinct short but broad crest. Area around the lores, eyes and ears are virtually bare, with some light grey feathers boarding the bare patch. Those on the neck are much reduced in length leaving a variable amount of skin of the head and neck bare. The feathers above the eye extending back to the nape contrast sharply with the darker crown, forming a pale grey streak (only really visible when the birds are in the hand). The feathers on the upper throat and chin are pale white. The lower back, rump and wings are washed reddish brown, with a white patch at the base of the primary feathers and white upper-tail coverts. Both these field characteristics are individually variable and usually concealed. Overall the underparts are grey becoming paler on the belly.

Figure 2: Malau caught and marked as part of the 1991-93 study. (A. Göth photo).

BARE PARTS: The bare skin of the head and neck is vermillion or dark red. The bill is bright yellow and the iris brown. The highly conspicuous legs and feet are bright yellow or orange-yellow, with those of the male being more (duskier) orange-yellow and those of the female brighter yellow. The difference between males and females is only discernible when both are together.

IMMATURE PLUMAGE: Immature birds are similar to adults except they are generally duller in coloration, with brown and black barring and less white in the tail and flight feathers. Flight feathers often have traces of buff marks and are

generally shorter. The iris tends to be darker brown and the legs and feet more brownish-orange.

CHICKS: The forehead, lores, cheek, chin and throat are ochre with no bare skin visible at the sides of the head. The crown and hind neck are fuscous. The mantle and upper-wing coverts fuscous-brown with the longer coverts contrastingly marked with broad deep black bars and narrow buff bars. Rump and upper-tail coverts are rufous-brown. Chest, side of breast and flanks are pale brown-grey. Flight feathers are grayish-black. Iris and the bill are brown.

1.4 Distribution and habitat

The Polynesian megapode is found on two small volcanic islands, Niuafo'ou and Fonualei.

Niuafo'ou is the peak of an active basaltic shield volcano with a summit caldera formed by the collapse of a composite cone (MacDonald 1948). Two large lakes separated by a line of volcanic ash hills cover most of the caldera floor, leaving the island with a land area of ca. 35 km^2. Volcanic eruptions comprise of either lava flows from cracks developing along faults on the outer slopes of the island (in 1853, 1867, 1912, 1929, 1935, 1943, 1946), or steam blast eruptions from within the caldera (in 1814 and 1886 – see Richard 1962).

Figure 3: Niuafo’ou Island from the air looking west with Mu’a village in left foreground (D. Butler photo)

The climate on Niuafo’ou does not vary considerably throughout the year. Todd (1983) reveals that monthly mean temperatures range from 25˚C in August to 28˚C in January, with a mean annual rainfall of 2,700 mm, most of which falls during the hottest period of the year.

The crater lakes are surrounded by a ridge up to 200 m high which is steep on the inner side, and descends gradually into the sea on the outer slope. Humid broad-leaved forest with a dense canopy is found on the inner slopes of the crater and on the islands in the main lake. In places where volcanic eruptions have occurred, the cinder hills and lava flows are covered with Ironwood trees (*Casuarina littorea*) (Göth & Vogel 1995). There a few forest areas that remain untouched by agricultural practices or disturbance caused by feral pigs but are accessed by local people for fishing or egg collecting (and in rare instances by tourists). These areas are confined to the inner slopes of the caldera and on the islands e.g. around Hikutemotu in the west of the inner slope, and in the south-east of the inner slopes from Kele’efu’efu toward Vai Kona.

The outer-rim of the island is dominated in the north, east, and south-east by human habitation and agricultural land-use, and in the west by older lava flows. There are only very small areas of apparently largely untouched forest between the villages of Mu’a and Tongamama’o. Many areas of secondary regenerating forest can be found on trails leading from the outer-rim to the peaks of the caldera e.g. along the trail from Sapa’ata village south into the caldera, and along the main dirt-track road from Mu’a village into the east of the caldera. The vegetation in these and other areas depends on the length of time since they were last part-cultivated, but the woody fauna are dominated by large, old mango trees (*Mangifera indica*) with strong evidence of understory and ground habitat disturbance by feral pigs.

The vegetation of the volcanic ash hills in the east of the crater that form the peninsula separating Vai Si’i and Vai Lahi lakes (Figure 4) is open ironwood (*Casuarina equisetifolia*) woodland with a few smaller woody plants. In many places dead trees are also a common component of this open vegetated landscape. Fires are frequent in these areas, in many cases deliberately lit.

Figure 4: Fires in ironwood forest of the peninsula between the lakes, Niuafo'ou. (D. Butler photo).

Göth & Vogel (1995) report that Polynesian Megapodes inhabit different types of broadleaved forest on Niuafo'ou in all successional stages, ranging from secondary forest dominated by coconut palms (*Cocos nucifera*), tavahi (*Rhus taitensis*) and mangoes, to undisturbed forest habitat. This latter forest type is dominated by trees such as *Syzygium clusiaefolium*, *Diopyros samoensis*, *Ficus* sp, and *Sterculia fanaiho* that provide a close canopy habitat with very open understory and a ground vegetation dominated by dense leaf-litter cover and rotting wood (Figure 5). These forest habitats cover an area of 719.3 ha although birds were only found in an area of 641.5 ha (Göth & Vogel 1995).

Figure 5: Malau habitat on the track to Kele'efu'efu (S. Fonokalafi photo).

Fonualei Island (c200ha) is formed of a volcanic cone with a fumarolicaly active crater c1.5km across and is located 65km north-west of Vava'u (Figure 6). A major eruption in 1846 was reported to have destroyed all the vegetation and as the photo shows it is now largely covered by a mosaic of scrub with smaller areas of broadleaved forest (dark green) where the megapode is found. No botanical surveys have been undertaken here. Steam is visible escaping from fissures near the coast on the western side of the island marking an active nesting ground where the birds were originally released (Figure 7).

Figure 6: Fonualei Island from the east (D. Butler photo)

Figure 7. Nesting ground on Fonualei with steam visible. (D. Butler photo).

They have also been found to occupy a forested gully (Figure 8) in the northern part of the island (the gully runs from the centre foreground to the right in figure 6).

Figure 8. Forest gully containing Malau viewed from sooty tern colony near summit (D. Butler photo)

1.5 Behaviour and diet

Polynesian Megapodes are usually found in pairs suggesting that the species is monogamous. Male and female are frequently found foraging on the ground, tending to remain within 3-10 m of each other. Pairs tend to spend relatively little time on the vicinity of the nesting grounds (Todd 1983, Jones et al. 1995). They occupy territories that they defend against other pairs, and most territories do not include nesting grounds (Ann Göth, *pers. comm*.). On Niuafo'ou, *Malau* are naturally difficult to observe whilst foraging on the ground. On approach they tend to be very wary and to disappear further into the undergrowth or fly into the sub-canopy of trees. Both adults and chicks are relatively strong flyers and have been seen flying across various sections of Vai Lahi (Ann Göth, *pers. comm*.). Birds on Fonualei seem 'tamer' and sometimes even approach the observer (Butler *pers. obs*.).

Malau forage by using their large feet to scrape away and uncovering prey items in dense leaf litter on the forest floor. Their diet consists mainly of animal food items and the male often offers food to the female (Jones et al. 1995). Prey identified by Todd (1983) from field observations included insects (53% of all

prey items), land snails (25%), centipedes (13%), and worms (9%). Fallen fruit of Syzygium spp trees comprised of 4 % of the diet. Finsch (1877) reports that F. Hubner recorded snail-shells, small crabs, centipedes and seeds in the stomach of birds he collected (Jones et al. 1995). Weir (1973) reported captive birds feeding on cockroaches, termites, ants, worms and coconut.

Typical foraging behaviour of a pair can be viewed freely online at: http://www.arkive.org/polynesian-megapode/megapodiuspritchardii/videos.html

1.6 Vocalisations

All known vocalisations of the *Malau* have been formally described by Göth et al. (1999) and most of the following information is derived from that publication. Examples of calls recorded during the 2010 survey of Niuafo'ou have recently been uploaded to the Xeno-Canto (XC) free access bird sound library website at http://www.xeno-canto.org/species/Megapodius-pritchardii

The most commonly heard vocalisations from both sexes are whistles. Single whistles or bouts of 3-5 whistles are often emitted (e.g. XC63001, XC63056) and have similar pitch but get softer toward the end. Whistles are uttered most commonly when individuals or pairs are flushed by observers, or in response to presumed natural predators e.g. barn owl (*Tyto alba*). These whistles are also given, particularly by males, in response to playback as they either fly up into the sub-canopy or from there down onto the ground, during which the female often follows him but silently (Lloyd et al. 2011).

Males and females produce a series of croaking calls when captured or in other threatening situations and these are often uttered in bouts for periods of up to 30-60 seconds (Göth et al. 1999). Chicks also utter similar calls to the distress calls of the adults, particularly when being handled. Adult males and females also emit a 'cluck' vocalisation which is only a fraction of a second in length. This vocalisation, only heard at extremely close range, is emitted when individuals appear out of range of their partner when fleeing disturbance or it is sometimes given by females when laying eggs and interspersed by single whistles (Göth et al. 1999).

In a duet, one member of the pair generally co-ordinates its vocalisations with that of its partner (Göth et al. 1999). During the duet the male and female produce different sounds and one member of the pair joins in before the other

individual has finished its part of the duet (e.g. XC 63007, XC63012). Normally the male initiates the duet. The song of the male is composed of three elements – described phonetically as “deeeded-drrrrr” (Göth et al. 1999). This presents the male part of the principal duet vocalisation which is typical of *Megapodius* species. The female’s part of the duet is the „coo’ -a quavering sound, varying in length but generally softer than the male’s duet vocalisation (e.g. XC63006 and XC63055). The notes of the terminal section of the female’s „coo’ vocalisation varies, and can continue to increase (e.g. XC63009) or initially increase and then descend at the very end (e.g. XC63014).

Malau sing or duet at all times of the day and year (Göth et al. 1999). Usually there is one song or a duet which is followed by a 5 minute pause before the next one. At dawn or dusk, pairs often counter-duet to each other. There also appears to be some ‘signal matching’ whereby pairs answer with the same type of vocalisations that the other pair has made (Göth et al. 1999). Pairs often respond to playback of the duet with their own duet, while they fly from the ground up into the mid-story or sub-canopy of the forest. The male always responds first, flying in the direction of the observer whereas the female follows either immediately behind or a few minutes later. Upon further duet playback, pairs will generally move from perch to perch in a circular pattern, through the mid-story or sub-canopy, again led by the male, who emits a variety of whistles (sometimes whilst flying) before landing and initiating the duet with the female once she has also landed close by (Lloyd et al. 2011).

1.7 Breeding behaviour

Polynesian Megapodes lay their eggs at communal, geothermally heated nesting grounds (Jones et al. 1995). The following information is from Todd (1983) and Jones et al. (1995). Generally pairs arrive at a nest between dawn and 10.00am, but some arrive to lay later in the day. The female alone is responsible for all the digging activity at the nest burrow, whilst the male remains nearby watching over the female. When birds approach the nesting ground, quite often they walk from nest burrow to nest burrow looking for a suitable place to bury their egg. While digging the female will periodically leave the burrow to look around, alert for any danger.

Figure 9. Nesting ground on Motu Molemole with multiple burrows. (H. Lloyd photo).

The female first digs by removing the sandy volcanic soil from the burrow entrance and then working her way back inside the burrow. The feet are used alternatively for powerful back kicks into the soil. Once the hole is deep enough the female then lays a single egg before beginning to cover the egg and fill the burrow. After the burrow has been filled, digging by the female becomes more random so that freshly turned loose soil is scattered over a wider area than the burrow entrance. This whole process (burrow excavation, egg laying and burrow filling) lasts between 2 h 10 min and 3 h 40 min (Todd 1983).

1.8 Nest, eggs and chicks

Polynesian Megapode nests are excavated burrows within the nesting grounds and are typically 15-20 cm in diameter (Jones et al. 1995) though sometimes much wider. Burrow diameter probably depends on the frequency of use, the number of adult pairs using the nest and also the rate of digging by egg collectors. Eggs can be deposited at a depth ranging from 0.2–1.7 m inside the burrow (Jones et al. 1995). The eggs are elongate-oval, brownish-buff to reddish-brown in colour when laid but mature into buff-ochre-brown during incubation. In some instances the outer layer light flakes off in places revealing white coloration underneath. Egg size varies from 70-80 x 39-47 mm (Todd 1983) or 73.2-76.4 x 41.1-44.5 mm (Rinke 1986), and weigh 65-82 g (Todd 1983) or 71-82 g (Rinke 1986) which corresponds to about 24% of the female's body weight (Göth & Vogel 1997). Females produce on average, 11.6–16.4 eggs per year with intervals of 14-16 days between successive eggs being laid (Göth & Vogel 1997). Incubation time varies between 47-51 days in soil temperature

ranging 29-38˚C (Todd 1983) or from 50-80 days across temperatures ranging 32-33˚C although some eggs are incubated in slightly colder temperature burrows (Göth & Vogel 1997).

One study has revealed a natural egg mortality of 2% (5 eggs from 224 that were laid during the 416 study period on Motu Molemole, Niuafo'ou (Göth & Vogel 1997)). Excavation of two nests on Motu Molemole and Motu Lahi in September 2010 found natural mortality of eggs and chicks of 9 and 11% (Lloyd et al. 2011). Information from egg collectors on Niuafo'ou state that eggs can be found every month of the year, but there is some debate as to whether there is a peak season (Jones et al.1995). Curio (1992) reported less digging/laying activity by females during January-February, whilst Weir (1973) suggested a peak during April-May. No significant variation in the number of eggs was recorded between May-September in 1979 (Todd 1983). In the most recent study, Göth & Vogel (1997) found that eggs were laid year-round but with greatly reduced number of eggs produced during January–August in 1992, although these findings may not be typical of the species due to an El Nino event that year (see Göth & Vogel 1997).

Upon hatching in the burrow the chicks first rest for several hours, then dig their way to the surface (Ann Göth, *pers. comm*.). Once emerged, they are highly precocial and are able to fly, walk and forage easily, without any help from their parents. Following emergence from the nest burrow the chicks have been observed to hide in dense vegetation a short distance away and remain still for about 10 minutes, presumably acclimatising to the new environment before moving away from the burrow (Lloyd et al. 2011).

Figure 10. Malau chick dug out of a burrow on Niuafo’ou. (D. Butler photo).

2. THREATS

Niuafo’ou

The main threats to the *Malau* population on Niuafo’ou are reported to be over-harvesting of eggs, and predation of egg-laying females and chicks by introduced feral cats (Elliot 1994, Göth & Vogel 1995).

2.1 Over-harvesting of eggs

Todd (1983) estimated the number of eggs harvested from nesting grounds varied at 150-300 per month, and egg harvesting was unevenly distributed among nesting grounds. Göth and Vogel (1995) stated that at least 50% of all eggs laid were collected or destroyed by being dug out during their 1991-93 study. At periods of the year however, the eggs of many active nesting grounds are harvested, but those at the most inaccessible sites are left (Rinke 1986, Göth and Vogel 1995).

Eggs are harvested ‘purposefully’ by a small number of traditional collectors or ‘opportunistically’ by individuals who are visiting areas close to nesting grounds for other reasons, particularly fishing for *Tilapia* on the main lakes. The number of collectors has declined, just as the total population on the island has. Göth and Vogel (1995) reported that there were some 15-30 local people who dug for

Malau eggs throughout the island. In 2010 the surveys of Lloyd et al. (2011) revealed that there were only four men who were considered by the Niuafo'ou community as collectors who purposely collect *Malau* eggs, all over 50 years of age. A son of one of the four was trained in the hope that he would maintain the tradition, but he has since left the island.

Figure 11. Egg collector Lafaele Pe'ei with eggs dug from burrow on Motu Molemole. (H. Lloyd photo).

A high school teacher interviewed in 2014 indicated that younger people showed no interest in maintaining this tradition and at community workshops some people considered collecting should be banned (Butler, unpubl. obs.). Lloyd et al. (2011) reported that *Malau* egg collecting was simply not viewed by younger parents or children as a daily part of life, or as a regular cultural experience, nor was it now strongly considered as a sign of 'man-hood' in Niuafo'ou society as it apparently once was. It was being replaced both 'culturally' and as a supplementary food source by fishing for *Tilapia* in the crater lakes.

The overall human population of Niuafo'ou is in decline with a drop of 19% from 646 to 523 between 2006 and 2011 censuses and there seems to be no current reason for this trend to reverse. So overall the rate of harvesting is considered to have declined and some of the less accessible nesting grounds will only be visited very occasionally.

2.2 Predation by feral cats

Todd (1983) reported that the remains of seven adult birds that had been killed by a cat were found at just one nest burrow. Cats are not often seen on the island, but this may be due to their shyness. It is difficult to assess their impact, as a single cat can clearly have a significant impact. The only direct evidence of predation by feral cats in recent years was the remains of one chick found near a nesting ground (Göth & Vogel 1995) and an adult carcass missing its head in 2013 (Butler 2014). Lloyd at al. (2011) and Butler (op. cit.) saw no cats outside villages during their survey, though forested areas were rarely visited at night when animals may be more active.

2.3 Other predators

Lloyd et al. (2011) found one dead adult, apparently killed (but not eaten) by a domestic dog near a nest burrow at Koko and they observed others flushing/chasing chicks. Dogs often accompany people when they fish for *Tilapia* in the main crater lakes and there is the potential for occasional opportunistic predation. There is possibly some natural predation of chicks by barn owls, though these owls do not appear numerous. Competition between *Malau* and domestic chickens can be ruled out today as the latter do not occur in forest habitat within the caldera (Göth & Vogel 1995). Trapping and hunting by people was reported to occur only on a small scale (Göth & Vogel 1995) but no longer occurs according to local people.

Other authors have suggested that introduced rats and pigs may pose a serious threat to the species on Niuafo'ou (Elliot 1994). However only the Polynesian Rat (*Rattus exulans*) is found on Niuafo'ou and this species is unable to dig out eggs from the burrows (Göth & Vogel 1995) and would be unlikely to be able to take a chick. Pig activity is very evident in many areas on the outer slopes of the caldera and on some of the access trails into it (Lloyd et al. 2011), where the

ground vegetation has been greatly disturbed with the top soil turned over many times and leaf-litter – the necessary foraging substrate for both adult and young *Malau* – largely absent. However pig activity was not observed within the caldera, so there is no significant impact on most of the megapode population.

2.4 Other threats

Habitat degradation and loss does not currently pose a problem within the caldera but will have had an impact on previous megapode populations on the outer rim, particularly near villages. Potential shifts in geothermal activity could be a threat. If the temperature regime of the soil were to change, e.g. get too hot or cold for successful incubation, this could have devastating effects on the species.

Fonualei

Currently the only clear threat to the megapodes on Fonualei itself is a major volcanic eruption. However the introduction of invasive species, particularly predators such as cats, ship rats or dogs is the key future threat that needs to be addressed.

There is also a possible genetic threat, due to high levels of inbreeding following a small number of individuals founding a population. It is quite likely that only a small number of the birds moved to Fonualei actually bred and contributed genetically to that population.

3. PAST RECOVERY PLANNING

The international Megapode Status Survey and Conservation Action Plan 2000–2004 (Dekker at al. 2000) identified three projects required for the Polynesian Megapode within these five years. The first was to monitor the population on Niuafo’ou and a census of three months duration was proposed. Such a study is still needed. The second was to raise awareness within Niuafo’ou over the threat of megapode extinction and encourage a reduction on egg collecting. All three recent surveys have included awareness programmes with schools and community members.

Figure 12. Presentation on malau to Niuafo'ou high school during 2014 survey. (S. Fonokalafi photo).

The third project was to continue translocations to Late Island and possibly Fonualei and monitor success. Since then the establishment of a population of, as yet, undetermined size has been confirmed on the latter.

The Conservation Strategy was developed more recently in 2011 (Lloyd *et al.* 2011). The only actions within it that have been achieved to date are further surveys on Niuafo'ou, Fonualei and Late, and some school visits and community workshops on the former.

4. CURRENT STATUS AND RECENT TRENDS

The IUCN Red List of 2012 lists the Polynesian megapode as 'Endangered' based on the criteria B1ab(v)[4]. Its citation notes that: *'This species is classified as Endangered because it has a very small population restricted to two tiny islands. Although the population on Fonualei, where it was recently introduced, is likely to be stable, the population on Niuafo'ou is suspected to be undergoing a continuing decline, owing to egg harvesting and predation (Baker et al. in press). If a population on the larger island of Late could also be established, then down-listing to Vulnerable may be warranted.'*

4B1ab(v) is defined as 'Geographic range < 5000km^2; less than five locations; continuing decline in the number of mature individuals observed, inferred or projected'.

The global population is estimated to be 680-970 and decreasing in BirdLife International' s latest (2014) spreadsheet on the species but this is based on an assessment made back in 2003 following Watling's (2003) survey on Fonualei. The population is considered to be greater now following a more recent visit to Fonualei (Butler 2013) as detailed below.

Previous estimations for the global population have varied considerably. Weir (1973) considered that the Niuafo'ou population was close to carrying capacity at that time, and numbered >2,000 adults. Bregulla estimated the population on the island to be as few as 100 adults (Ziswiler 1970). Todd (1983) estimated the global population to number around 820 individuals from an area of 500 ha but 1,500 ha of suitable habitat were estimated in extent, giving a total carrying capacity for Niuafo'ou of 2,500 individuals. Elliot (1994) report that the global population was estimated to be 400-800 individuals and considered to be stable. In the most comprehensive and robust population study to date, Göth & Vogel (1995) used playback methodology and estimated the global population to be 188-235 pairs, from a total area of occupancy of 641.5 ha. Furthermore, these authors report that the number of pairs-ha from seven different localities on Niuafo'ou range from 0.1–2.1 pairs. Their evidence also shows that the *Malau* occupies 89% of 719.3 ha of suitable habitat for the species on Niuafo'ou – which they largely attribute to predation on birds and/or over-harvesting by egg collectors.

Two surveys have been conducted on Fonualei Island since the transfer of birds there during 1991-1993. Watling (2003) reported observing 56 *Malau* during a two-day visit which represented a minimum of 38 different individuals, and photographed an active nesting ground. Based on the area of the island, and the potential extent of suitable habitat, he estimated that a population of 300-500 *Malau* could be considered reasonable. In 2012 *Malau* were present in the same area and were found to be abundant in a further site in the north of the island and the population estimated at 600-1000 once all apparently suitable habitat has been occupied (Butler 2013).

Three surveys have also been carried out by the same authors on Late Island and no megapodes detected. Watling (2003) conducted walking transects using playback of calls in the northeast and in 2004 he camped for a week visiting the area around the lake where the eggs were buried (Watling unpubl. data). Based

on his advice, the 2013 survey covered an area further west and included an altitudinal transect to the summit (Butler 2013). Though the full extent of the island has not been surveyed, it was concluded that a population has most likely failed to establish.

4.1 Distribution and numbers of *Malau* nesting grounds on Niuafo'ou

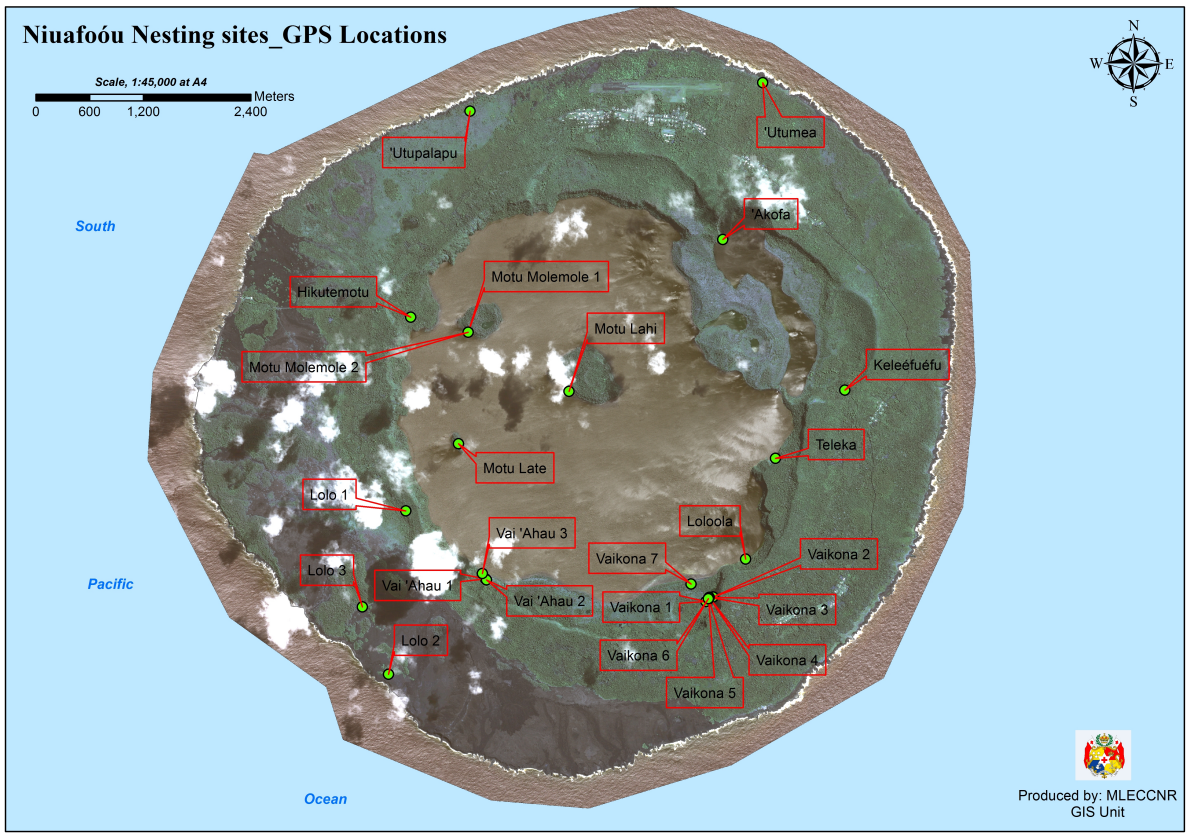

Figure 13: Map of nesting grounds on Niuafo'ou Island, September 2014

Malau bury their eggs in burrows, and usually several such burrows are in vicinity to each other in an area defined as 'nesting ground'. Table 1 presents information on the use of nesting grounds. It shows that after an earlier decline in the number of active nesting grounds, this number has remained unchanged since the detailed study of Göth and Vogel in the 1990s[5].

Table 1: Changes in Nesting Ground Activity over time (* indicates grounds that were active, i.e. used by *Malau* for breeding)

5This conclusion differs from that provided in the 2011 Conservation Strategy which recorded a decline when it appears to have erroneously counted nesting grounds not visited as inactive. It also differs from the findings of the 2012 survey, which reported an increase by assuming that a small island holding malau represented a new nesting ground whereas this appears not to be the case.

NESTING GROUND	Historical	1979	1991-1993	2010	2012	2014
Utupalapu	*		*	Not visited	*	*
Utumela	*					
Lolo	*	*				
Akofa	*	*	*	*	*	*
Kele’efu’efu	*	*	*	*	*	*
Teleka	*	*	*	*	*	*
Lalo’ola	*	*	*	Not visited	*	*
Vai Kona	*	*	*	*	*	*
Vai Ahau	*	*	*		*	*
Hikutemotu	*	*				
Koko	*	*	*	*	*	*
Motu Molemole	*	*	*	*	*	*
Motu Lahi	*	*	*	*	*	*
Total active	**13**	**11**	**10**	**7**	**10**	**10**
Source	Lloyd et al. 2011	(Todd 1983)	Göth & Vogel 1995	Lloyd et al. 2011	MLECCNR 2012	Butler 2014

4.2 Decline in burrow numbers at nesting grounds on Niuafo’ou

An analysis by Butler (2014) (Table 2) shows what appears to have been a significant decline in the numbers of active burrows at nesting grounds between 1991-1993 and 2012-14. Additionally, the 2010 survey found only 10 active burrows at seven nesting grounds, though not all grounds were visited (Lloyd et al. 2011). Different observers are likely to have assessed ‘activity’ differently, and the later surveys were only brief so that some active burrows may have been missed. However all the recent surveys (2010, 2012 and 2014) visited the nesting grounds with experienced egg collectors so the number missed would have been insufficient to account for the differences shown. To minimise this possibility an analysis was done on four compact nesting grounds on the shore of the lake Teleka, Lalo’ola, Vai Kona, Vai Ahau whose full extent was considered surveyed by Butler (2014) and a similar picture was found for three of these

(Table 3). These nesting grounds are described as ‘compact’ because they cover a relatively small area and their borders are clearly defined by dense vegetation where no burrows are found. Hence, at these compact grounds, the number of burrows can be counted more easily than at other nesting grounds, where the burrows are spread over a wider area and some are more likely to be missed during surveys.

Table 2: Burrow activity at nesting grounds 1991-2014

	1991-1993	**2012**		**2014**		
	No. active burrows	**No. active burrows**	**No. inactive burrows**	**No. active burrows**	**No. inactive burrows**	
‘Utupalapu	?[1]	1	0	4	0	[1] *Göth & Vogel*
Akofa	25	3	0	5	7[4]	
Kele’efu’efu	20+	5	0	5	11	
Teleka	6+	2	0	7	1	
Lalo’ola	35+	2	0	3	3	
Vai Kona 1-6	36	12	0	9	7	
Vai Kona 7	7	1	0	3	3	
Vai Ahau	25+	3	0	1	1	
Koko	9+	2	0	2	2	
Motu Molemole	16	2	0	2	0	
Motu Lahi	8+	1	0	3	2	
TOTAL	**187+**	**33**	**0**	**44**	**37**	
Source	Göth & Vogel 1993	MLECCNR 2012		Butler 2014		

(1983) did not list ‘Utupalapu in their analysis. But in a recent discussion Ann Göth identified that they found a few small burrows that did not appear recently active (as confirmed by Butler (2014) and she concluded that the site was probably occasionally used by a very small number of Malau.

Table 3: Comparison of numbers of active burrows in four compact nesting grounds, 1991/93 to 2014.

Nesting ground	No. of active burrows		% change
	1991-93	2014	
Teleka	6	7	+16.7
Lalo'ola	35	3	-91.4
Vai Kona	43	12	-72.1
Vai Ahau	25	1	-96.0
Source	Göth & Vogel 1993	Butler 2014	

4.3 *Malau* numbers on Niuafo'ou

Göth and Vogel (1995) studied *Malau* over an extended period from October 1991 to January 1993, carrying out detailed surveys of several sites, and came up with a population estimate of 188-235 pairs. More recent surveys have been only brief (2-4 weeks on the island) and have located 28-53+ birds (Butler 2014). The procedures differed between surveys so the results are not directly comparable and cannot be related back to the earlier information. Establishing a monitoring system remains a priority.

4.4 Protected status

The *Malau* is currently protected by law under the Birds and Fish Preservation Act from the Law of Tonga, Act No.13, of 1934, G118/31 and 29/33 to the extent that it is forbidden to remove any eggs or birds throughout the year (Göth and Vogel 1995). Lloyd et al. (2011) found that the large majority (96%) of those responding to a questionnaire survey felt that the *Malau* required formal protection.

5. ABILITY TO RECOVER

There is early evidence that Polynesian megapode can recover from a few individuals in a relatively short time. Birds which had suffered substantial losses due to major steam blast eruption in 1886 were already widespread again 11 years later (Friedlander 1899 in Göth & Vogel 1993).

The recently established population on Fonualei has also increased significantly in numbers and spread across the island in around 20 years.

6. OPTIONS FOR RECOVERY

Do nothing – In this scenario the Niuafo'ou population is considered likely to continue to survive at its current low level but be vulnerable to changing circumstances. The Fonualei population is likely to grow to the point that it occupies all the forest on the island, but would also be vulnerable, e.g. to the arrival of invasive species or volcanic events. The species would retain an endangered status.

Manage population on Niuafo'ou – There are options to increase the numbers of *Malau* within the interior crater, primarily through the reduction of egg collecting. Expanding the area occupied by the birds to include secondary forest, plantations and villages on the outer slopes of the crater is impractical given the multiple threats to the birds in this area. An increased population on Niuafo'ou makes it more likely that the Malau will survive volcanic events or other new threats.

Manage population on Fonualei – The key management required is to keep this island free of invasive species that would threaten megapodes which could arrive with visitors or accidentally (e.g. shipwreck). The island needs an appropriate conservation status to allow the Government to manage outside visitors and the Vava'u community who occasionally fish in the area require information so they can manage any risks from their activities.

Establish further populations – establishing a further population would substantially reduce the threat of extinction through exceptional events on the two currently occupied islands. This in turn would be likely to be reflected by a 'downgrading' by the IUCN from 'endangered' to 'vulnerable'. There are two islands likely to have appropriate active volcanic status, Late and Tofua.

7. CONSERVATION STRATEGY: GOAL, AIMS & OBJECTIVES

7.1. Long-term Goal

The Polynesian Megapode is no longer endangered, based on a thriving population on Niuafo'ou and its successful establishment on two other islands. The people of Tonga, and Niuafo'ou in particular, take pride in the megapode as an important part of their culture and are actively involved in its conservation.

7.2. Aims

1) Increase the size of the *Malau* population on Niuafo'ou to levels that approach the island's estimated carrying capacity, and document this increase.

2) Ensure the continued survival of the Polynesian Megapode population on Fonualei

3) Establish self-supporting populations of the Polynesian Megapode on 1-2 other islands

4) Establish the institutional, social and informational framework to support Polynesian Megapode conservation.

Priority should initially be placed on managing the species on Niuafo'ou and Fonualei as transfers to further islands could be relatively costly and their success is uncertain.

7.3. Objectives

Aim 1: Increase the size of the *Malau* population on Niuafo'ou to levels that approach the island's estimated carrying capacity, and document this increase.

Objective 1. Establish a sustainable egg harvesting regime on Niuafo'ou that enables the preservation of local culture and the future survival of the Malau.

Reducing the take of eggs to sustainable levels is the key requirement to increase the *Malau* population.

Objective 2. Minimise other threats to the survival of the Malau on Niuafo'ou.

Controlling other threats such as predatory mammals or the loss or deterioration of habitat will be difficult. However they may need to be tackled if reducing egg harvesting does not lead to a significant increase in population.

Objective 3. Establish and implement a monitoring programme to periodically assess the Malau population on Niuafo'ou.

The numbers of *Malau* can best be monitored using the responses they make to the playback of their calls. Trials are needed to establish an appropriate system that provides data that can be compared from year to year.

Objective 4. Provide the scientific knowledge required to support the population recovery and conservation of the Malau on Niuafo'ou.

Detailed research is required to understand the current dynamics of the current population and quantify the threats to it, to guide management.

Objective 5. Establish an appropriate legislative and policy context for megapode conservation.

Currently egg collecting is banned under legislation but this is not enforced, nor realistically, enforceable. This legislation should be reviewed and revised in light of decisions made about egg collecting and its management on Niuafo'ou.

Aim 2: Ensure the continued survival of the Polynesian Megapode population on Fonualei

Objective 6. Take steps to prevent invasive species that would threaten megapodes, from reaching Fonualei.

The key threat to the Polynesian Megapode population on Fonualei would be the introduction of predatory mammals, e.g. feral cats, ship rats and domestic dogs, or other invasive species that would affect its food supply through damaging forest habitats, e.g. feral pigs and weeds.

Objective 7. Carry out periodic monitoring to check the status of the megapode population on Fonualei.

The island should be visited by a Government team at regular intervals to assess the population, primarily through checking nesting grounds, the extent of occupied habitat, and assessing bird numbers through measuring responses to the playback of calls. The monitoring protocol can be based on that established for Niuafo'ou.

Aim 3: Establish self-supporting populations of the Polynesian Megapode on 1-2 other islands

There are two further active volcanoes in the Kingdom, Late and Tofua Islands, that are priorities for consideration. It can be noted that Steadman (1999) has identified that the Polynesian megapode also once occurred on the limestone islands of Eua and Foa (Ha'apai Group), so the species may, at some time in the past, have been able to raise young without volcanic heat, though these findings may represent birds dispersed from Niuafo'ou. However transfers to such non-volcanic islands seem both unnecessary and highly unlikely to succeed.

Objective 8. Develop a plan for a transfer to Late Island once the planned programme to eradicate Polynesian rats has been successful.

Late Island has been assessed as having suitable geothermally heated soils and was the site for a previously transfer of eggs that seems to have been unsuccessful. This transfer recorded that there are geothermally heated sites along the small crater lake in the west of the island, and these were used to bury the eggs translocated in 1992 (Göth & Vogel 1993). Future translocations should also focus on areas where such geothermally heated sites are available for breeding.

Currently a feasibility study and a draft operational plan for the eradication of Polynesian rats have been prepared by MEECCDMMIC and Island Conservation and funding is being sought. A transfer should not be considered till after the planned rat eradication as there could be a risk of megapodes taking bait.

Objective 9. Investigate the feasibility of establishing a population on Tofua Island.

Tofua Island in the Ha'apai Group is an active volcano 8-10km in diameter that has mature forests on inner and outer slopes of the crater (Göth & Vogel 1993). It is not permanently inhabited but men from nearby Kotu Island visit for a few weeks each year to harvest kava. Göth & Vogel (1993) report temperatures within the normal range of incubation temperatures for Malau, in sandy slopes near the northern beach of Tofua's crater lake. However, further temperature measurements need to be taken before any translocation can being considered.

Aim 4: Establish the institutional, social and informational framework to support Polynesian Megapode conservation.

Objective 10. Increase community support for the conservation of the megapode on Niuafo'ou.

The 2011 Conservation Strategy placed significant emphasis on the involvement of community members including monitoring their own activities, e.g. egg collecting. It also sought to enhance the status of egg collecting and repeated the views of the collectors that their work benefited the birds.

This plan takes a different approach following results and insights gained in the 2012 and 2014 surveys. It recognises that the people of Niuafo'ou take a lot of pride in the presence of malau on the island and that it forms part of their identity. It also recognises that egg collecting is on the decline, reflecting cultural changes on the island and new alternative protein sources such as the Tilapia within the lake and imported foods. It thus aims to engage with the whole community to conserve the *Malau* and not assign a particular guardianship role to the few egg collectors who remain.

Objective 11. Establish a recovery group to oversee the implementation of this plan

The implementation of a threatened species recovery plan is usually coordinated and monitored by a recovery group. This group would be led by an officer of the MEECCDMMIC and potentially include other Ministry staff, biosecurity staff, NGO's, members of Niuafo'ou and Vava'u communities and scientific experts. It would act as a point of contact for international expertise and resources.

Objective 12. Circulate this recovery plan widely and keep it under review

This plan should be circulated internationally so that all with an interest in the conservation of the species can identify opportunities for support (financial or other resources) and involvement.

Objective 13. Develop educational resources.

There is a greater need for environmental education nationally that addresses the plight of Tonga's native habitats and endemic terrestrial species. More specific material on megapodes should be developed primarily for schools on Niuafo'ou, but also made available more widely to increase national knowledge of the species.

Figure 14: Malau presentation to Niuafo'ou primary school, 2010 (H. Lloyd photo).

Objective 14. Establish a national repository for information on the Polynesian Megapode.

The MEECCDMMIC is the appropriate organisation to undertake this role and maintain paper and electronic files on the species.

8. CONSERVATION STRATEGY: WORK PLAN

Objective 1. Establish a sustainable egg harvesting regime on Niuafo'ou that enables the preservation of local culture and the future survival of the Malau.

Action 1.1. Encourage the people of Niuafo'ou to form a *Malau* Management Committee, perhaps under the chairmanship of the Government Representative, primarily to manage egg collecting.

The MEECCDMMIC needs to be formally linked to this committee, either with a representative on the committee or a formal advisory role.

Options for management include:

1. Banning collecting from certain nesting grounds – perhaps through the formal creation of protected areas or special management areas. The islands of Motu Molemole and Motu Late could be a start, as few egg collectors visit them anyway. Surplus young from these islands would

continually disperse to supplement the population inside the caldera. Also valuable would be to ban collecting on one of the grounds on the shore of the lake that used to hold many more burrows in the past such as Lalo'ola or Vai Kona.

2. Allow collecting for a restricted season only. It is unclear if there is a peak nesting season, though Göth & Vogel (1997) did record reduced egg laying in January-August 1992 which might have been related to a period of particularly low rainfall. Peak demand for eggs for traditional purposes may be around the end of the year so a restricted season might need to avoid December/January.
3. Only take a proportion of the eggs from each burrow. It may be challenging for egg collectors to leave some eggs having gone to the effort of digging them out. However all but the most recently laid eggs will hatch successfully if kept warm and then returned to the ground (Ann Göth, pers. comm.).
4. Ban collecting altogether (as some at community workshops in 2014 advocated).

Figure 15: The islands Motu Molemole (foreground) and Motu Late viewed from the crater rim (Butler photo)

The evidence of reduced burrow numbers at nesting grounds within the crater (Tables 2 & 3) suggests that there is an opportunity to significantly increase the population of malau in this area by reducing the take of eggs.

Objective 2. Minimise other threats to the survival of the Malau on Niuafo'ou.

Action 2.1. Work with the community to identify and implement ways of protecting and enhancing *Malau* habitat within the crater, including the islands.

Current threats that could be reduced in this area include fire, which could be discouraged or banned, and dogs. People visiting the lake should be discouraged from taking dogs there. Feral cats are very hard to manage and might be tackled by trapping or poisoning if research (objective 3) showed them to be a major cause of mortality. The community should prevent new threats, as they apparently did in the past by removing goats from the islands.

Action 2.2. Work with the community to identify and implement ways of making the forests on the outer slopes of the crater more suitable for *Malau*.

There are more threats to *Malau* in these forests including feral pigs and more burning and tree clearance for plantations. The priority must be to increase *Malau* numbers within the crater and then look for ways to reduce *Malau* mortality in these other forests.

Objective 3. Establish and implement a monitoring programme to periodically assess the Malau population on Niuafo'ou.

Action 3.1. Design a *Malau* monitoring protocol for Niuafo'ou.

It is essential to be able to monitor the success of any management. Monitoring bird numbers in specific areas using well-defined call playback survey methods is the recommended way to check on *Malau* numbers. The following steps are required to develop a protocol:

a) Consult with experts who have visited Niuafo'ou to determine sites for monitoring, details of calls to be used, the intervals (time and distance) at which the calls will be played, the time of day and the time of year.
b) Repeatedly apply the agreed technique on Niuafo'ou to measure the day to day variation in results. Develop a modified technique if this variation is considered so large that year to year variation will not be detectable.

The protocol should be readily implemented by Government biodiversity staff or members of the island's community without the involvement of overseas experts.

Action 3.2. Implement the monitoring programme on Niuafo'ou at regular intervals.

The programme should be repeated in the year following its development to establish a strong baseline and then every 3 to 5 years.

Objective 4. Provide the scientific knowledge required to support the population recovery and conservation of the Malau on Niuafo'ou.

Action 4.1. Source the funds and expertise required to undertake major field research on the *Malau* to examine its ecology and demographics.

One cost-effective option would be to secure funding to work with an overseas university partner to support a student to undertake an MSc or PhD on the species.

Action 4.2. Support the implementation of this research.

Research is required to underpin the conservation of the *Malau* on Niuafo'ou. Full use should be made of the wide range of equipment available to capture data remotely, such as radio-telemetry, automatic sound recorders and remote cameras.

Research is required on the following key topics:

a) Density of *Malau* in different areas to build an up-to-date distribution and population estimate (in comparison with Göth & Vogel 1995)
b) Developing an indexing method in an area of known population size that can be used for future monitoring
c) Identification and quantification of threats to the chicks and adults
d) Spatial ecology of adults, including numbers using each nesting ground, patterns of habitat use,
e) mortality and productivity rates that can be used to estimate a sustainable egg harvest
f) Dispersal behaviour and survival rates of chicks

The research would also aim to monitor whatever regime is put in place to manage egg collecting and assess its implementation.

Action 4.3. Conduct a DNA-based genetic study[6] of the Polynesian Megapodes on Niuafo'ou and Fonualei.

6During the September 2010 survey feathers were collected from four individual chicks that can contribute to this study. These are stored at Newcastle University, UK together with samples from Göth and Vogel's study and are awaiting study.

This study would assess the levels of genetic variation in each population and assess the levels of inbreeding and likely numbers of founders. It would assess whether birds should be transferred between Niuafo'ou and Fonualei in the future to increase the variability of either population. It could also identify where the founders should be obtained for any future transfers to Late or Tofua.

Action 4.4. Monitor changes in geothermal activity on Niuafo'ou.

This study would assess whether the soils of nesting grounds are cooling or heating to the extent that successful *Malau* egg incubation could be threatened.

Objective 5. Establish an appropriate legislative and policy context for Malau conservation.

Action 5.1. Review current legislation, draft amendments that reflect the current reality and have them enacted in law.

The majority of people on Niuafo'ou know that the species is threatened and formally protected. However, the law has proved impossible to enforce and it conflicts with the cultural practices on the island.

The Birds & Fish Preservation Act 1988 (amended 1989) lists 'Local Name: malau, English name: Megapod' in Schedule 1 as a Protected Bird and it is an offence to take the birds or eggs of 'protected birds'. This needs to be amended[7].

It is suggested that the legislation regarding the megapode should reflect whatever is decided by the Megapode Management Committee regarding the species on Niuafo'ou. The following would be proposed at this point:

- Polynesian Megapode adults and chicks are fully protected on Niuafo'ou. Permits are required to handle birds.
- Polynesian Megapodes are fully protected on Fonualei. Permits are required to handle adults, chicks or eggs
- The harvesting of eggs of Polynesian Megapodes on Niuafo'ou is permitted according to protocols established by the *Malau* Management Committee.

The Polynesian Megapode could then be listed in a Second Schedule of Partially Protected Birds if egg collecting is permitted to continue. Mention of permits is added as scientists and Government staff will need to handle birds in the course

7Note: While amendments are needed for the Polynesian Megapode, the Act should also be updated for other species most of which have names either missing or out-dated.

of research or island transfers, and a permitting system is the best way to ensure that birds are not handled without a good reason.

Note: Whether a *Malau* Management Committee is specifically mentioned within legislation needs careful consideration. Alternatively the management of egg harvesting could be left with the Minister of MLECCNR and he/she would ensure the legislation matched the decisions of the Committee.

Action 5.2. Review whether there are other legislative mechanisms that could contribute to *Malau* conservation on Niuafo'ou.

The 2011 Conservation Strategy proposed reviewing land-use policies and legislation relating to land tenure, agriculture, feral animal control (pigs, cats, and dogs), forestry and habitat restoration, to identify conflicts with or opportunities for *Malau* conservation. However the extent to which such mechanisms operate on Niuafo'ou suggests that this may have limited benefit and the following action addressing the future may be more important.

Action 5.3. Ensure that the conservation of the *Malau* is taken into account in future planning for the development of Niuafo'ou.

One can identify a few potential scenarios for the future development of Niuafo'ou that could have impacts on the *Malau*, e.g. the introduction of new agricultural crops leading to forest clearance within the caldera, or more widespread use of livestock such as goats, or the creation of a wharf that would increase biosecurity risks. To ensure that such impacts are understood and taken into account, the MEECCDMMIC needs to be involved in discussing such developments and Environmental Impact Assessments (EIA's) need to specifically address the *Malau*.

Aim 2: Ensure the continued survival of the population on Fonualei

Objective 6. Take steps to prevent invasive species that would threaten Polynesian Megapodes from reaching Fonualei.

Action 6.1. Develop an appropriate legislative framework to restrict visits to the island.

Every visit to the island carries risks of introducing invasive species of one type or another to this pristine island, as well as presenting safety hazards to those

involved. One way to manage visitation is to provide it with a form of protected area status under legislation, which bans people from landing unless they first obtain a permit from MEECCDMMIC. In New Zealand Nature Reserve or Scientific Reserve would be two possible forms of protected area to be used for an island like Fonualei. This protected area status would be developed in consultation with communities in Vava'u to ensure their support, e.g. particularly of fishermen who use the waters around the island. A requirement of protected area status would be the development of a management plan for the island.

Action 6.2. Develop and implement biosecurity protocols for visitors to the island.

Anyone who receives a permit to visit Fonualei would receive information on the biosecurity requirements that they need to comply with. In some examples, e.g. a tourism boat, visitors might have to be accompanied by a biosecurity officer at their expense to ensure compliance (who could also serve as a guide). There is considerable expertise available internationally (e.g. in New Zealand and Australia) on developing biosecurity plans and protocols for islands, and examples that could be adapted for Fonualei.

Action 6.3. Develop plans for rapid response in the event of a boat getting wrecked on the island.

In the event of a shipwreck a team needs to visit the island as soon as possible with detection and control devices to deal with the possible arrival of invasive species, particularly rats. Equipment and supplies should be held by MEECCDMMIC for this purpose.

Objective 7. Carry out periodic monitoring to check the status of the Polynesian Megapode population on Fonualei.

Action 7.1. Monitor population at 3 to 5-yearly intervals

A team led by MEECCDMMIC should visit the island every three to five years to check on the Polynesian Megapode population. They would check the two areas of forest visited in 2013 to confirm the presence of birds in these areas in good numbers, survey other areas of suitable habitat, and set detection devise and survey carefully for invasive species, particularly rats. [8]

Aim 3: Establish self-supporting populations of the Polynesian Megapode on other islands

8Data should be collected on other bird species including the size and extent of sooty tern colonies.

Figure 16: Late Island (D. Butler photo).

Objective 8. Develop a plan for a megapode transfer to Late Island once the planned programme to eradicate Pacific rats has been successful.

Action 8.1. Develop a transfer plan that reviews previous transfers and addresses a range of issues.

There is detailed information on the previous transfer attempt to Late Island (Göth & Vogel 1993) but little available on the Fonualei one and efforts should be made to contact Dieter Rinke who coordinated this. An assessment is required to try to identify why the previous transfer to Late appears to have failed. One possibility is that the eggs did not arrive in a viable state following the relatively long-distance shift. If this was the problem, a transfer of adult birds might now be considered with Fonualei as a possible additional source. Alternatively, the eggs generally hatched successfully but sufficient birds did not survive to breed and establish the next generation. If this was the problem, international guidelines (below) suggest that a further transfer should not be attempted until the threats to the birds are identified and addressed. The eradication of Polynesian rats would have wide impacts on the island's ecology but whether this would directly enhance conditions for the Megapode is unclear.

Figure 17: Forest interior, Late Island (D. Butler photo).

The transfer plan should follow the international guidelines developed for the Reintroduction of Galliformes for Conservation Purposes (WPA & IUCN/SSC 2009). Issues that need to be covered include:

- Identification of source population(s) - ensuring the transfer does not pose a threat to it and assessing whether a mix of birds from the two current populations would have significant genetic benefits
- Are there any important native species on Late that might be negatively impacted by a megapode transfer
- What combination of adults, chicks and/or eggs to transfer?
- How many transfers to undertake? (e.g. how many unsuccessful attempts would be made before the island is not considered suitable)
- Detailed transfer procedures
- How to monitor to confirm success or failure?

Action 8.2. Put in place similar protection mechanisms to those recommended for Fonualei Island (Objective 6).

Late Island is currently of very high biodiversity value and it should have protected area status and strict biosecurity protocols for visitors. From a megapode point of view these should be in place before a transfer can be considered.

Objective 9. Investigate the feasibility of establishing a population on Tofua Island.

Action 9.1. Visit the island to check on the presence of suitable nesting grounds and forest habitat, what threats might be present.

Action 9.2. Hold consultations with the local communities who utilise the island to assess whether the presence of megapodes would be compatible with their activities and whether they would play a role in the conservation of a population if it was to become established. (Note: egg collecting could not be permitted during this establishment).

Aim 4: Establish the institutional, social and informational framework to support Polynesian Megapode conservation.

Objective 10. Increase community support for the conservation of the Malau on Niuafo'ou.

Many in the Niuafo'ou community are aware of the *Malau* and its threatened status and the majority (89% in questionnaire survey) consider it to be important for the people of the island (Lloyd et al. 2011). The future of the species would be enhanced if they actively supported megapode conservation particularly by adhering to an egg collecting regime with less 'opportunistic' take. The fact that Niuafo'ou was the only island on which the megapode was found was important to them and concern was expressed at 2014 workshops about the establishment of a second population on Fonualei. The message today should be that the people of Niuafo'ou have been successful guardians of the megapode which died out on other islands and their island is still critical to the survival of the species. National support for the conservation of the megapode and other threatened species and habitats needs to be increased through the distribution of awareness materials nationally, particularly on Tongatapu.

Increasing the knowledge of the *Malau* among young people is covered under a separate educational objective 12 below.

Action 10.1 Promote Niuafo'ou as the destination for international visitors wishing to see the megapode and learn of its cultural history.

Community members expressed concern that now megapodes were established on Fonualei, birdwatchers would go there to see them rather than Niuafo'ou. However Fonualei is hard to access, more dangerous for visitors and visitation

would be discouraged for biosecurity reasons. So the tourism sector should be encouraged to see Niuafo'ou as the place to see megapodes, locals could act as guides who take tourists to see the Malau's habitat and egg burrows. The latter do not necessarily need to be dug up, as this may damage eggs and not be in line with the expectation of tourists who are conservation minded. Instead, a model of an egg could be shown together with some diagrams of how egg burrows look like underground.

Objective 11. Establish a recovery group to oversee implementation of this plan

Action 11.1: Identify the individuals to be invited to join this group, form group, appoint a leader and organise annual meetings.

Individuals may be invited because they hold relevant positions in Government or NGO's or communities, or because of their particular interest in or knowledge about the species. Overseas experts should be invited to be part of the group and would participate in meetings remotely (Conference calls, email, etc). These could include scientists who are familiar with the Malau and megapodes in general, and who reside in Australia or New Zealand, such as Ann Göth, Darryl Jones and David Butler, or Huw Lloyd in the UK.

Contact details for the group need to be sent to the Galliformes Specialist Group of the IUCN and their input invited.

Objective 12. Circulate this recovery plan widely and keep it under review

Action 12.1. Send plan to the Galliformes Specialist Group, Birdlife International, IUCN SSC Task Force, Regional conservation organisations, Conservation agencies and universities in New Zealand and Australia, and local, regional and international donors.

Action 12.2. Review the action plan annually to assess progress and identify new issues that need to be addressed.

Action 12.3. Formally review the plan after five years (2019)

Objective 13. Develop educational resources.

Action 13.1. Develop new education materials on the *Malau* for students at both primary schools on Niuafo'ou.

It is proposed that a pilot primary school education programme be developed for both primary schools on Niuafo'ou with an emphasis on the native forest, the *Malau* and other endemic terrestrial taxa that form the basis of many aspects of their cultural heritage and traditional folklore. This should be reviewed after three years with a view to develop suitable materials for the higher education curriculum in the Niuafo'ou high school.

Objective 14. Establish a national repository for information on the Polynesian Megapode.

Action 14.1. Establish physical and electronic file folders for information on the species at MEECCDMMIC.

Action 14.2. Prepare and publish a bibliography on the Polynesian Megapode, including stories and legends about the bird.

Action 14.3. Maintain a list of experts on megapode conservation with contact details.

Acknowledgements

The Ministry of Environment, Energy, Climate Change, Disaster Management, Meteorology,
Information and Communications acknowledges all who have contributed to our understanding of the Malau and encouraged its conservation over many years.

This recovery plan was drafted by David Butler and benefited from comments received from Ann Ann Göth, Huw Lloyd, Mark O'Brien, Sione Tukia and Gianluca Serra. It acknowledges the major contributions of Sione Faka'osi (formerly with the Tonga Community Development Trust), Huw Lloyd (formerly with the World Pheasant Association) and Claudia Torres-Sovero who developed the first Conservation Strategy for the species in 2012.

The development of this plan, together with expeditions to Niuafo'ou Island in 2012 and 2014 and Late and Fonualei Islands in 2013, was funded through the GEF-PAS Integrated Island Biodiversity Project, carried out by MEECCDMMIC, executed by the Secretariat of the Pacific Regional Biodiversity Program (SPREP)

and implemented by the United Nations Environment Programme. This project was very ably coordinated by Ana Fekau and supported by the Minister of MEECCDMMIC Hon. Samiu Vaipulu, CEO Mr. Paula Ma'u, and Mr Asipeli Palaki. Gianluca Serra and Easter Galuvao, provided support and advice on behalf of SPREP.

Members of the Niuafo'ou have been generous with their time supporting the researchers and survey teams who have visited their island to study the *Malau*. They have acted as custodians of the *Malau* which features strongly in their cultural history and island identity. We thank them for those conservation measures that they have applied over the years and encourage them to work with the Ministry to ensure a stronger future for this special bird. The people of Vava'u also have a role in the future of the species now that megapodes are living on the island of Fonualei and we thank them for their support of the work there.

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