STATUS OF BIRDS, PEKA (FLYING FOXES) AND REPTILES ON NIUE ISLAND

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REPORT TO THE SECRETARIAT OF THE PACIFIC REGIONAL ENVIRONMENT PROGRAMME (SPREP) AND THE DEPARTMENT OF ENVIRONMENT (DOE), GOVERNMENT OF NIUE

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EXECUTIVE SUMMARY

During 10–21 September, quantitative surveys were carried out of birds and flying foxes using the same techniques as applied in earlier surveys, and searches carried out for a rare parrot and lizard.

Bird counts showed that the lupe or Pacific imperial-pigeon population has recovered following a decline between 1994 and 2004 though the current hunting rate is considered unsustainable. Miti or Polynesian starling numbers have gradually declined over the period 1994–2012 which is a concern and hard to explain. Rat predation is a possible cause. There was also an indication that pekapeka or white-rumped swiftlet numbers have declined though more investigation is needed to confirm this. We were unable to find any hega or blue-crowned lory though a few individuals were reported to us. Numbers are clearly very low and the next step must be to gain a better understanding of where the species regularly occurs so that management can be applied.

Numbers of flying foxes or peka have increased since the last survey in 2004 following Cyclone Heta and were similar to those recorded in 1998. A three-year ban in hunting after the cyclone appears to have been effective in allowing the population to recover but the current hunting rate is considered unsustainable.

Hunting of lupe and peka is currently managed by defining a 1–3 month annual shooting season and restricting the supply of ammunition. However the season is largely ignored with hunting apparently occurring year-round and illegal importation of ammunition undermines the second approach. Hunting needs to be better controlled if these species are to survive in the long-term.

We were unable to locate the large Olive Small-scaled Skink but were informed of a few sightings including one very recent one so this species persists. Feral cats and rats are likely to have caused its decline and it is clearly now very rare and likely to be lost unless some active management occurs.

The help of the public is needed to identify where the hega and Olive Small-scaled Skink are found. If significant breeding populations can be found then programmes need to be developed to reduce the predatory impact of feral cats and rats and possibly yellow crazy ants.

1 INTRODUCTION

On Niue Island, fruit-eating birds, such as lupe (Pacific imperial-pigeon, *Ducula pacifica*), kulukulu (purple-crowned fruit dove, *Ptilinopus porphyraceus*) and miti (Polynesian starling, *Aplonis tabuensis*), and peka (Tongan flying fox, *Pteropus tonganus*), a fruit-eating bat, are important seed dispersers, and so are important in the ecology of the island's forests (Cox *et al*. 1991, Lee *et al*. 1991). Therefore the conservation of such keystone species is important because their loss may have major implications for the forest ecosystem (Esselstyn *et al*. 2006). For example, there is evidence that fruit bats may disperse seeds widely only when bat density is sufficient to promote competition for fruit. Thus, when bat, and probably lupe, abundance is low they may not disperse seeds adequately. To ensure successful regeneration of the full complement of the Niuean forest flora throughout the island it is essential that fruit-eating birds and the peka are fairly common and visit all forest patches. If these seed-dispersing species become scarce then the forest's ability to recover after cyclones and fires is likely to be compromised.

On 6 January 2004, Tropical Cyclone Heta devastated much of the island of Niue. The forest suffered extensive damage, particularly to the north-western sector, with many trees uprooted and others stripped of branches and foliage. Even though some patches of forest in the southeast sustained little damage, many lupe, kulukulu and peka entered eastern villages in search of food and water after the cyclone, a very unusual behaviour. A survey of forest bird populations using 5-minute bird counts in September 2004 was compared with results from a survey in September 1994 using the same technique to determine the possible impact of the cyclone on their populations (Powlesland *et al*. 2008). Likewise, the peka population was surveyed using dusk counts from prominent landforms in September 2004, and compared with the results of a survey in 1998 using the same methodology and count sites (Brooke 2004). From these surveys it was evident that both lupe and peka populations had declined markedly between the respective surveys. It was not possible to determine whether Cyclone Heta, hunting by people, or a combination of the two were responsible for the decline of these two species.

We were contracted by the South Pacific Regional Environment Programme (SPREP) to carry out further surveys during September 2012 of peka and forest birds, using the same techniques as previously, to determine population trends since September 2004. This report compares the results of these surveys with those from previous surveys, particularly for peka and lupe. In addition, information about other species, in particular hega (blue-crowned lory, *Vini australis*), pekapeka (white-rumped swiftlet, *Collocalia spodiopygia*), and lizards is provided.

2 STUDY AREA

Niue is an isolated raised coral atoll in the south-central Pacific. It is approximately 480 km east of Tonga, 930 km west of Rarotonga, and 660 km south-east of Samoa. Niue is roughly circular (18 x 21 km), 259 square kilometres (25,900 ha) in area, and formed of two terraces. There is a prominent lower terrace at 18–24 m a.s.l. which encircles much of the island. There is a steep rise to an upper terrace at about 55 m a.s.l. in the east and 60–65 a.s.l. in the west. This terrace is generally about 1 km inland. From the crest of the upper terrace the land slopes down towards the island's centre, but is essentially flat across most of the interior at about 30 m a.s.l. Some parts of the coastline, particularly in the west and north, are fringed by a narrow wave-cut platform close to the shore.

Niue may have been inhabited by Polynesians for about 2000 years (Walter & Anderson 1995, Worthy *et al*. 1998.). The population was estimated at 1769 people in 2001 (Richmond-Rex *et al*. 2001) and 1625 in 2006 (Visitor information brochure 2012). Alofi, on the western coast, is the administrative centre and port. In addition, there are 12 villages near the coast, connected by a 64 km long perimeter road (Fig. 1).

Niue is of recent geological origin (Schofield 1959) and formed in isolation from other land masses. All but one species of bird, the introduced moa (feral fowl, *Gallus gallus*), must have flown to the island, even if assisted by storm-force winds. All the species presently breeding on Niue are of western Polynesian origin, and most have originated from Tonga, Samoa or Fiji (Gibb *et al.* 1989). Although the heahea (Polynesian triller, Lalage maculosa) and miti (Polynesian starling, *Aplonis tabuensis*) have evolved into distinct subspecies on Niue, all other species are found elsewhere in the Indo-Pacific region. A notable feature of Niuean birdlife is its lack of introduced species, except for the moa. This is in contrast to other Pacific island groups, such as Fiji and Samoa, where several species have been introduced, sometimes to the detriment of the native fauna and agricultural crops (Watling 2001).

The *peka* or flying fox found on Niue, *Pteropus tonganus tonganus*, is a medium sized bat found throughout the South Pacific. It is also known as the white-collared flying fox, the Tongan flying fox, or the insular flying fox. Three subspecies of *P. tonganus* are recognized. *Pteropus tonganus tonganus*, the sub-species present on Niue, is found in the Cook Islands, Samoa, Fiji, Tonga, Wallis and *Futu*na. *Pteropus tonganus geddiei* is from New Caledonia, the Solomon Islands, and Vanuatu*. Pteropus tonganus basiliscus* is restricted to the islands off the coast of New Guinea (Mickleburgh et al. 1992). Wodzicki and Felten (1975) were uncertain whether the population on Niue and Rarotonga should be considered *P. tonganus tonganus* or a new sub-species because the bats appear to be smaller than those from other islands. *Pteropus tonganus* is highly colonial (Pierson and Rainey 1992). During the day, large groups of bats hang from the same tree or group of trees, known as a roost the size of which can vary in the region from a few individuals to 4,000 or more (Brooke et al, in press).

Niue has a variety of introduced mammals. Two species of rat are ubiquitous; the kuma or Pacific rat (*Rattus exulans*), introduced by the early Polynesian settlers, and the ship or black rat (*R*. *rattus*), which arrived between 1902 and 1925 (Smith 1902, Wodzicki 1971). Mice (*Mus musculus*), dogs (*Canis familiaris*) and cats (*Felis catus*) are common about villages, and feral cats are widespread over the island. Escaped pigs (*Sus scrofa*) are present in some areas of forest.

Although the soils of Niue tend to be fertile, they are shallow (Lane 1994). As a result they are suitable only for the traditional 'slash and burn' cropping techniques whereby garden areas are left fallow for up to 10 years before being reused for one year, unless composted material is added to soil. As a result of the continuing practice of shifting agriculture, much of the island is now a mosaic of varying stages of regeneration, interspersed with cultivated gardens. There are also scattered coconut (*Cocos nucifera*) plantations and two experimental farms each with some pasture.

Conservation of Niue's flora and fauna depends, in part, on the continued presence of habitats that existed before people colonized the island (Richmond-Rex *et al*. 2001). The natural vegetation consists of limited areas of rainforest, with a 20 m high canopy, but much of it has been modified to some degree. Open habitat, covering 30.1% of the island in 1994, included bush gardens under cultivation, and areas dominated by fou (*Hibiscus tiliaceus*) and fernlands, mostly *Nephrolepis hirsutula* (Martell *et al*. 1997). A further 8.7% was covered by coastal forest, which included areas c. 50–100 m from the coast, with generally good cover, but where the trees were stunted by salt spray and strong winds. This coastal forest on the eastern side of the island and on the encircling terrace at c. 60 m a.s.l. was mainly on makatea (rocky ground with many sharp coralline limestone pinnacles up to 5 m tall, and deep holes). Of the total land area, 48.6% was previously in cultivation and is now under regenerating scrub and forest. Just 12.6 % of the island in 1994 was covered by mature tropical forest (Martell *et al*. 1997), concentrated in the triangular area delimited by the villages of Alofi, Lakepa and Hakupu. The largest block is Huvalu Forest, containing two 'tapu' areas which people are forbidden to enter.

Bush garden on Vinivini Track. Photo: David Butler.

3 METHODS

3.1 Five-minute bird counts

In September of 1994, 2004 and 2012, index counts of forest birds were made using the five-minute count technique (Dawson & Bull 1975), an index of 'conspicuousness'. Transects of count stations were along vehicle tracks through mature forest, regenerating scrub (former gardens), and gardens under cultivation. At the start of each trip, the 200 m distance between successive counts stations was measured with a tape-measure or GPS (global positioning system) unit, and the locations marked with flagging tape. At each station all birds seen or heard within a 100 m radius of the observer were noted during a five-minute period.

Transects were established at three sites. The Mutalau transect (20 stations) ran north-south through the middle of the northern end of the island off the Alofi – Lakepa road (Fig. 1). It traversed small areas of gardens and forest, and extensive areas of regenerating scrub. Within the 100 m radius about 12 of the Mutalau stations were a combination of forest and regenerating scrub, the other stations having a combination of forest, regenerating scrub and garden habitat types (Table 1).

Twenty count stations were used along each of the Fue and Vinivini transects in 1994. However, because many trees along the Fue and Vinivini transects had been up-rooted during Cyclone Heta and not cleared, only 14 and 16 count stations were accessible along these transects respectively in 2004. By 2012, the Vinivini track had been cleared (20 count stations accessible), but still just 14 on the Fue track. Four of the count stations along the Vinivini transect were in forest, seven were in a combination of forest and regenerating scrub, and the others were in a combination of forest, regenerating scrub and garden habitats. In comparison, 10 of the Fue stations where in forest, two were a combination of forest and regenerating scrub, and one was in a combination of forest, regenerating scrub and garden habitats.

Figure 1. Niue Island, showing the locations of villages, sealed roads (solid lines), and the three tracks (dashed lines) along which the 5-minute bird counts were carried out.

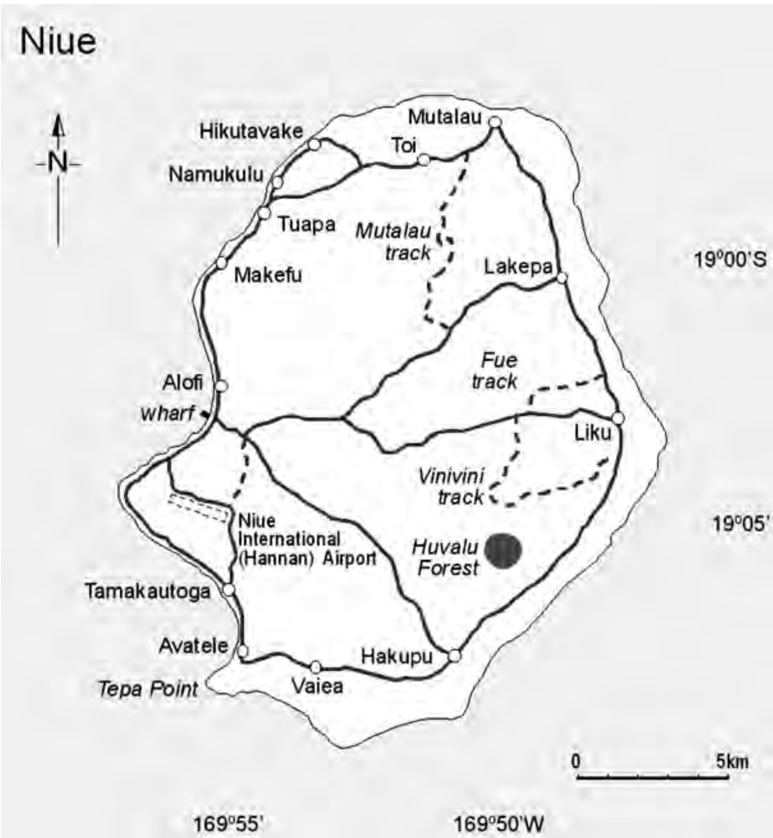


Table 1. Habitat types present within 100 m radius of count stations along the Mutalau (20 stations), Vinivini (16 stations) and Fue (14 stations) transects in September 2012, Niue Island.

Habitat types	Mutalau	Vinivini	Fue
Forest		4	10
Forest & regenerating scrub	12	7	3
Forest & regenerating scrub & garden	8	5	1

When determining whether the differences in the counts for a species between different transects was significant or not, the mean of the means for each station were used. Only stations where counts were taken in all three surveys (1994, 2004, 2012) were included in the analyses. A *t*-test on the station difference for each transect was used to establish whether the mean difference was significantly different from zero. This is equivalent to a two-sided paired *t*-test for a difference between the means for 1994 and 2004, or 1994 and 2012. For each transect, the mean of the included stations means was calculated. Based on Johnson (1995), a *t*-test approach was seen as appropriate for comparing means, in particular means of these station means, in preference to nonparametric approaches. No adjustment for multiple comparisons was made because each of five species on each of three transects was evaluated separately and all the results presented.

3.2 Birds per kilometre

When traveling along roads by day, a record was kept of the number of each species seen, the kilometres travelled along each section of road, and the time of day. Each section of road was categorised as either *lower terrace* (Hikutavake – Avatele along the western side of the island), *upper terrace* (Hikutavake – Avatele along the eastern side), or *inland* (inland roads between Alofi and Tamakautoga, Hapuku, Liku or Lakepa). Observations were made during dry weather, and usually at a speed of 30–40 km per hour. Observations were made from a motor-bike in 1994, and a car in 2004 and 2012. Table 3 summarises the number of kilometres travelled along each of the three sections of road in each year.

3.3 Hega (blue-crowned lory) survey

In 2012, an important aspect of the work was to determine the status of the hega. We enquired of many Niueans during the visit whether they had even seen the species, and when and where they had last seen hega. In addition, using a Sony® MP3 player connected to a RadioShack® mini amplifier/speaker, hega calls were broadcast for 2.5 minutes at eight locations about the island in an effort to stimulate wild hega to call or approach such that they would be detected by us.

3.4 Kiu (Pacific golden plover) survey

On 9 September 2012, most sites where kiu (Pacific golden plover, *Pluvialis fulva*) were likely to occur were visited between 08:00 and 12:00, and kiu were counted. Sites checked for kiu, such as village greens and house front-lawns, were those readily accessible from the road about the island that connects the various villages. In addition, the Paliati High School sports grounds, Niue golf course and Hanan International Airport areas adjacent to the runway (both sides) were visited in order to count kiu present on the extensive areas of mown lawns.

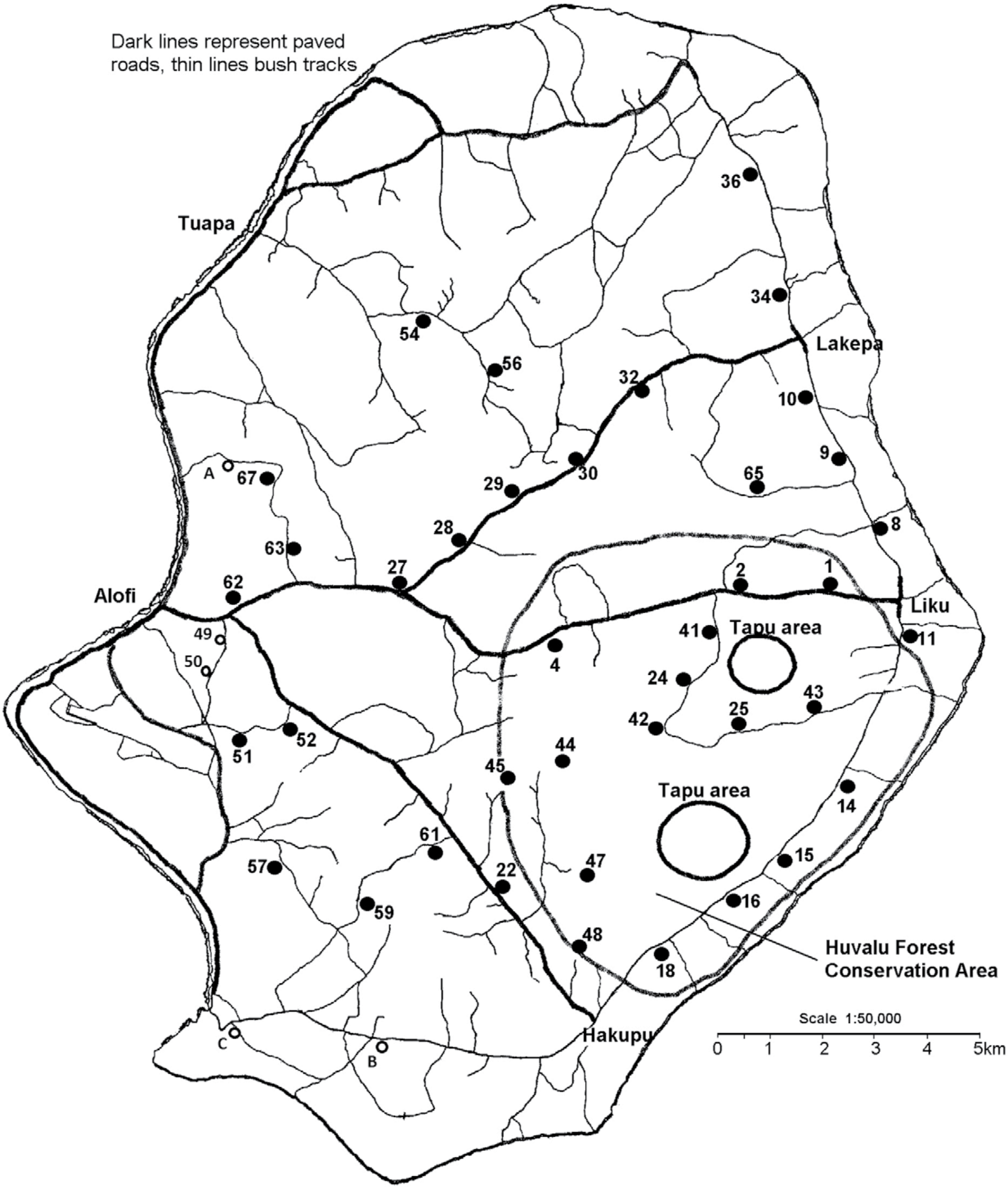
3.5 Survey of hunters and hunting effort

Information was collected from 14 hunters through questionnaires and interviews, and the Police Department provided data on the number of guns registered, the amount of ammunition sold, and enforcement practices relating to hunting regulations.

3.6 Peka (flying foxes) survey

The survey was based on evening dispersal counts conducted between 10–18 September covering 25 sites, 21 of the 'long-term survey stations' (Brooke 1998) and 4 additional ones (Fig. 2). Field surveys were done by the authors, Logo Seumanu, Misa Kulutea, Haden Talagi, Ioane Talagi, Daniel Makaia and Ioane Mamaia.

Figure 2: Survey stations for peka survey. Reproduced from Brooke (1998) Figure 3. (All numbered sites except 51, 54, 56 and 63 were counted. Sites 49 & 50 (Brooke 1998 – all survey stations) and new sites A, B & C were also surveyed).



Counts were made as flying foxes left roost sites and flew to foraging areas using the methodology of Brooke (1998). All surveys were conducted between 1800–1900 hrs until it was too dark to see clearly with the unaided eye. During each count we recorded the number of bats observed in five-minute intervals and the flight direction of each bat. Care was taken to avoid counting the same individual twice within each session and most bats flew directly through the survey areas. All surveys were conducted on dry nights with no to moderate wind.

3.7 Lizard survey

Limited searches were carried out for the rare Olive Small-scaled Skink (*Emoia lawesii*) following a request from Dr Robert Fisher of US Geological Survey to obtain samples for taxonomic analysis and several individuals were interviewed about it. A recent review has re-classified *Emoia adspersa* in Niue as *Emoia lawesii* Gunther and noted it as confined to the island and Au'nuu, Ta'u and Olosega Islands in American Samoa (Schwaner & Brown 1984). The Niuean animals could theoretically be a different species from those in American Samoa. In the course of this work photographs were taken of other species and submitted to experts to update information on the full lizard fauna of Niue.

Regenerating scrub with forest in background, Fue Track. Photo: David Butler.

Forest along Fue Track. Photo: David Butler.

4 RESULTS

4.1 Five-minute bird counts

The results of analyses of the 5-minute bird count data for 1994, 2004 and 2012 surveys are shown in Figure 2 and Table 2.

The pattern of change for heahea has been an increase to 2004 for each transect, and then a retention of abundance to 2012 (Mutalau) or a decline, but not back to 1994 levels (Table 2, Fig. 3). Overall, the increase in abundance from 1994 to 2012 was significant along the Fue (P = 0.03) and Vinivini (P < 0.01) transects (Table 2).

From 1994 to 2012, miti declined significantly along the Mutalau (P < 0.01) and Vinivini transects (P< 0.01), and the means show an overall pattern of slow decline (Table 2), from an average of 2.52 to 1.84 miti per count for the three transects combined over 18 years. A continued decline at this rate could lead to the species extinction on Niue in 50 years.

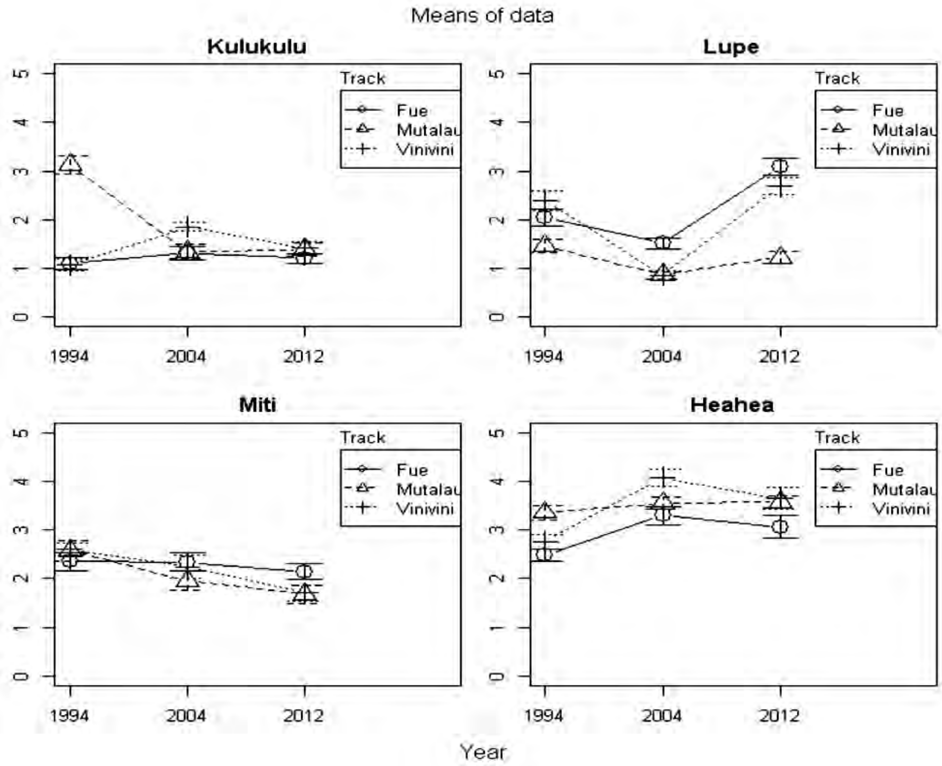
But for a comparatively high count of kulukulu on the Mutalau transect in 1994, the results for this species have been fairly stable during the three surveys (Fig. 3, Table 2). In contrast, the results for lupe along all three transects show declines from 1994 to 2004, followed by recovery to 2012 (Fig. 3). While the 2004 to 2012 recovery along each transect was significant (Fue & Vinivini P < 0.001, Mutalau P = 0.02), for the period 1994 to 2012, the result for only the Fue transect was significant (P < 0.01).

Table 2. Results of *t*-tests carried out on 5-minute bird count data obtained during September 2012, Niue Island, for five forest bird species counted along three transects. *CI = confidence interval

Species	Transect	Period	Change	Lower 95% CI*	Upper 95% CI	*P* value
Heahea	Fue	2004–2012	−0.233	−0.863	0.397	0.438
Heahea	Mutalau	2004–2012	0.025	−0.381	0.431	0.899
Heahea	Vinivini	2004–2012	−0.430	−0.836	−0.024	0.039
Miti	Fue	2004–2012	−0.195	−0.667	0.278	0.389
Miti	Mutalau	2004–2012	−0.281	−0.782	0.219	0.254
Miti	Vinivini	2004–2012	−0.531	−1.099	0.036	0.065
Kulukulu	Fue	2004–2012	−0.109	−0.367	0.148	0.376
Kulukulu	Mutalau	2004–2012	0.038	−0.281	0.356	0.808
Kulukulu	Vinivini	2004–2012	−0.440	−0.790	−0.090	0.017
Lupe	Fue	2004–2012	1.570	1.202	1.939	<0.001
Lupe	Mutalau	2004–2012	0.369	0.062	0.676	0.021
Lupe	Vinivini	2004–2012	1.828	1.401	2.255	<0.001
Pekapeka	Fue	2004–2012	0.024	0.001	0.046	0.040
Pekapeka	Mutalau	2004–2012	−0.181	−0.293	−0.070	0.003
Pekapeka	Vinivini	2004–2012	0.116	−0.041	0.272	0.136
Heahea	Fue	1994–2012	0.551	0.051	1.050	0.033
Heahea	Mutalau	1994–2012	0.223	−0.218	0.664	0.303
Heahea	Vinivini	1994–2012	0.883	0.340	1.425	0.003
Miti	Fue	1994–2012	−0.226	0.689	0.237	0.311
Miti	Mutalau	1994–2012	−0.905	−1.496	−0.314	0.005
Miti	Vinivini	1994–2012	−0.891	−1.367	−0.414	0.001
Kulukulu	Fue	1994–2012	0.091	−0.260	0.443	0.584
Kulukulu	Mutalau	1994–2012	−1.749	−2.193	−1.305	<0.001
Kulukulu	Vinivini	1994–2012	0.344	−0.054	0.742	0.085
Lupe	Fue	1994–2012	1.019	0.356	1.681	0.006
Lupe	Mutalau	1994–2012	−0.235	−0.712	0.241	0.314
Lupe	Vinivini	1994–2012	0.289	−0.206	0.784	0.233
Pekapeka	Fue	1994–2012	−0.056	−0.106	−0.005	0.035
Pekapeka	Mutalau	1994–2012	−0.146	−0.239	−0.054	0.004
Pekapeka	Vinivini	1994–2012	−0.023	−0.279	0.232	0.848

Thus, while the populations of heahea and kulukulu have been fairly stable over the 18 year period of 1994 to 2012, the lupe population has recovered well from the decline that occurred between 1994 and 2004, but the miti population has been in gradual decline

Figure 3. Mean 5-minute bird count results for four forest bird species along three transects (Mutalau – 20 stations, Vinivini – 16 stations, Fue – 14 stations) during September 1994, September 2004 and September 2012, Niue Island.



4.2 Birds per kilometre

Eleven native species were seen while travelling by vehicle about the island during September 2012, including three seabirds (tuaki, taketake and gogo), seven forest species (veka, heahea, miti, kulukulu, lupe, pekapeka and long-tailed cuckoo), and one wader (kiu). In addition, while not counted, the introduced species, the moa (both domestic and feral), was regularly seen at roadsides when travelling through villages and where regenerating scrub or forest was present adjacent to roads.

Table 3 shows the rate (birds seen per kilometre) at which the various species were seen during September 2012 in comparison to the results obtained in September 1994 and September 2004. However, because the data were obtained on a casual basis (no attempt was made to structure the data collection with regard to particular sections of road travelled or times of day), we caution the use of the results. With that in mind, the observations from year to year along inland roads are likely to be reasonably comparable because our accommodation was at lower terrace sites and so in order to access the three transects (Mutalau, Fue, Vinivini) to carry out five-minute bird counts we travelled mainly along two (Alofi – Lakepa, Alofi – Liku) inland roads.

Table 3. A comparison of the number of birds seen per kilometre for 10 species along three sections of road (Lower, Upper, Inland) of Niue Island in September 1994, September 2004 and September 2012.

SPECIES	Lower terrace			Upper terrace			Inland		
	Birds / km			Birds / km			Birds / km		
	1994	2004	2012	1994	2004	2012	1994	2004	2012
Km travelled	117.4	243.1	176.8	206.9	96.9	83.7	194.3	490.3	123.6
Heahea	0.33	0.09	0.11	0.23	0.07	0.18	0.28	0.17	0.12
Miti	0.16	0.07	0.12	0.15	0.24	0.16	0.30	0.13	0.08
Kulukulu	0.04	0.00	0.02	0.19	0.00	0.07	0.07	0.01	0.04
Lupe	0.01	0.00	0.01	0.48	0.09	0.16	0.40	0.07	0.17
Pekapeka	0.97	0.43	0.08	0.42	0.11	0.12	0.37	0.56	0.02
Veka	0.07	0.03	0.05	0.44	0.18	0.18	0.21	0.10	0.10
Kiu	0.37	0.69	0.46	0.34	0.68	0.42	0.10	0.15	0.05
Tuaki	0.06	0.07	0.03	0.12	0.22	0.02	0.06	0.15	0.02
Taketake	0.20	0.25	0.06	0.24	0.10	0.04	0.15	0.09	0.15
Gogo	0.04	0.02	0.02	0.03	0.08	0.05	0.00	0.04	0.04

Therefore, with regard to results from observations along inland roads, both heahea and miti show a similar pattern of decline, markedly from 1994 to 2004, and then less so from 2004 to 2012. Likewise, the results for kulukulu and lupe are similar too, showing a decline from 1994 to 2004, and then an increase to 2012, but not to 1994 levels. The results for pekapeka suggest there has been a marked decline in the population from 2004 to 2012. The results for veka suggest numbers declined between 1994 and 2004, and have been stable since. Although there have been some fluctuations between surveys for the other four species, overall the results suggest their populations have been fairly stable.

4.3 Hega (blue-crowned lory) survey

No hega were heard or seen during the 5-minute bird count observations along the Mutalau (160 counts), Vinivini (160 counts) and Fue (168 counts) transects in September 2012. Nor did hega respond by calling or coming into view in response to the broadcasting of hega calls at eight locations. Locations included sites where the species had been seen in 1994 and 2004 (Vinivini and Fue tracks), at Vaipapahi Farm where there were a variety of shrubs and trees flowering, the lookout at Namukulu Cottages & Spa where the species had been seen a few months previously, and at two sites where several plants of a yellow-flowering legume were present and on which hega have been seen feeding in the past (M. Kulatea pers. comm.). We did not see or hear any hega while traveling by vehicle or walking about the island during our visit (31 August – 21 September). However, we did hear of a few recent sightings of the species. About two years ago two birds were seen in flight near Avatele (M. Kulatea pers. comm.), a guest at the Namukulu Cottages & Spa saw two birds from the lookout and another took a photograph of one there (T. Scott pers. comm.), and there have been irregular sightings of the species about the New Zealand High Commission (M. Blumsky pers. comm.).

4.4 Kiu (Pacific golden plover) survey

On 9 September 2012, 132 kiu were seen while driving the island's ring road, plus while visiting a few large areas of lawn elsewhere. Such a tally is considerably fewer than the 200 plus kiu counted during the previous two surveys (Table 4).

4.5 Pekapeka (white-rumped swiftlet)

From his observations, Misa Kulatea suggested to us that pekapeka numbers had declined on Niue Island since cyclone Heta. As a result we took a closer look at our results (5-minute bird counts along the three transects, numbers seen per kilometre traveled along roads) to see whether they also showed evidence of a population decline. Mean numbers seen per 5-minute bird count show differing results depending on the transect (Fig. 4); since 2004 numbers have declined markedly along the Mutalau transect, there has been a recovery to almost 1994 numbers along the Vinivini transect, and numbers have recovered to some extent along the Fue transect but not to the level of 1994. With regard to pekapeka seen when we were traveling along roads, numbers per kilometre declined markedly along inland roads between 2004 and 2012 (Fig. 5).

Table 4. Comparison of kiu (Pacific golden plover, *Pluvialis fulva*) numbers at various locations on Niue Island on 25 September 1994, 19 September 2004 and 9 September 2012.

Locations	**1994**	**2004**	**2012**
Alofi south to airport (lawns + roads)	1	6	0
Niue Sports Ground (golf course)	42	45	0
Airport front lawns	9	9	0
Airport runway & adjacent lawns	9	20	72
Alofi south, including museum and hospital*, lawns	0	10	0
Tamakautoga to Alofi south	4	2	0
Tamakautoga	1	/	1
Avatele	16	5	1
Niumaga (Island style)	2	1	0
Vaiea and farm paddocks from road	14	14	0
Hakupu	6	6	3
Hakupu to Liku	1	0	0
Liku	30	27	13
Lakepa	26	6	14
Lakepa to Mutalau	0	/	2
Mutalau	4	5	4
Toi – Makauga	8	6	5
Vaipapahi Farm	8	4	1
Hikutavake	2	4	2
Namukulu	3	4	2
Hio (VJ's)	/	/	0
Tuapa	4	9	3
Palaha	0	/	0
Avaiki (Sails)	0	1	0
Makefu	5	4	2
Alofi north lawns and road	16	5	2
Paliati High School	15	12	5
Alofi central	0	1	0
Alofi Primary School	/	0	0
TOTAL	226	206	132

* Museum & hospital were damaged by Cyclone Heta in January 2004, and subsequently removed / not counted

Figure 4. Mean number of pekapeka seen during 5-minute bird counts along the Mutalau (20 stations), Vinivini (16 stations) and Fue (14 stations) transects in 1994, 2004 and 2012, Niue Island.

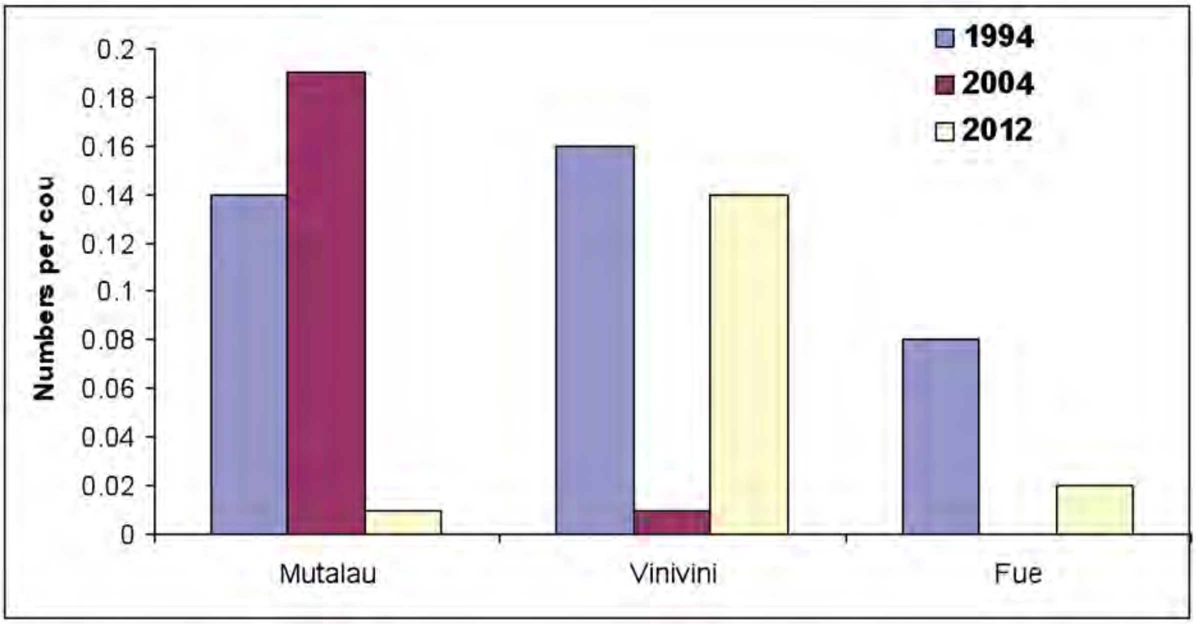
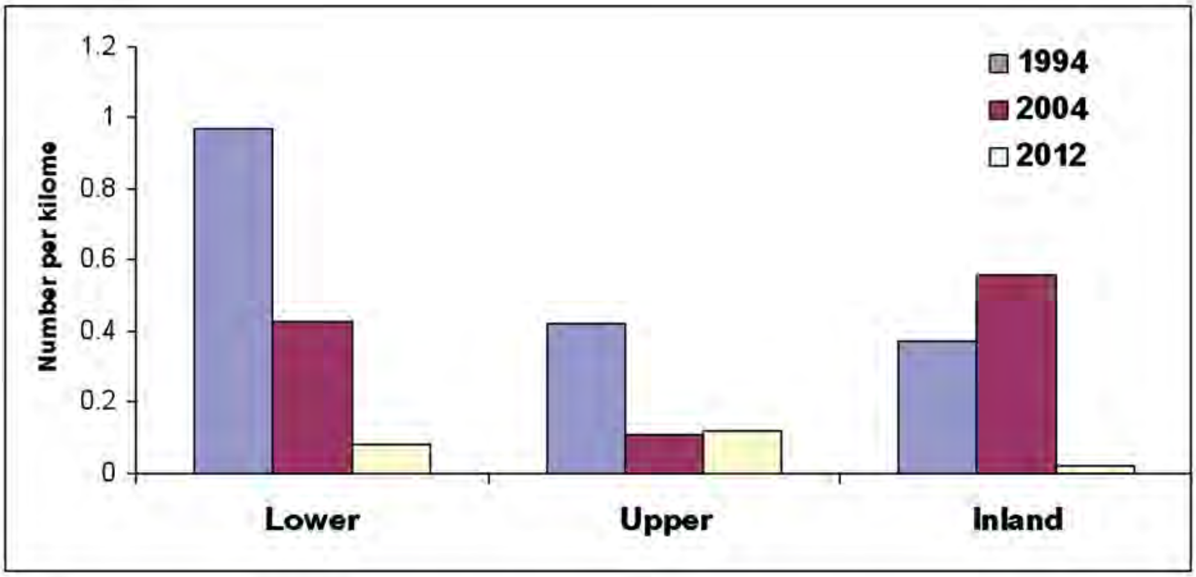


Figure 5. Number of pekapeka seen per kilometre traveled along three sections of roads (lower terrace, upper terrace and inland) during September 1994, September 2004 and September 2012, Niue Island.

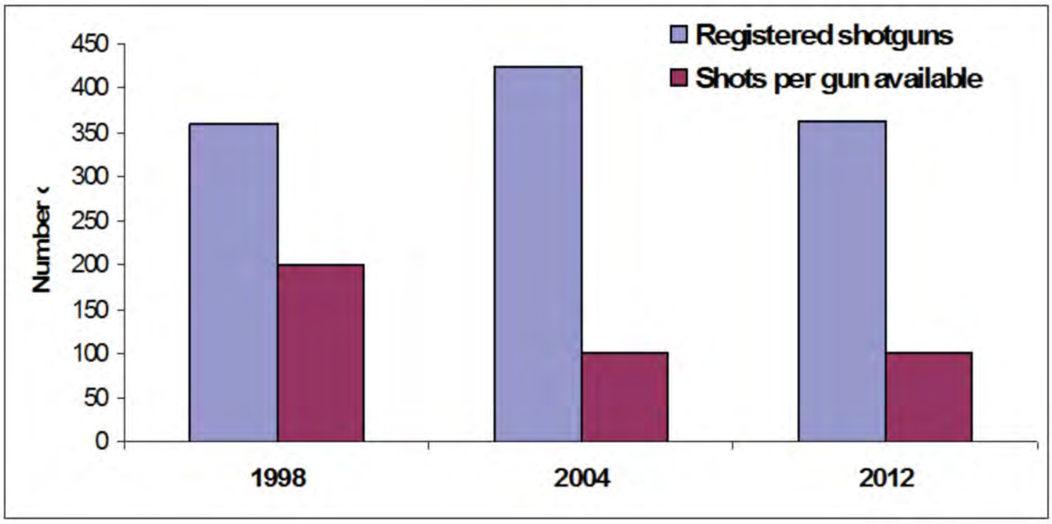


4.6 Hunting effort

We received 14 completed questionnaires from hunters who between them shot an estimated 254 to 284 peka during the 2011/12 year – an average of 18–20 animals each.

Police information records that 362 guns were registered for the 2011/12 season: 267, single-barreled shotguns, 47 double-barreled, 32 pump action, and 16 semi-automatic. This was a very similar number to those registered in 1998 (Fig. 6). One hundred rounds of ammunition were available for purchase per gun for use for hunting peka and lupe, which meant that overall there were fewer shots available than the two previous years surveyed: 36,200 compared to 42,500 in 2004 and 72,000 in 1998.

Figure 6. Numbers of registered guns and ammunition available (source: Police Department).



While the greatest amount of hunting is undoubtedly done during the legal hunting season (typically December-January), out of season hunting is an accepted practice and there is no enforcement of the hunting season regulations. We heard shots at dusk on 43 occasions during the dispersal counts. One individual described the Hakupu area as 'like a war zone' because of the amount of peka shooting occurring.

We were advised by the Police Department of concerns of the illegal importing of ammunition, most likely in containers. For the past few seasons only one type of ammunition has been sold, a 'Buffalo' brand with a clear casing. So any others were most likely illegal imports.

We located 119 spent cartridges on the 3 bush tracks used for bird surveys and on roadsides when conducting peka surveys of which 83 (67%) were Buffalo and 40 (33%) other coloured brands. We don't have information on how long a cartridge lasts, so some of the coloured ones may have come from legal distributions in the past but others were clearly recent.

Table 5 records the duration of shooting seasons since 2004/05 beginning with a 3-year ban on hunting in response to Cyclone Heta. The system for determining the duration of the season is that the Police Department makes recommendations and the Environment Department provides comments which Cabinet then considers in making a decision.

Table 5 Duration of lupe and peka hunting seasons 2004–2011.

Year	Season	No. of Months
2004/05	None – complete closure	0
2005/06	None – complete closure	0
2006/07	None – complete closure	0
2007/08	7 May – 8 June, 1 Dec – 31 Jan	3
2008/09	1–31 Dec	1
2009/10	1 Dec – 31 Jan	2
2010/11	Not reported	?
2011/12	1 Dec – 31 Jan	2

4.7 Peka (Tongan flying fox)

A total of 30 dispersal counts were conducted and 623 peka recorded this survey (Annex 1) and results are compared with previous surveys in Table 6). Brooke (1998) identified that the data are non-normally distributed with few to no bats counted at most sites so the mean number of bats per survey cannot strictly be computed. However maximum counts can be considered comparable.

Table 6: Total counts of peka during three surveys.

	1998	2004	2012
No. counts	70	27	31
No. bats	1715	60	623
Max no. bats/count	225	12	188

Total counts also include some repeat counts (4 in 1998 and 3 in 2012). More comparable are counts conducted at long-term monitoring sites identified by Brooke (1998) (Table 7). 414 bats were counted at 21 of the 22 long-term monitoring stations this survey. (One station was not counted due to poor road access but this only held 2 bats in 1998 and was also omitted in 2004 so was not a significant omission). This represents a significant increase since the low point of 2004 after Cyclone Heta and is similar to the results of 1998.

Table 7: Counts of peka at long-term monitoring sites.

	1998	2004	2012
No. stations	22	9	21
No. bats counted	447	13	414

Brooke (op. cit.) noted that direct comparison of counts at the different sites is of little value as roost sites change when food resources change or they are disturbed by people. But taken together the long-term monitoring sites cover access to and from the main areas of forest so provide a comparable index of the population at any given time. (Brooke (pers. comm.) noted that she did not follow the long-term points in the 2004 survey after cyclone Heta because the numbers were so low that more counts were needed.)

Peka were concentrated in the central part of the island, as in the 1998 survey, with two apparently large roosts located in the northern part of the Huvalu Forest and southwest of Lakepa. Smaller roosts were considered to be located southeast of Alofi and near Avatele (a site not apparently covered in previous surveys) (Fig. 2).

Ten of the long-term monitoring sites are in and surrounding the Huvalu Forest KBA (Table 8) and results suggest that peka numbers may be higher in this area than in the past.

Table 8: Peka counts at Huvalu Forest

	1998	2012
No. stations	10	10
No. bats counted	140	215

Dispersal times

Peka began to exit the roost areas at c.1800h and the greatest numbers were seen dispersing between 1830h and 1840h (37.6%) (Table 9).

Table 9: Dispersal times of peka when leaving roosts

Time Interval (pm)	No. of bats counted (%)
6.00–6.10	42 (7.0)
6.10–6.20	55 (9.1)
6.20–6.30	119 (19.7)
6.30–6.40	227 (37.6)
6.40–6.50	139 (23.0)
6.50–7.00	21 (3.5)

Only a single bat was observed between 6.00–6.10pm during 25 of the surveys, but in one 41 bats passed during this interval. This survey was a repeat of one conducted eight days earlier when the first bat was not seen till 6.15pm.

Number of colonies

Based on the number and direction of bats seen in all surveys, we identified the location of two sizeable colonies (>100 bats) and two to three small ones.

4.8 Lizard survey

The Olive Small-scaled Skink is a much larger skink (snout vent length (SVN) 81:110mm) than the more common *Emoia cyanura* (SVN 39:56mm) (Brown 1991) and *Cryptoblepharus poecilopleurus* so we asked many individuals if they had seen such a skink. Only two people had seen individuals in recent years and only two or three more were aware of its existence. Three were seen on the coast between Vaiea and Hapuku (c.2010) (Misa Kulutea pers. comm.) and one at Coral Gardens, Makefu this year (Stafford Guest pers. comm.).

Searches were carried out along the coast at Coral Gardens, Namukulu Cottages and Hikutavake including turning over sheets of corrugated iron. In addition c. 50 trap-nights of trapping were carried out at Coral Gardens with glue traps. No individuals were found.

Photographs were taken of 5 species: 3 skinks *Emoia impar* (including a black melanistic form), *Emoia cyanura* and *Cryptoblepharus poecilopleurus*, and 2 geckos *Lepidodactylus lugubris* and *Gehyra oceanica*. We also confirmed that others have heard the introduced house gecko (*Hemidactylus frenatus*) at two sites though we did not hear it at Namukulu.

Mokotaliga Emoia impar, Dark-bellied copper-striped skink. Photo: Ralph Powlesland.

5 DISCUSSION

5.1 Lupe

The 2012 5-minute bird count survey results of the lupe population along each of the three transects indicates that the population has recovered following its decline between 1994 and 2004 (Fig. 3). It seems that there was a three-year moratorium on lupe hunting following Cyclone Heta. We assume that this moratorium was an important factor, along with forest recovery from defoliation and loss of branches caused by Cyclone Heta, in the recovery of the lupe population. While the human population on the island declined during 1994–2012 (estimated at 1769 in 2001 (Richmond-Rex *et al*. 2001), 1625 in 2006 (a visitor information brouchure), and c.1420 in 2012 (M. Blumsky, New Zealand High Commissioner to Niue, pers. comm.)), we suspect that this did not result in a major reduction in harvesting of lupe. While the number of registered shot guns declined by 11.8% between 2004 and 2012 (425 and 362 respectively, Police Department, Government of Niue), the amount of ammunition remained at 100 per gun. Thus, at least 36,200 shells were available for hunting of lupe and peka each year during this period. In addition, it seems that there is some illegal importation of shells, and that harvesting of lupe occurs outside the legal shooting season (usually December-January).

To calculate the number of lupe on Niue in 2012, we have used the same methodology and assumptions as were used in Powlesland *et al*. (2008). We assume that about 33.5% or 8755 ha of Niue's land area was suitable for lupe (coastal forest, mature tropical forest and late-stage regenerating forest (Martell *et al*. 1997), and that there were 6.00 lupe per hectare in September 2012 as determined from the figure of 2.37 per 5-minute count area of 3.14 ha (radius 100 m), but with only 50% of the area being suitable habitat, and that only 25% of lupe were seen or heard. This gives an estimated total of 52,530 lupe in September 2012.

Fourteen hunters surveyed in 2012 indicated that they shot 48 lupe each during the 2011/12 season. This would result in a harvest of about 8700 lupe (assuming the 362 licenced guns represented 181 hunters with 2 guns each). Such a harvest represents 17.4% of a population of about 50,000 lupe. That would leave about 20,000 pairs of lupe to replace about 10,000 (shot lupe plus some natural mortality) prior to the next hunting season, requiring 50% of pairs to nest successfully (usual clutch size is one egg (Watling 2001)). We are not aware of any studies into the nesting success of lupe, but such a high success rate is usually not achieved by the New Zealand pigeon (*Hemiphaga novaeseelandiae*) in forests where introduced predators are unmanaged (Innes et al. 2010),

The long-term health of the lupe population, such that it is available for harvest each year, depends not only on the continued existence of a variety of scrub and forest habitats, but also on appropriate hunting regulations (duration of hunting season, number of firearms per person, number of shells per person) and their enforcement. Given the likely vulnerability of the lupe population to unsustainable hunting practices, particularly as a result of the use of semi-automatic firearms, hunting outside the legal season, the use of extra ammunition as a result of illegal importation, and following major cyclones when some birds venture into villages to search of food and water), regular monitoring of the population (every five years) would be prudent. The present method involving 5-minute bird counts at stations along three forest tracks, that was carried out in September in each of 1994, 2004 and 2012, provides a useful database for comparison with future data.

5.2 Miti

The 5-minute count results show a gradual decline in the miti population along all three transects from 1994 to 2012. This is of concern because none of the populations of the other three fairly common forest bird species that were monitored over the same 18 year period has shown the same pattern. While miti feeds on invertebrates to a limited extent, its diet is mainly fruit (Feare & Craig 1999, Watling 2001), as are the diets of lupe and kulukulu (Gibbs *et al.* 2001). Therefore, a change in the availability or quality of fruit on Niue does not seem to explain the decline in the miti population. One feature that sets this species apart from the other three is its habit of nesting in tree or coconut palm cavities. Prior to the arrival of the kuma or Polynesian rat (*Rattus exulans*), probably with Polynesian setters, and the ship rat between 1900 and 1950 (*R. rattus*) (Wodzicki 1969), there was probably no predator that was able to assess nests of miti. The ship rat, in particular, is an agile climber and is a known predator of nesting adult birds of some species, and their eggs and young in New Zealand (Innes 1990, Innes *et al*. 2010). Cavity-nesting birds of the size of miti (c. 50–60 g, Kinsky & Yaldwyn 1981) are particularly vulnerable to ship rats (adults males can be > 200 g, King 2005) because occasionally a parent bird is killed in the nest with its eggs or chicks, being unable to escape past the predator entering via a single narrow entrance (Hicks & Greenwood 1989). As a result of its depredations, the ship rat has caused the extinction of forest bird species on several islands that were previously rodent-free (Innes 1990).

To determine whether rat predation is a possible cause of the apparent miti population decline, a first step could be to assess whether miti will use artificial cavities (boxes) to nest in when they are erected in forest habitat occupied by miti. Having a door to each box would enable the contents to be checked readily. If miti do use boxes for nesting in then a comparison of their nesting success in rat-proof boxes with those that are not, along with the survival of marked adults during the breeding season, would determine what impact ship rats are having on the miti population.

5.3 Pekapeka

While not definite, there is an indication from the results of 5-minute counts along forest tracks and the numbers of birds seen when driving Niue's roads that the pekapeka population may have declined. As a result the trend in the pekapeka population deserves further investigation. This would require further counts of pekapeka numbers during future forest bird assessments, such as the 5-minute bird counts along the Mutalau, Vinivini and Fue transects. While the methodology of recording numbers of birds seen when driving along various sections of the island's roads has been useful in helping to assess the status of this species, a more robust approach is needed. This could involve designating specific sections of roads for counts, e.g. lower terrace (Tuapa – Alofi, quarry – Tamakautoga), upper terrace (Hakupu – Liku, Liku – Lakepa), inland (High School – Lakepa, High School – Liku, High School – Hakupu), and getting Department of Environment staff when traveling these sections of roads to record their counts and associated data (observer, time of day). The observations could be restricted to one month of the year – September.

It is not obvious to us why the pekapeka population might be declining. Other than short term declines in food availability, such as during a drought, it seems unlikely that there would have been a major and long term change in the availability of foods of pekapeka (aerial insects and drifting spiders (Higgins 1999)) on Niue to cause a population decline. Pekapeka would seem relatively immune to predation since there are no aerial predators (hawks and falcons) on the island, and pekapeka usually roost and nest in caves on steep walls ensuring that few, if any, nests or birds are accessible to predators (Higgins 1999). The one situation where pekapeka are vulnerable to predation is when exiting and entering caves via narrow entrances. Cats have been known to wait at cave entrances and take birds in flight as they enter or exit, and that such depredations have been blamed for population declines elsewhere (Higgins 1999). Since feral cats are widespread on Niue this is a possible cause should the population be in decline there. Investigating this possibility would involve visiting caves that are known to have been used by pekapeka in the past, checking whether they are still occupied, and looking about the entrance for sign of predation (pekapeka feathers, wings or feet discarded by feeding cats).

5.4 Hega

There has been a dramatic decline of the hega population on Niue. During the 1940s and 50s the species was common, so much so that it was snared at coconut palm flowers, and flocks were large enough that they were fired into with shotguns to obtain these small birds for food (M. Kulatea pers. comm.). However, by 1972 the species was already uncommon (Kinsky & Yaldwyn 1981). During our visits (1994, 2004, 2012) to Niue to carry out bird surveys, our infrequent sightings of hega suggest the species is endangered, as indicated in 2000 (Powlesland *et al*. 2000). During our 5-minute counts along the Mutalau, Vinivini and Fue tracks during

September in 1994, 2004 and 2012, very few records of hega were obtained: one on the Fue track in 1994 (470 counts from the 3 tracks), five on the Fue and Vinivini tracks in 2004 (474 counts), and no sightings in 2012 (488 counts). Likewise, very few incidental sightings of hega were obtained while traveling and walking about the island during our visits: 1 in 1994, 9 in 2004 and none in 2012.

That the hega has declined to such low numbers while most other forest bird species have remained relatively common suggests that hunting by people, impacts of cyclones on its habitat, and the reduction in forest area are unlikely to have been major causal factors. Other possible causes are an introduced disease, honeybees competing with hega for nectar and tree cavities for nesting in, or predators taking adults, eggs and chicks. There is no evidence of a disease outbreak in hega, although it would be difficult to detect given the scarcity of the species. The most likely cause of the decline is a combination of competition for nectar sources and nest sites with bees, and predation at nests, particularly by ship rats. The ship rat is an agile climber and is a known predator of nesting adult birds of some species, and their eggs and young in New Zealand (Innes 1990, Innes *et al*. 2010). Cavity-nesting birds, such as hega, are particularly vulnerable to ship rats because occasionally a parent bird is killed in the nest with its eggs or chicks, being unable to escape past the predator entering via a single narrow entrance (Hicks & Greenwood 1989). As a result of predations, the ship rat has caused the extinction of forest bird species on several islands that were previously rodent-free (Innes 1990). Given the apparent decline in hega since 1994 as evident from our 5-minute bird counts, and the species likely vulnerability to competition and predation during nesting, we expect that without concerted conservation management in the near future the hega will become extinct on Niue.

The first requirement towards management of the species is a better understanding of where on Niue the species regularly occurs. This would enable conservation management, such as pest control and/or capture of birds for captive management, to be focused in a relatively small area. The people of Niue could contribute to such hega conservation efforts by reporting the dates, locations and numbers of birds seen during sightings. It is hoped that the production of a poster about threatened species of Niue, containing information about the identification of the species and requesting reports of sightings, will assist this process.

5.5 Kiu

That fewer kiu were count on 9 September 2012 (132) than on 25 September 1994 (226) or 19 September 2004 (206) relates to the timing of the specie's migration. While no detailed study has been carried out into the timing kiu migration to and from Niue, movements of Australian birds suggest that the majority of those that spend their non-breeding season on Niue would depart during April-May, and return during August-October (Marchant & Higgins 1993). Therefore, the fewer kiu present on Niue in September 2012, compared with in 1994 and 2004, probably reflects that the survey was undertaken 10–14 days earlier in 2012 than previously at a time when many kiu are returning to the island. Thus, the results of the 2012 survey are not comparable with those of 1994 and 2004. If the aim of such a survey was to determine the maximum number of kiu that occupy Niue, and to determine population trends over time (e.g. impact of climate change) then the survey should be carried out after migration to Niue has been completed, such as during December or January.

5.6 Peka

Population changes

Peka numbers have clearly recovered since the low recorded in 2004, eight months after the devastating cyclone Heta, and are similar to those recorded in 1998 (Brooke 1998). Reporting on that survey, Brooke reviewed earlier literature on the species in Niue. In the early part of this century, flying foxes were reported to be numerous (Loeb 1926). After the cyclone of 1960, the flying fox population declined substantially and in 1968, Wodzicki and Felten (1975) reported that the population was still quite low. Following the 1998 survey Brooke & Tschapka (2002) estimated the population at 2040–4080 bats and noted that Niue could support a much larger population based on densities recorded in other Pacific Islands. The low numbers observed in 2004 represented a 95% decline since 1998 (Brooke 2004) and were attributed to the impacts of the cyclone (thirst, hunger, and shooting and predation by cats and dogs of weakened animals spending time on the ground) and unsustainable levels of hunting over previous years.

The recovery since 2004 is likely to have been related to increased productivity as the forest condition improved and reduced mortality through hunting. Hunting was banned for three seasons following Cyclone Heta and a few hunters indicated that they have not hunted peka since because of the lowered numbers.

In 1998 three roosts with several hundred peka each were identified (Brooke 1998) and we located two such roosts. There was a suggestion that there may be more smaller roosts present around the island in 2012 as only 2 (9.5%) of the counts of the long-term monitoring sites recorded no bats compared to 7 (31.8%) in 1998.

It is quite difficult to use information from hunters to try to gauge hunting pressure. In 1994 an Environmental Officer in an interview suggested that 300–500 bats were shot during the month-long hunting season in each of ten districts for a take of 3,000–5,000 animals. However an individual hunter estimated that about 60 hunters shoot around 20 bats each season, for a lower take of c.1,200 bats (Grant 1994). In 1997/98, surveys gave an average of 21.3 bats shot per hunter but Brooke considered this a high figure because the written questionnaires were preferentially given to hunters known to be good shots and revised a total estimate to 1,000 – 1,500 bats killed (Brooke 1998). In 2012 hunters surveyed shot an average of 18–20 bats, very close to the hunter estimate in 2004 and the 1998 result. Similar numbers of guns were registered in 2012 as in 1998 so it seems reasonable to assume a similar number of people hunted bats and killed a similar 1000–1500 in total. However there was half the ammunition available (100 rounds/gun compared to 200/gun in 1997/98) so the actual take may have been lower than this.

Brooke & Tschapka (2002) calculated that the maximum sustainable harvest was 9.97% of the population. Based on their population estimate of 2040–4080 peka this equated to 203–407 individuals, well below the 1000+ that we consider were shot in 2012. This suggests that the current level of hunting is unsustainable and the fact that peka numbers have recovered to around their 1998 level was largely due to the 3-year hunting ban. Measures are clearly needed to reduce hunting if peka are going to thrive in the long-term.

5.7 Management of hunting

There are various measures that can be used to manage hunting. The first is the timing and duration of the season. Some suggested that the typical December-January season was too early as a proportion of the population were breeding (carrying young) at this time. However whether this is a significant proportion indicating a defined breeding season, or whether as in American Samoa *P. tonganus* bears young throughout the year (Brooke 1997) is not known. (Note: Young bats are carried by the mother until they are able to fly at 2–3 months of age). Moving the season away from the Christmas/New Year holiday period would be unlikely to be supported even if it made biological sense. Keeping the season to one month (December) like in 2008/09 or no more than two (Dec/Jan) would be beneficial.

However managing the issue through a defined season is largely nonsense if this is widely ignored and people shoot year-round or whenever it suits them. This is clearly the case based on our observations and those of previous studies and everyone knows it. Such a situation is not helpful for the integrity of the legislature, for the work and reputation of the Police Department, or for the flying foxes. Addressing this is considered a priority.

Another approach is to manage the situation by restricting the number and types of guns and ammunition. There are several aspects to this. Firstly it was suggested to us that only a proportion of guns were registered and this could be tightened up. The approach of registering owners rather than guns was apparently tried a few years ago and did not prove helpful. Secondly, there clearly has been an increase in the numbers of semi-automatic weapons, allowing multiple attempts to shoot a bat as it flies overhead, and consideration could be given to restricting or banning these. Thirdly the amount of ammunition available in any season is currently related to the budget available, whereas it would be better if was defined to ensure a sustainability of harvest. There should be no increase from the current 100 rounds/gun level.

Managing hunting by restricting the amount of ammunition available only works if illegal imports can be stopped. It was suggested by the Police that inspections of containers and the penalties for anyone caught needed to be increased.

5.7 Reptiles

Niue's National Biodiversity Strategy and Action Plan (Richmond-Rex et al. 2001) quotes Wodzicki (1969) as recording five species of terrestrial reptiles on Niue, two nocturnal geckos (*Gehrya oceanica*) and (*Lepidodactylus lugubris*) and three diurnal skinks (*Emoia cyanura*, *Ablepharus boutonii poecilopleurus* and one he noted as *Emoia adspersa*).

Recent communication with herpetologists coordinated by Robert Fisher identifies that there are 9 species here as follows:

Geckos:

Lepidodactylus lugubris – Mourning Gecko

Nactus pelagicus – Pacific Slender-toed Gecko

Gehyra oceanica – Oceanic Gecko

Hemidactylus frenatus – House Gecko (a recent introduction)

Skinks:

Emoia cyanura – White-bellied Copper-striped Skink

Emoia impar – Dark-bellied Copper-striped Skink

Emoia lawesii – Olive Small-scaled Skink (previously considered *Emoia adspersa*)

Lipinia noctua – Pacific Moth Skink

Cryptoblepharus poecilopleurus – Snake-eyed Skink (formerly *Ablepharus boutonii poecilopleurus)*

The Olive Small-scaled Skink is clearly a major conservation concern as it is clearly very rare. Our results suggest that it is restricted to coastal areas, but these are also where people are more likely to see them. In the past they have been found in the heads of coconut trees by men climbing them to collect nuts. Deploying glue traps well up on such trees in areas where one has been sighted would be a useful survey technique as this will keep them out of reach of the smaller skinks, though geckos will be caught. It seems likely that feral cats and ship rats are the key threats to the survival of this species and it is likely to be lost unless these can be managed.

The yellow crazy ant (*Anoplolepis gracilipes)* an alien invasive species appears to be found in a patchy distribution in Niue but is likely to spread across the whole country if unchecked. It poses a threat to the country's lizards and invertebrates including the iconic coconut crab (*Birgus latro*) and information should be collected on its distribution and spread.

The spread of the House Gecko may threaten one or more of the native geckos and this situation should be monitored.

6 RECOMMENDATIONS

6.1 Lupe

6.1.1 That the lupe population continues to be monitored at about 5-yearly intervals using the 5-minute count technique at stations on the Mutalau, Vinivini and Fue tracks for comparison with the previous data sets obtained in 1994, 2004 and 2012.

In order to encourage the long-term sustainable harvesting of the lupe population:

6.1.2 Enforce the annual hunting season such that lupe are not hunted at other times of year.

6.1.3 Limit the number of shotguns (2) and ammunition (100) available to each hunter per hunting season.

6.1.4 Ban the use of semi-automatic shotguns for the hunting of lupe.

6.1.5 Stop the illegal importation of ammunition.

6.1.6 Ban hunting of lupe after cyclones and other natural disasters (fire), that are destructive to forests, until such time as fruit is readily available again.

6.2 Miti

6.2.1 That the miti population continues to be monitored at about 5-yearly intervals using the 5-minute count technique at stations on the Mutalau, Vinivini and Fue tracks for comparison with the previous data sets obtained in 1994, 2004 and 2012.

6.2.2 That a design for an artificial nest box likely to be used by miti is determined, and that 10–20 such boxes are erected in miti occupied forest to determine whether miti will use them.

6.2.3 If miti do use artificial nest sites, encourage an MSc or PhD student study of adult survival and nesting success of miti on Niue to determine whether rat predation is occurring at nest sites.

6.3 Hega

6.3.1 Encourage the public to report sightings of hega to Department of Environment, Niue Government, by placing a request on a poster of threatened species of Niue (include phone number/email address of DOE, and indicate would like name of observer, date, location and number of hega seen) that includes information and a picture of the species.

6.3.2 Provide Department of Environment with an Excel spreadsheet into which hega sightings can be documented.

6.4 Pekapeka

6.4.1 Encourage Department of Environment staff to record counts of pekapeka along certain sections of road in September each year when traveling to and from work and while traveling for work activities.

6.4.2 Provide Department of Environment with an Excel spreadsheet into which pekapeka

road counts can be documented.

6.4.3 Encourage residents and Department of Environment staff to visit cave entrances and report presence/absence of pekapeka entering/exiting, any sign of pekapeka (feathers, bits of carcasses) and cats nearby.

6.5 Peka

6.5.1 Undertake annual monitoring of peka and hunting to provide more accurate information on population trends to allow appropriate population management to be put in place

6.5.2 Enforce the annual hunting season such that peka are not hunted at other times of year.

6.5.3 Limit the number of shotguns (2) and ammunition (100) available to each hunter per hunting season.

6.5.4 Ban the use of semi-automatic shotguns for the hunting of peka.

6.5.5 Stop the illegal importation of ammunition.

6.5.6 Ban hunting of peka after cyclones and other natural disasters (fire), that are destructive to forests, until such time as fruit is readily available again.

6.6 Lizards

6.6.1 Encourage the public to report sightings of olive small-scaled skinks to Department of Environment, Niue Government, by placing a request on a poster of threatened species of Niue (include phone number/email address of DOE, and indicate would like name of observer, date, location and number of skinks seen) that includes information and a picture of the species.

6.6.2 Encourage herpetologists to visit Niue and carry out a survey for the species.

6.6.3 Monitor the spread of house gecko by inviting people to report where they hear them – the call is very distinctive.

6.7 Management of predators

6.7.1 Recognising that predation by introduced species (e.g. by rats, feral cats and yellow crazy ants) currently threatens the hega and olive small-scaled skinks with extinction and is probably causing declines in other birds, a management approach to this situation needs to be developed. There are several options that can be considered including ground control with toxins or the use of predator-proof nest-boxes or enclosures.

6.8 Public awareness

6.8.1 Public assistance is needed to identify sites where the hega and olive small-scaled skink survive and to advocate for hunting of peka and lupe to be managed sustainably. A poster being produced as another output of this project should be widely circulated to assist with this.

6.8.2 Displays on terrestrial fauna should be established in the Visitors Information Centre to raise awareness among visitors to the island

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We wish the people of Niue every success with looking after their beautiful environment, fauna and flora and particularly the few individuals who are taking the lead.

Ralph Powlesland (2nd from right) and Department of Environment team. Photo: David Butler.

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ANNEX 1: Peka Counts 2012

(See figure 2 for locations)

Station	Location	Date	Observer	No. peka counted
4	Alofi-Liku	13/9	Logo	23
9	Kaupa-Liku-Lakepa	10/9	Ioane	19
11	Kavaka-Liku-Hakupu	11/9	Haydn	10
14	Vakevake-Liku-Hakupu	11/9	Ralph	9
16	Hakupu-Liku	11/9	Misa	3
18	Ana-Hakupu-Liku	11/9	Dave	2
27	Mana-Niufela-Alofi-Lakepa	10/9	Haydn	3
29	Niufela-Alofi	10/9	Ralph	2
32	Niufela-Alofi	10/9	Dave	1
34	Lakepa	12/9	Huggard	8
36	Lakepa-Viatafe	15/9	Huggard	3
41	Vinivini Track	11/9	John T	30
42	Vinivini Track-gate	11/9	Logo	105
43	Vinivini-Fuluhina	12/9	Logo	27
44	Pagopago north	12/9	Dave	4
47	Pagopago south	12/9	Misa	2
49	Power plant road	13/9	Misa	1
50	Power plant road	15/9	Dave	2
52	Lalokaffika	13/9	Dave	4
57	Fuata	12/9	Daniel	11
61	Talamaitoga	12/9	Ralph	0
62	High School	13/9	Ralph	0
64	Bush track Liku-Lakepa	18/9	Misa	6
65	Bush track Liku-Lakepa	10/9	Logo	147
67	Tusekolo	14/9	Dave	4
Repeat counts				
9	Kaupa-Liku-Lakepa	18/9	Ralph	4
49	Power plant road	15/9	Ralph	5
65	Bush track Liku-Lakepa	18/9	Dave	188
New stations				
A	Water tank 0.6km along track from coast road towards station 67 (Coord. 19–01–51.1 169–54–49.4)	14/9	Ralph	0
B	Avatele – road towards Vaiea (Coord. 19–07–39.7 169–53–40.9)	16/9	Dave	0
C	Avatele – TV tower (Coord. 19–07–55.6 169–54–33.3)	16/9	Ralph	0