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Population status of great spotted kiwi (*Apteryx haastii*) near Saxon Hut, Heaphy Track, New Zealand

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Abstract Recaptures of banded birds, and call counts, indicate a population of great spotted kiwi (*Apteryx haastii*) near Saxon Hut, Heaphy Track, in Kahurangi National Park has remained stable between 1987 and 2004. The number and the locations of occupied territories have changed little. Although few juveniles were encountered during searches with dogs, at least 10 of 22 territorial adults present in 1987 were replaced by a total of 12 birds over 17 years implying that recruitment kept pace with the annual adult mortality of about 4%. We suggest that the incidence of the main predators of kiwi (stoats, ferrets, cats and dogs) was low in this very wet area (rainfall >5500 mm/ year). Our findings support the current 'Vulnerable' conservation threat ranking for the species.

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Keywords great spotted kiwi; *Apteryx haastii*; population; conservation status; predation

INTRODUCTION

McLennan & McCann (2002) estimated approximately 22,000 great spotted kiwi (*Apteryx haastii*) were distributed over 6000 km² in the north-west of New Zealand's South Island. Most now live in high rainfall mountainous regions; northern north-west Nelson, from Karamea to Golden Bay, is the stronghold of the species, with about half the population living there. McLennan *et al*. (1996) showed that the critical agents of decline of kiwi populations living on the New Zealand mainland are introduced mammalian predators. Predation by stoats (*Mustela erminea*) on kiwi less than about six months old is probably the most important factor nationally, but the episodic killing of adult kiwi by dogs (*Canis familiaris)* or ferrets (*Mustela furo*) can lead to rapid reductions in local populations. Population modelling (McLennan *et al*. 1996) showed that brown kiwi (*Apteryx mantelli*) populations were halving every 12 years. Because great spotted kiwi is less productive than brown kiwi, theoretically it should be declining at an even faster rate if mortality rates at all life stages are similar to those of brown kiwi.

Between June 1987 and December 1990, JAM and AJM studied a population of great spotted kiwi living in a high rainfall site in north-west Nelson. This study population was revisited by HAR and RMC in 1994, 1999, and 2004 as part of the long-term monitoring of banded kiwi populations by the Department of Conservation under Bank of New Zealand kiwi recovery programme. We report the results of four surveys over a period of 17 years.

STUDY AREA

The study population occupied 250 ha, just to the west of Saxon Hut, Heaphy Track, Kahurangi National Park (40° 53′ 172° 18′) (Fig. 1). The landscape comprises wide, poorly-drained tussock-covered valleys, flanked by steep bush-clad hills rising 200 m to a height of 900 m above sea level. Beech (*Nothofagus* spp.), kamahi *(Weinmannia racemosa*) and rata (*Metrosideros* spp.) forest predominates on the lower slopes of the valleys, but gives way to dense, stunted *Dracophyllum* spp. near the tops of the hills. Prolific growth of mosses

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and lichens carpet both the forest floor and the trunks of canopy trees, and much of the forest floor is covered in ferns. The climate is cool and wet, with mean annual rainfall of c. 5600 mm (Stuart Burgess, NIWA, unpubl. data). Frosts and snow falls are common in winter and early spring, though snow seldom persists on the ground for more than a few days.

METHODS

Banding study

Great spotted kiwi were caught by using trained and muzzled dogs, or by imitating kiwi calls on a shepherd's whistle or amplified tape-recorder. All birds were measured and tagged with a small radio-transmitter and most were marked with a uniquely numbered metal band. During the initial study, suitably large bands were not available for marking some females, and so they were individually identified by their bill length and the unique pattern of colours on their toe nails. The sizes and shapes of territories were determined from radio-telemetry fixes; between 1987 and 1990 these were obtained at approximately monthly intervals, in 1994 the radio-tagged birds were followed intermittently for 5-11 (mean 7) months before and after an aerial 1080 toxin operation, while between 11 and 21 March 1999, and again between 13 and 22 March 2004, a sample of the birds were radio-tagged and their locations recorded.

All birds handled were weighed and the bill length recorded. Bill length was useful for identifying unbanded adults that had been previously measured, because there is very little variation (<1.5% = *c.* 1.5 mm) in repeat measurements of an individual adult by the same or different observers, but there is considerable variation (up to 20%) between individual adults of the same sex at the same location. HAR and RMC also recorded the pattern of toenail colours on unbanded females to compare with earlier descriptions of unbanded females handled by JAM and AJM. McLennan & McCann (1993) found each kiwi's unique toenail colour pattern did not change over their three years of monitoring.

Call counts

In the autumns of 1994-96, staff from the Nelson/Marlborough Conservancy of the Department of Conservation recorded the number of calls of great spotted kiwi heard at five sites on or near Gouland Downs (Fig. 1). A total of 124 hours listening was done in these baseline surveys, usually in the first two hours of darkness. In autumn 2002, calls heard during 54 hours of listening at the same five listening sites and at similar times of the night were recorded. Hourly calling rates at each station were compared using the Mann-Whitney U-test between baseline and repeat surveys.

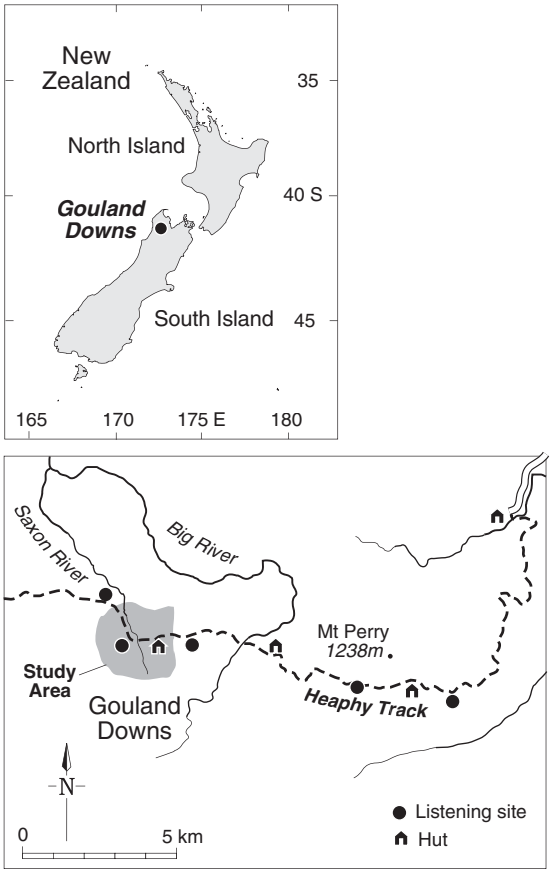

Figure 1 Map of New Zealand showing the location of Gouland Downs, the location of the study area near Saxon Hut, and five listening sites along the Heaphy Track.

RESULTS

1987-90 study

Twenty-two great spotted kiwi were caught (Appendix), and subsequent radio-tagging and banding by JAM and AJM revealed there were 11 pairs and one unpaired female in the Saxon study area at the start of the study in 1987 (Fig. 2a). Four of these birds (three males and one female) died over the next three years. One male was kicked to death by another kiwi, a male died after his eye was punctured, probably on a sharp stick, and the other two (a male and a female) were injured by a prototype transmitter attachment, and died in the following 3-6 months. The male who lost his mate re-paired almost immediately with an unpaired female in an adjoining territory. One widow re-paired immediately with an immigrant adult male, one re-paired after 36 months, probably to the male of a neighbouring pair, and one was still unpaired,

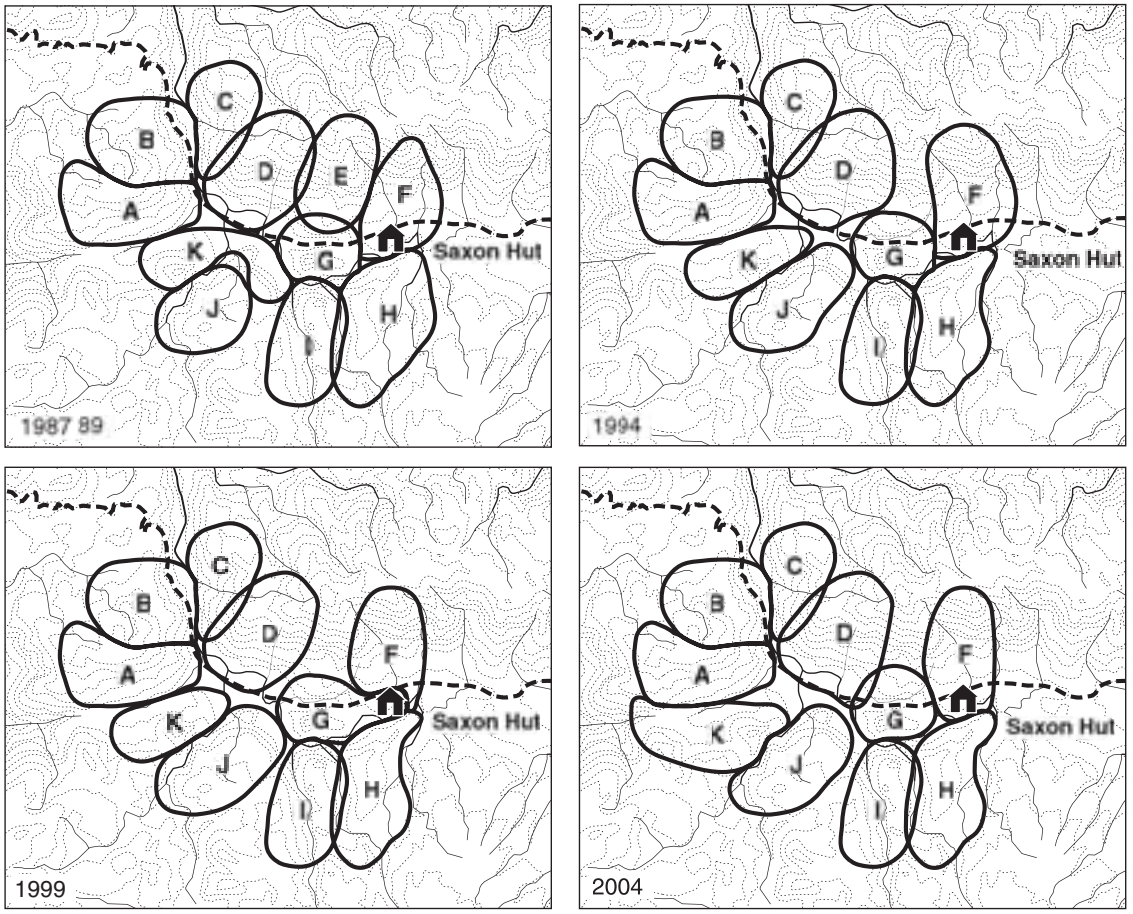

Figure 2 Approximate territory boundaries of great spotted kiwi in the study area near Saxon Hut, Heaphy Track in: (a) 1987-89, when most original inhabitants were radio-tagged, (b) 1994, (c) 1999, and (d) 2004.

38 months after losing her mate, when the study finished.

At the end of the study in December 1990, the population comprised nine pairs and two unmated females, a decline of 13%. Although JAM & AJM considered that the Saxon population was more-or-less stable, but slow to recover from losses, and there was a shortage of potential recruits; indeed they found no juvenile or subadult kiwi despite searching for hundreds of hours with trained kiwi dogs.

1994 study

HAR and RMC caught and radio-tagged four banded birds (three males and a female) from within the original study area, and another banded male was seen, but not caught (Appendix). Five new birds were caught adjacent to the original study area, to the east of Saxon Hut. The locations of radio-tagged birds, and of birds seen or heard, indicated 10 territories within the original study area were occupied by pairs (Fig. 2b). The four recaptured birds were all using the same four territories that they had used during the original study.

1999 study

Fourteen birds, including seven in the original study area (Appendix), were caught. Four (two ♂♂, two ♀♀) of the seven had been banded during the 1987-1990 study. Another banded male from the original study was seen, but not caught. Three unbanded females were caught inside the original study area and although their mates were heard calling, or moving through vegetation nearby, they were not captured. Judging by their bill lengths and toe nail patterns, all three unbanded females were new recruits and had replaced original territory inhabitants.

By plotting nocturnal and daytime locations of radio-tagged birds, and of birds seen or heard, we determined that 10 territories were still occupied

Table 1 Mean number of great spotted kiwi calls heard at five listening sites on or near Gouland Downs 1994-96 and 2002, and a statistical comparison between the interval means.

Site	Name	1994-96 mean	1994-96 s.d.	1994-96 *n*	2002 mean	2002 s.d.	2002 *n*	z	*p*
GD1	Flanagan's Lookout	14.2	5.6	26	12.7	3.9	12	-1.13	0.258
GD2	Perry Saddle	8.0	3.4	26	7.8	2.4	12	-0.03	0.975
GD 3	Little Teddy	13.4	6.7	21	16.0	4.3	8	1.2	0.232
GD 4	Blue Duck Creek	9.7	4.8	27	6.4	3.8	12	-2.62	0.009
GD 5	Saxon Hut	9.2	5.6	24	12.7	5.3	10	1.95	0.052
Total		10.9	6.0	124	10.9	5.1	54	0.07	0.945

by pairs in the original study area (Fig. 2c). Three original birds that were recaptured were still using the same territories they had occupied 10 years earlier, however, a female had moved to an adjacent territory (G) but still used open tussock and bush patches near Saxon Hut. One pair, the original inhabitants of territory B (Fig 2a) were still in residence there.

2004 study

Seventeen birds were caught, including 10 birds within the original study area (Appendix), and a 350g independent juvenile outside the original study area. Two banded males survived from the 1987-90 study period, and two females had been initially caught in 1999, including a subadult that was now fully-grown. Six unbanded birds (two pairs, one ♂, and one ♀) were caught inside the original study area; all were new recruits, the new pairs having replaced the original inhabitants of territories F and K, the new male was in territory A, and the new female in territory B (Fig 2d).

By plotting nocturnal and daytime locations of radio-tagged birds, and of birds seen or heard, we determined that 10 territories were still occupied by pairs in the original study area (Fig. 2d). Two birds were still using the same territories they had occupied 15 years earlier, but the layout of territories J and K had changed since the original study.

Mortality between 1987 and 2004

A survival estimate for males was obtained by assuming that very wary territory holders had previously been caught there, birds that were replaced had died rather than emigrated, and replacement birds were captured, or seen to be, unbanded before they themselves died.

Excluding the two birds that apparently died as a result of transmitter injuries in the original study, there were five deaths of male kiwi in 164 possible bird-years, a mean annual mortality (m) of 0.030 (3%) and a mean life expectancy (1/m) of 32.8 years, and there were seven deaths of females in 163 bird-years, an annual mortality of 0.043 (4.3%) and life expectancy of 23.3 years. Using the pooled data from both sexes, we calculated the mean annual mortality of adult great spotted kiwi to be 0.037 (3.7%) and mean life-span to be about 27 years.

This method may underestimate mortality slightly. JAM & AJM found that although some territory holders were replaced rapidly, some remained unpaired for several years. If it took an average of one year for a bird to be replaced, then the overall mean annual mortality estimate increases to 3.8% and life span decreases to 26 years. Where replacement was observed, it was possible that two or more replacements happened in the interval between five-yearly checks. With a mean annual mortality rate of 3.7%, there is a 9% chance $(1-0.037)^{2.5}$ that a replacement bird died before it was detected, assuming that the original territory holder died half-way between visits, and was immediately replaced. Applying this correction would add one further death in the 327 bird-years, making annual mortality 4.0% and life span 25 years.

The main source of error in our mortality estimate probably comes from our assumption that wary birds had been caught previously. Some wary birds may well have been new recruits that were naturally wary, or wary because we had chased them but failed to catch them on previous occasions. However, some support for our assumption that wary birds had been handled previously comes from the 1999 recapture of the banded male in territory H when he was found by a dog during the daytime – at no stage did he approach our taped calls at night, even though he was resident and heard calling in the territory. If, for example, half (5) of the wary birds in 2004 were new birds, then the mortality estimate rises to 5.2% and life span drops to 19 years. Our estimate may be conservative if territory holders emigrated rather than died, but we have caught only one territory holder out of its normal territory, and so this seems unlikely to influence our estimates greatly. Taking all these possible errors into account, it seems that mortality

rates of great spotted kiwi in the Saxon Hut area is about 4% per year, and the lifespan of a territorial adult is about 25 years.

Changes in call rates

Call rates recorded at the five listening sites on or near Gouland Downs were virtually identical between baseline counts in 1994-96 and in 2002 (Table 1). However, there was variation in call rates at individual listening stations; those heard at the Blue Duck Creek site, within the 250 ha study area, declined significantly (z = -2.62, p < 0.01), whereas those heard at the nearby Saxon Hut listening site (to the east of the study area) increased (z = 1.95, 0.05 < p < 0.10). We concluded that the variation between counts at individual listening stations probably resulted mainly from the loss or gain of particular individuals within the listening range.

DISCUSSION

Kiwi populations throughout New Zealand have declined, mainly because of the impact of mammalian predators (McLennan *et al*. 1996). McLennan & McCann (2002) conservatively estimated that the distribution of great spotted kiwi had contracted by about 30% since European settlement, mainly in dry areas (<2500 mm rainfall) dominated by beech forest. Few, if any, great spotted kiwi survive in the Spencer, Victoria and Brunner ranges of inland North Westland (McLennan & McCann 2002). The former distribution of great spotted kiwi has traditionally included South Westland (e.g., Heather & Robertson 2000); however, the identity of large spotted kiwi known historically in the Franz Josef area (e.g. Pascoe 1957) is now in doubt. A bird caught near Franz Josef in 1992 was identified morphologically as a great spotted kiwi, but genetically it proved to be a hybrid between rowi (*Apteryx rowi*, refer Tennyson *et al*. 2003) and little spotted kiwi (*A. owenii*) (Herbert & Daugherty 2002). Call count surveys indicate that great spotted kiwi inhabit a wide range of habitats, but the densest populations are now found in high-rainfall areas, usually at high altitude McLennan & McCann (2002). They speculated that these harsh upland sites were probably unfavourable for rodents, and therefore, could have very low densities of the larger predators (stoat, cat (*Felis catus*), ferret) that also prey on immature kiwi. This hypothesis remains untested.

The Saxon Hut study area on the Heaphy Track is a remote high-altitude and very wet site, and stoat is the only kiwi predator to have been recorded in the area. Even so, few sightings or reports from Department of Conservation staff or trampers have been received, and stoats were consistently scarce in the 1987-90 study period (JAM and AJM pers.obs.)

We concluded that our study population near Saxon Hut remained stable over 15 years despite experiencing a considerable turnover of individuals. Compared with other kiwi taxa, especially those living in areas where predation on adults is low, great spotted kiwi in the Saxon Hut area have a moderately high annual mortality rate. For example, annual mortality for both little spotted kiwi on Kapiti Island, and brown kiwi at Lake Waikaremoana was 2.5% (Robertson & Colbourne 2004, McLennan *et al*. 2004), and for rowi at Okarito was 1.8% (H. Robertson unpubl.). The harsher climatic conditions in the Saxon Hut area, which may make life difficult for stoats and other mammalian predators, may also take their toll on great spotted kiwi.

The results from our banding study suggest that this upland population of great spotted kiwi is holding its own without specific management other than approximately 7-yearly aerial applications of 1080 (sodium monoflouroacetate) to control possums. However, an interval of 17 years may not be sufficient to detect a lower-than-necessary rate of recruitment among a relatively small banded population of a moderately long-lived species. The results of the call counts also showed little change over a 7-year time span across the larger Gouland Downs area, and so the study population may not be atypical of the population scattered across the whole Gouland Downs and surrounding Gouland, Slate and Tubman Ranges, all of which receive annual rainfall in excess of 5000 mm.

The results of our study support the classification by Hitchmough (2002) that great spotted kiwi is in 'Gradual Decline', and BirdLife International's (2000) listing of great spotted kiwi as a threatened species, with a 'Vulnerable' ranking. The overall rate of decline of the species appears to be slower than that recorded for other kiwi species that live in drier lowland sites on the mainland of New Zealand. However, banded populations at Saxon Hut and the North Hurunui Valley in Arthur's Pass National Park will be monitored at five-yearly intervals, and call counts at Gouland Downs, the north and south branches of the Hurunui River and at three other sites (Heaphy River, Mt William Range, and Taramakau Valley) will be made at similar intervals to check whether these populations are maintaining themselves.

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Appendix

List of owners of eleven territories near Saxon Hut, from 1987 to 2004.

		Male		Female				Male		Female	
Terr.	**Year**	**Band**	**Bill**	**Band**	**Bill**	**Terr.**	**Year**	**Band**	**Bill**	**Band**	**Bill**
						B	1987	R 43591	100.6	✓	
							1988	R 43591		R 43562	121
A	1989	R 43599	99.3	RA 0871	128.4		1989	R 43591		R 43562	
	1990	✓					1990	R 43591		R 43562	
	1994	✓		✓			1994	R 43591	99.3	✓	
	1999	✓		**RA 0156**	129.6		1999	R 43591	99.6	R 43562	120.4
	2004	**R 31754**	100.6	✓			2004	R 43591	99.2	**RA 0436**	129.1
C	1987	R 43585	94.3	unb	126.1	**D**	*1987*	*R 43582*	*102*	R 43581	114
	1988	R 43585		unb			*1988*	*R 43582*		R 43581	
	1989	R 43585		unb			1989	**R 43596**	100.3	R 43581	
	1990	✓		✓			1990	R 43596		R 43581	
	1994	✓		✓			1994	R 43596	100.7	✓	
	1999	band seen		✓			1999	✓		**RA 0157**	127.3
	2004	R 43585	95.3	✓			2004	✓		RA 0157	126.7
E	*1987*	*R 43590*	*103.5*	✓		**F**	1987	*R 43586*	*98.8*	R 43587	116.8
	1988	✗		✗			1988	✗		✓	
	1989	✗		✗			1989	✗		✓	
	1990	✗		✗			1990	✓		✓	
	1994	✗		✗			1994	✓		✓	
	1999	✗		✗			1999	✓		✓	
	2004	✗		✗			2004	**R 45927**	100.9	**RA 0437**	120.6
G	1987	R 43588	95.5	R 43589	119.5						
	1988	R 43588		R 43589							
	1989	R 43588		R 43589		**H**	1989	R 43600	90.9	RA 0851	127.4
	1990	✓		R 43589			1990	R 43600		RA 0851	
	1994	✓		✓			1994	✓		RA 0851	127.9
	1999	✓		R 43587	117.7		1999	R 43600	91.1	✓	
	2004	✓		✓			2004	✓		✓	
						J	1987	R 43569	100.2	✓	
							1988	R 43569		unb	120
I	1989	R 43597	97.6	RA 0879	134.5		1989	R 43569		✓	
	1990	R 43597		RA 0879			1990	✓		✓	
	1994	✓		✓			1994	R 43569	100.8	✓	
	1999	✓		✓			1999	✓		**RA 0965**	121.3
	2004	✓		✓			2004	✓		RA 0965	124.4
K	1987	R 43584	98.4	*R 43583*	*116*						
	1988	R 43584	98.6	**unb**	125.5						
	1989	R 43584		unb							
	1990	R 43584		unb							
	1994	band seen		✓							
	1999	✓		✓							
	2004	**R 31756**	98.2	**RA 0440**	118.9						

KEY

✓	Territory holder present, not seen
✗	No territory holder detected
unb	An unbanded radio-tagged bird was in this territory
band seen	A banded bird was seen in this territory, but not caught
Italic typescript	signifies that a territory holder died

Bold typescript signifies a new territory holder