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Population density changes of adult North Island weka (*Gallirallus australis greyi*) in the Mansion House Historic Reserve, Kawau Island, in 1992-1999

A.J. BEAUCHAMP
71 Church Street, Onerahi, Whangarei, New Zealand
tonyb@nhl.co.nz

R. CHAMBERS
7 Holiday Road, Stanmore Bay, Whangaparaoa, New Zealand

Abstract The total population of North Island weka *(Gallirallus australis greyi)* is about 4150 adults spread over five islands, one North Island population, and a number of captive birds in aviaries and mainland island programmes. Between 77% and 84% of the adult weka population are on Kawau Island. Density changes in the Mansion House Historic Reserve, and anecdotal records suggest that adult weka populations on Kawau Island has fluctuated between c.2100 and c.5000 during 1992-1999. The largest declines occurred within 12 months of the 1990-91 and 1997-98 droughts.

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Keywords census; weka; *Gallirallus australis;* Rallidae; population density

INTRODUCTION

The North Island weka (*Gallirallus australis greyi*) is an endangered, flightless, forest-dwelling rail. The principal remaining population is on Kawau Island (2350 ha), on land controlled by 65 landowners. The Department of Conservation has 220 ha, mostly within the Mansion House Historic Reserve (Fig. 1A). The island's vegetation has been modified significantly by introduced wallabies (*Macropus* spp.), and is now mainly monocultures of kanuka (*Kunzea ericoides*) and pines (*Pinus radiata*). These trees produce leaf litter that does not support large populations of invertebrates, the principal food of weka. The leaf litter and subsoil dry rapidly, and during droughts invertebrates enter cracks in the soil and become unavailable to weka.

Rail populations have been surveyed using driving counts (Perez 1968), footprint searching (Elliott 1989) walking and five-minute counts (Dawson & Bull 1975; Beauchamp 1987a; T. Lovegrove pers. comm.) and call counts (Ripley 1977). Calls have been used to monitor and map rails of the genera *Rallus, Gallirallus, Crex, Laterallus*, and *Porzana* because these rails occupy dense habitats or are crepuscular (Irish 1974; Bateman 1977; Ripley 1977; Gill 1979; Zembal *et al.* 1985; Swan 1986; Bramley 1994). Few authors have used natural calling records in known density populations to define call count accuracy (Franklin *et al.* 1979; Cadbury 1980; Kaufmann 1988). Generally, calls have been elicited by methods such as throwing rocks (Schmitt 1974), imitating calls (Russell 1966), or using tape recordings of known sex-specific calls or duets (Huxley & Wilkinson 1979). Taped calls have been used to assess populations for which there is limited knowledge of the function of the calls, or the disturbance caused by using them (Tomlinson & Todd 1973; Zimmerman 1977; Manolis 1981; Kaufmann 1983; *Zembal et al.* 1985; Massey & Zembal 1987). However, it is generally recognised that taped calls can cause disturbance (Kaufmann 1988; Elliott 1989) and strange

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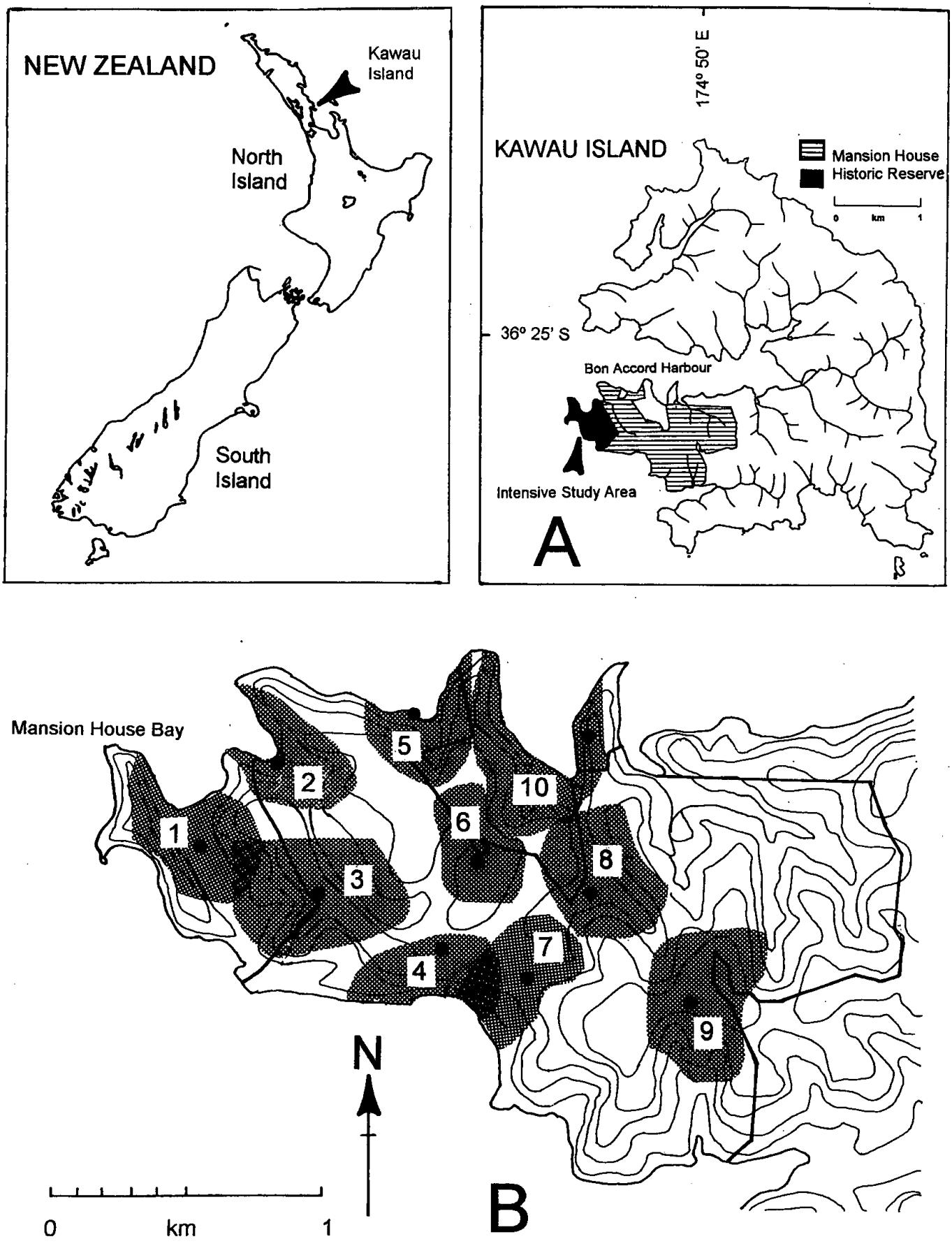

Fig. 1 A,B A, Kawau Island study area and reserve; B, count stations in the Mansion House Historic Reserve Kawau Island. 1, Mansion House; 2, Two House Bay; 3, Wallaby water tanks; 4, Coppermine lookout; 5, Sunny Bay; 6, Graveyard; 7, Coppermine Junction; 8, Schoolhouse Road; 9, Harris Bay track top; 10, Schoolhouse Bay.

and non-mate songs might deter a response (Huxley & Wilkinson 1979), so the use of calls is frequently controlled (Zembal *et al.* 1985).

Paired weka call in duet using a spacing call (Beauchamp 1987a; Marchant & Higgins 1993), that has territorial, spacing, and community cohesion functions, and is also used for long range contact between partners (Beauchamp 1987a). Spacing calls are given by the non-incubating weka in the breeding season (Beauchamp 1987a). Males give the lower and slower call in the duet. Spacing calls are not given by non-paired sub-adult and adults in stable populations, but may be given by dispersing weka in response to other calls (Beauchamp 1987a; G. Staples pers. comm.).

The value of using tapes to monitor Weka is limited by the low responsiveness of individual weka to strange spacing calls (Beauchamp, unpubl. data). Weka recognise partners and other individuals by call, and respond best to their partner's call and those of neighbours (Beauchamp, unpubl. data).

Beauchamp (1987a) found that territorial weka on Kapiti Island called throughout the year, and that 41.5% of choruses occurred in the hour before and hour after sunset. These choruses comprised the largest number of birds, and were heard predominantly from 30 minutes before sunset to 30 minutes after (Beauchamp, unpubl. data). Maximum chorus rates occurred in spring, summer, and autumn. At Mansion House, Kawau Island, weka seldom call during the day and most spacing calls were heard in the evening (Beauchamp, unpubl. data).

Historically, the use of counts of weka spacing calls as a census technique has been limited by a lack of correlation between call rates and known densities and population structures, and the best time to undertake surveys was unknown (Beauchamp 1997a; Beauchamp *et al.* 1993, 1998). For consistency, counts were targeted at periods with no moonlight at dusk, little or no wind, stable to improving weather conditions, and when the population was not breeding. Call rates on any one evening were variable (Bramley 1994; Beauchamp *et al.* 1998), and repeat counts at the same site over many months, or counts on consecutive evenings, have been used to more accurately estimate the population (Beauchamp *et al.* 1993, 1998; Bramley 1994).

Bramley (1994) used the running three-point mean of the number of calling weka hour^{-1} night^{-1} to define the best months for counting weka in a population that was attempting to breed much of the year. He found that the best months to count weka were January and February and the worst were September to November (Bramley 1994). In January 1994, he listened for five nights at a site within the calling range of five weka, and found that between two and four birds called each night.

During Easter 1991, observers led by RC conducted walk counts at five locations in the Mansion House Historic Reserve, to estimate weka numbers. The surveys were conducted differently from subsequent counts used in this study, and followed a significant drought in the summer and autumn of 1990-91. Observers heard few weka and saw only two within the intensive study area (Fig 1A; R. Chambers, unpubl. data).

In this paper we assess the use of call rates and mapping of weka as census techniques, using one site within an intensively-studied seasonally-breeding population in the 22 ha surrounding and including the Mansion House gardens (Fig. 1A; Beauchamp 1997b). The results are then applied to annual counts for other parts of the Mansion House Historic Reserve, to estimate the population density of weka there and throughout Kawau Island, between 1992 and 1999.

METHODS

Mansion House gardens survey

The Mansion House workshop site (site 1, Fig. 1B) was used from 29 October 1995 to 15 May 1999 to assess the call rates of paired Weka (Table 1). Weka were counted in the half hours before and after sunset by AJB in all months except during Easter surveys (Tables 1, 2).

Weather conditions were defined for counts as follows: a) Good - no rain, settled weather with wind <10 knots; b) Marginal - winds stronger but not from the north west; c) Poor - rain during count, or wind >10 knots from north west.

Weka calls were recorded as coming from an individual or a pair and were located on a map. The population density of paired birds within range of the count station was determined after consideration of all existing and subsequent information. The breeding status of pairs was determined from parent distress calls and the presence of estimated or known-aged chicks (Beauchamp 1998). The number of weka breeding was probably under-estimated, as some clutches and chicks were lost between visits

Table 1 Call rate of North Island weka (*Gallirallus australis greyi*) at the Mansion House Workshop site and its surroundings. Status, status of weka in area (B, breeding activity; N, non-breeding activity; M, moulting; I, incubation). Weather, weather conditions during count. *, total from site including outside of boundary; #, best estimate based on existing and subsequent knowledge

Date	Paired weka heard at site*	Paired weka within site#	Percent paired weka calling	Status of weka	Number of calls in area	Average call rate in area	Number of breeding weka	Number of weka breeding and not calling	Number of weka not breeding or calling	Weather conditions during count
1995										
29 Oct	14	28	50	B	16	1.14	12	8	2	Good
8 Dec	17	28	61	B	33	1.94	12	6	0	Good
1996										
19 Feb	13	28	46	M	21	1.62	0	0	15	Good
21 Mar	12	28	43	N	20	1.67	0	0	16	Good
5 Apr	24	24	100	N	.	.	0	0	0	Good
19 May	20	24	83	N	43	2.15	0	0	4	Good
29 Jun	19	22	86	N	28	1.47	0	0	3	Good
21 Sep	9	28	32	B	9	1.00	16	13	3	Good
20 Oct	17	26	65	B	24	1.41	20	8	0	Marginal
2 Dec	8	26	31	B	8	1.00	12	12	6	Poor
1997										
19 Jan	12	26	46	B & M	17	1.42	2	2	12	Good
8 Mar	26	26	100	N	42	1.62	0	0	0	Good
29 Mar	24	26	92	N	.	.	0	0	2	Good
19 Apr	10	26	38	N	10	1.00	0	0	16	Marginal
30 Aug	33	34	97	I	45	1.36	6	4	0	Good
11 Oct	18	32	56	B	28	1.56	20	10	0	Marginal
1 Nov	13	32	41	B	13	1.00	12	10	7	Good
14 Nov	18	32	56	B	26	1.44	16	11	0	Good
13 Dec	18	32	56	B	30	1.67	12	7	2	Good
1998										
10 Jan	13	32	41	B & M	43	3.31	0	0	19	Good
24 Jan	28	32	88	M	31	1.11	0	0	4	Good
14 Mar	28	32	88	N	.	.	0	0	4	Good
11 Jul	25	30	83	N	30	1.20	0	0	5	Marginal
11 Sep	17	22	77	I	26	1.53	10	7	0	Good
16 Oct	19	22	86	B	20	1.05	8	6	0	Marginal
7 Dec	12	22	55	B	12	1.00	8	6	2	Good
1999										
10 Jan	3	22	14	M	3	1.00	8	6	11	Good
6 Feb	18	20	90	N	18	1.00	0	0	2	Marginal
3 Apr	18	20	90	N	19	1.06	0	0	2	Good
15 May	11	20	55	N	11	1.00	0	0	9	Poor

(Beauchamp, unpubl. data), but the estimated duration of the breeding period was more accurate. Moult was assigned as the period when recaptured weka, or discarded feathers, showed that remiges were being replaced.

Mansion House Historic Reserve surveys

Counts were conducted at fixed locations during one or two evenings over Easter in each year between 1992 and 1999 (Fig. 1B). Count volunteers were instructed on the difference between male and female spacing calls, and duets, using tapes. They were also instructed on behavioural uses of spacing calls by weka (Beauchamp 1987a) and told to listen to choruses and then record that time and location. The observers plotted the position of the weka heard and for which they could assign a precise position, and recorded the direction and time of other calls. Each volunteer surveyed a different site each night. Where possible, each count station was counted at least once by an experienced observer. In 1998, because of the

shortage of volunteers, stations were counted by three experienced, and one inexperienced, observers.

Eight counting sites were used in 1992. The number was increased to 10 in 1994 and all 10 sites were counted in all remaining years except 1998 (Table 2). In 1995, we placed experienced observes within the predicted area of coverage of the more difficult sites, and revised the coverage area at three locations. This reduced the final area covered by the surveys to ~100 ha (45.4% of the Mansion House Reserve; Fig. 1B).

RESULTS

Mansion House gardens survey

Most counts (73.3%) were conducted in good conditions. Six (20.0%) counts were conducted in marginal conditions, and two were made in poor conditions and were excluded from the analysis (Table 1).

Weka called on average 1.395 (n = 27, $SE_{\bar{x}}$ = 0.502, range 1.00 - 3.31) times during each hour within the study area at the workshop site (Fig. 1B), and on average 1.865 (n = 27, $SE_{\bar{x}}$ = 0.714, range 1.00 - 4.33) times within this area and the surrounding area. The average call rate per individual did not differ significantly between the breeding and non-breeding periods (Mann Whitney U = 123.5, 1 df, P = 0.334), and the average call rate was poorly correlated with the number of individuals calling (r_s = 0.486).

The breeding and moult status of the population influenced the percentage of weka that were recorded in any count. However, nights with low numbers of calls occurred occasionally at all stages of the annual cycle (Tables 1, 2). Significantly higher numbers of weka called outside of the breeding and moult periods (Mann Whitney U = 160.0, 1 df, P = 0.01), and significantly fewer weka called during moult than at other times (Kruskal-Wallis H = 12.81, 2 df, P =0.002).

Mansion House Historic Reserve surveys

The Easter counts were conducted during the non-breeding period (Beauchamp, unpubl. data) so a median of 86% of the weka present were expected to call each night (Table 2). Counts on one or two nights by inexperienced and experienced counters gave 50-100% recovery (Table 3), and the number of weka recorded at the Mansion House workshop site was highly correlated (r_p = 0.947, P = 0.001) with the known number of weka there.

Table 2 Percentage of North Island weka calling during the annual cycle at the Mansion House site

Period	Median, x, $SE_{\bar{x}}$, range, n
Pre-basic moult	46, 47.0, 26.5, 14 - 88, 5
Incubation and breeding period	56, 58.5, 17.9, 32 - 97, 14
Non-breeding and moult period	86, 81.2, 20.9, 38 - 100, 11

Table 3 Adult numbers and call rates of North Island weka in the Intensive Study Area from 1992 to 1999. First, Percentage of the known adult paired weka calling at first assessment; Both, Percentage of the known adult paired weka calling in both assessments.

Year	Adult weka within range of the Mansion House Workshop station	Assessment	
		First	Both
1992	Unknown	.	.
1993	16	.	75
1994	20	50	80
1995	20	.	75
1996	24	50	100
1997	26	67	92
1998	32	100	100
1999	20	72	90

Table 4 summarises the number of paired weka calling within the range of stations. There were low numbers of weka in 1992 and 1993. Weka increased rapidly in 1993-94 (~31%) and then fluctuated until 1999, when they declined (~39%) within 12 months of the 1997-98 drought.

The known trend at the Mansion House intensive study area was not as highly correlated as expected with the trend in weka numbers in the wider Mansion House Historic Reserve (r_s = 0.587). The major difference was an increase in the number of weka in 1996-97 in the wider Mansion House Historic Reserve, but a decline in the intensively monitored population resulting from an unknown factor, possibly disease or brodifacoum poisoning (Beauchamp 1997b).

All adult weka tended to depend less on human supplementary feeding than did sub-adults, and so were more exposed to natural fluctuations in food supplies. There was a high correlation between annual numbers of paired adult weka at sites influenced by human activity and those lacking human activity (r_p = 0.94; P = 0.001, Table 4).

Table 4 Numbers of North Island weka calling at sites in the Mansion House Historic Reserve during surveys in 1992 -1999. #, sites with human interaction; ~, sites without human interaction; *, total of the six stations counted each year.

Year	Mansion House Workshop#	Two House Bay#	Wallaby Water Tanks#	Copper Mine Lookout~	Sunny Bay	Grave yard	School-house Road	Copper Mine Junction~	Harris Bay track~	School-house Bay	Total*
Total *											
1992	12	1	6	5	.	.	6	12	14	9	50
1993	12	7	4	8	4	9	.	10	14	9	55
1994	16	12	12	8	6	11	10	12	20	16	80
1995	15	7	8	9	8	14	11	10	14	13	63
1996	24	10	15	10	5	13	6	17	19	16	95
1997	24	14	24	15	11	22	18	16	26	11	119
1998	28	11	23	19	.	24	16	20	16	.	117
1999	18	10	8	10	10	12	7	14	17	3	77

DISCUSSION

Survey method

Spacing calls are given throughout the year and in this way differ from many other rails (Repking & Ohmart 1977; Todd 1977; Johnson & Dinsmore 1988; Kaufmann 1988). This study found that, without prompting, 43 - 100% of North Island Weka were heard to call each evening in the non-breeding period at the Mansion House Workshop site when observation conditions were good. Our results suggest that the best assessments are obtained for weka before the breeding period and in autumn. In weka populations where the breeding period is unknown, the most appropriate time for surveys is early autumn, as this follows moult, and is the low point in breeding activity in most of the populations studied (Carroll 1963; Coleman *et al.* 1983; Beauchamp 1987a; 1987b, Beauchamp *et al.* 1998).

Tape-recorded calls were used to assess weka presence in a low density (<0.2 weka ha^{-1}) and widely distributed population near Rakauroa, Gisborne in 1990 (A. Graeme pers. comm.). Tapes of spacing calls were also played at the end of listening periods in the surveys in the Toatoa and Whitikau Valleys, to induce calls from previously silent birds (M. Lewis pers. comm.). However, there are no quantitative data on the usefulness of tapes for estimating weka population density, and the call type, duration of call and silent periods, and play amplitude of tapes has not been standardised (Kaufmann 1988).

We found that mapping weka to location was a more reliable way to assess moderate to high density (>0.5 ha^{-1}) weka populations, than using call rates (h^{-1}) alone. Consistent results were obtained with limited observer training, with 50 - 100% of adult Weka calling on the first night and 75 - 100% of weka being heard calling over two nights. However, it is important that in population assessments that only the weka that the observer can place to a precise location, are plotted, and that other weka are assigned a direction only.

The ability to plot birds accurately is more difficult in practice, restricted in use, and more open to error over flat terrain where observers tend to overestimate the distance of calling birds (Beauchamp & Chambers, unpubl. data). More accurate results are possible if weka are counted from high vantage points, or in open valleys where the population is on the surrounding hills (Beauchamp 1997a).

Any call census method will not replace accurate population studies, as non-paired weka will not call (Beauchamp 1987a). Similar problems have been identified in call censuses of banded rails *Rallus philippensis* (Elliott 1989) and spotless crakes *Porzana tabuensis plumbea* (Kaufmann 1988) in New Zealand.

Population changes

The population density of weka at the Mansion House Workshop site, and other areas on Kawau Island where people fed them, were highly correlated with the density of weka at sites without human interference. This was not unexpected as supplementary feeding of adults was generally limited to a few pairs near occupied houses,

and most pairs near human habitation were influenced more by natural changes in food availability.

The number of weka declined after significant droughts. The magnitude of the decline in 1990-91 is unknown, but anecdotal records indicate that weka disappeared from parts of Kawau Island (Beauchamp, unpubl. data), and there were few weka in the intensive study area and poor recruitment to the study area population (Beauchamp, unpubl. data). The 1991-93 period was also very dry (Beauchamp *et al.* 1998) which probably hindered recruitment.

The decline in 1998 resulted from losses of both sub-adult and adult weka between April and September. There was a poor breeding success in 1998-99, a late summer drought in February - March 1999, and brodifacoum was found in potentially lethal concentrations of 0.11 and 0.036 ppm in the livers of two sub-adult weka (Beauchamp, unpubl. data).

Population density

Kiwi surveys between 1993-97 covered different and more extensive sites on Kawau Island. During these surveys, weka were found at high density throughout Kawau Island (Beauchamp, unpubl. data). The results of this survey, when applied to the total land area of Kawau Island at 80% call density, suggest that the adult paired weka population varied between c.2100 and c.5000, with a mean of c.3750. The 1998-99 breeding season was poor and surveys suggest that in April 1999 there were c.3200 adult and sub-adult weka on Kawau Island. At that time there were c.650 North Island weka in the Toatoa Whitikau Valleys (S. Sawyer pers. comm.), c.135 on Rakitu Is, c.70 on Pakatoa Is, c.20 on Whanganui Is, c.100 on Mokoia Is, and 36 in captivity, which gave a total of c.4150 North Island weka.

Stability of North Island weka population on Kawau Island and future prospects for the subspecies

Weka releases by the Royal Forest and Bird Protection Society breeding and recovery programme have extended the range and reduced the risk of extinction of North Island weka, but have not reduced the risks of a catastrophic decline in numbers. Kawau Island still holds 77 - 84% of the total population, and a 25% reduction in the average Kawau Island weka population still represents the equivalent numerical loss of all other populations. The demographic profiles of weka populations on Hauraki Gulf islands indicate that the birds depend greatly on consistent annual breeding to maintain their populations. Two successive years of drought could have a severe impact on the number of North Island weka (Beauchamp, unpubl. data).

We do not know if the remaining populations in the North Island at the Toatoa and Whitikau Valleys are stable in the long term, but they are currently increasing in the absence of high numbers of stoats and ferrets, and have promising demographic profiles (S. Sawyer pers. comm.). A secure mainland island (250 ha) is being established at Karori Sanctuary, Wellington, but it is too early to assess how many weka will be held there. The population on Mokoia Island appears to have increased after rats were removed in 1989, and then after mice were reduced to low numbers in 1996 (K. Owen pers. comm.). The population on Rakitu Island was stable during surveys in 1992-96 (Beauchamp *et al.* 1993, unpubl. data). A new population is being established on Whanganui Island, but the island is only 50 m from the Coromandel Peninsula during spring low tides, and constant rabbit, rat, and mustelid management will be required to maintain a population of weka there. It is essential that further populations of weka are established in a wide range of pest-free locations in the North Island to help ensure the long-term survival of the subspecies.

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