# Research summary and options for conservation of kaka (*Nestor meridionalis*)

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# Research summary and options for conservation of kaka (*Nestor meridionalis*)

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## ABSTRACT

This report summarises the major findings from a 6-year research programme (1996–2002) to investigate the ecology of mainland kaka populations. We found that predation by stoats and possums was the most likely cause of the continuing decline of kaka populations. Intensive pest control that, over considerable periods, substantially reduced populations of possums (to a target catch rate of < 5% animals per 100 trap nights) and stoats (to a target catch rate of < 0.5 animals per 100 trap-nights or < 5% of tracking tunnels tracked) provided most benefit to kaka populations. The methods used to achieve this (aerial baiting, bait stations, or trapping) were not critical and appeared not to have direct, deleterious impacts on kaka. Kaka were vulnerable to predation at all stages of the breeding cycle, including fledglings up to four months of age. Consequently, predator control must be maintained for some time following fledging. A brief summary of data collected on diet, movements, home range, and breeding biology of this episodic breeder is also provided. Distance sampling methods have been assessed as a means of estimating the density and abundance of kaka populations, and found to be useful in areas where kaka are still present in reasonable numbers. Populations of kaka could be established by release and supplementary feeding of wild-caught and/or captive-bred birds. We suggest an adaptive monitoring framework is adopted and outline a series of monitoring options for kaka populations. Priority sites for the management of predators and the most appropriate monitoring options for kaka are also discussed.

Keywords: kaka, *Nestor meridionalis*, mainland populations, research findings, monitoring, management, New Zealand.



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# 1. Introduction

From 1996 to 2002, staff of the Science & Research Unit were asked to investigate the ecology of mainland populations of kaka (*Nestor meridionalis*) at a number of sites throughout New Zealand. Research focused on measurement of productivity where pests were being controlled with differing intensity, identification of significant threats, development of methods for assessing population size, and measurement of basic ecological parameters where these were unknown (diet, home range, etc.). This report aims to provide a summary of the major preliminary research findings, a list of priority sites for the management of mainland kaka populations, and a description of appropriate monitoring options.

# 2. Research summary

## 2.1 IMPACT OF LARGE-SCALE PEST CONTROL OPERATIONS

Direct impacts of large-scale pest control operations on kaka populations (mainland and offshore islands) have been monitored since 1994 (Pierce & Moorhouse 1994; Greene 1998). The largest operations have involved aerial applications of 1080 baits (carrot and cereal) and anticoagulant toxins. Both types of toxins have also been used in operations using bait stations. Table 1 summarises those operations for which kaka were explicitly monitored for deaths caused by the toxin (direct impacts), and the consequences of successfully controlling the target pest(s) (indirect impacts).

Although none of the kaka (> 100 birds) monitored during the use of 1080 (ground or aerial) operations was killed (Spurr & Powlesland 1997; Powlesland et al. 2003), the longer-term indirect impacts were either non-existent or of little benefit (Table 1). This appeared to be related to the timing of pest control operations relative to years in which kaka bred. If no breeding was attempted in the summer after 1080-based (or other acute toxin-based) pest control, no long-term population impacts were observed. If breeding did occur, it was only likely to be more successful if it occurred in a 5- to 6-month period immediately following the application of the toxin. After this interval, predator numbers quickly recovered and kaka mortality increased, especially for remaining nesting birds and fledgings (T. Greene unpubl. data). For example, following the 1080 operation immediately prior to the 2001/02 breeding season within the Waipapa Ecological Area, 10 of the 17 fledglings tagged with transmitters died (nine of which were killed by mustelids) and four more were missing within 3–5 months of fledging (A. Jones pers. comm.). On the recovery of one of the radio-tagged fledglings from a mustelid den, three additional juvenile kaka skulls were also discovered. These results suggest that the net productivity

TABLE 1. IMPACT OF PREDATOR MANAGEMENT REGIMES ON KAKA POPULATIONS.

| Location | Year | Pest management | Pest species targeted | No. of kaka monitored | Direct effects on kaka population | Indirect effects on kaka population |
|---|---|---|---|---|---|---|
| Waihaha Ecological Area, Pureora | 1994 | Aerial 1080 (carrot bait 0.08% w/w 1080 @ 15 kg/ha) | Possums (with non-target rat & secondary mustelid(?) kill) | 21 | Nil | Limited? |
| Windbag Valley, Paringa, South Westland | 1998 | Aerial 1080(Wanganui #7 cereal baits 0.15% w/w @ 3 kg/ha) | Possums (with non-target rat & secondary mustelid(?) kill) | 15 | Nil | Limited? |
| Whirinaki | 2000 | Aerial 1080(carrot bait 0.08% w/w 1080 @ 10 kg/ha) | Possums(with non-target rat & secondary mustelid(?) kill) | 17 | Nil | Negligible. Majority of young/few adult females killed |
| Waipapa Ecological Area, Pureora | 2001 | Aerial 1080(Wanganui #7 cereal baits 0.15% w/w @ 2 kg/ha) | Possums (with non-target rat & secondary mustelid(?) kill) | 20 | Nil | Negligible. Majority of young/few adult females killed |
| | 1996–2000 | Intensive use of anti-coagulants and acute toxins in bait stations Some intensive areas of rat snap trapping | Possums and rodents (with secondary stoat kill) Rats | > 40 | Nil | Increase |
| Nelson Lakes Mainland Island | 1996–2000 | Intensive use of anti-coagulants and acute toxins in bait stations | Possums and rodents (with secondary stoat kill) | > 15 | 2 deaths due to toxin used | Increase |
| | 2000–2003 | Traps | All of above | > 15 | Nil | Increase |
| Eglinton Valley, Fiordland | 1998–2003 | Landscape-scale trapping | Mustelids | > 25 | Nil | Increase |
| | Winter '99 | Ground baiting with 1080/feratox (bait bags) | Possums (with secondary rat kill) | < 10 | Nil | Increase |
| Marotere (Chickens) Is | 1994 | Aerial application of anticoagulants | Rodent eradication | 5 | Nil | Increase |
| Kapiti Island | 1996 | Aerial application of anticoagulants | Rodent eradication | 20 | 4 deaths due to toxin used | Unknown, assumed increase |

of kaka for the 2001/02 breeding season, the first breeding attempt since the 1998/99 season, was extremely low.

It is also worth pointing out that good stoat kills (through secondary poisoning) appear less likely if rat densities in the area are low, and that stoats have been known to reinvade areas within 2 months of a 1080 operation (Parkes & Murphy 2004, E. Murphy pers. comm.). The risks of relying solely on an aerial 1080 operation to protect kaka are, therefore, considerable. This situation will be exacerbated if the rate of stoat reinvasion is high, mast fruiting of dominant forest tree species is likely to prolong the kaka breeding season (i.e. the production of more than one brood), or if kaka choose not to breed immediately following a periodic application of toxin.

Intensive long-term pest control using slower-acting toxicants, such as anticoagulants, was a highly effective means of sustaining positive recovery of kaka populations (Moorhouse et al. 2003). Although the primary aim of these operations was to reduce possum and rat numbers, secondary poisoning of mustelids was an important contributor to increased kaka productivity (e.g.

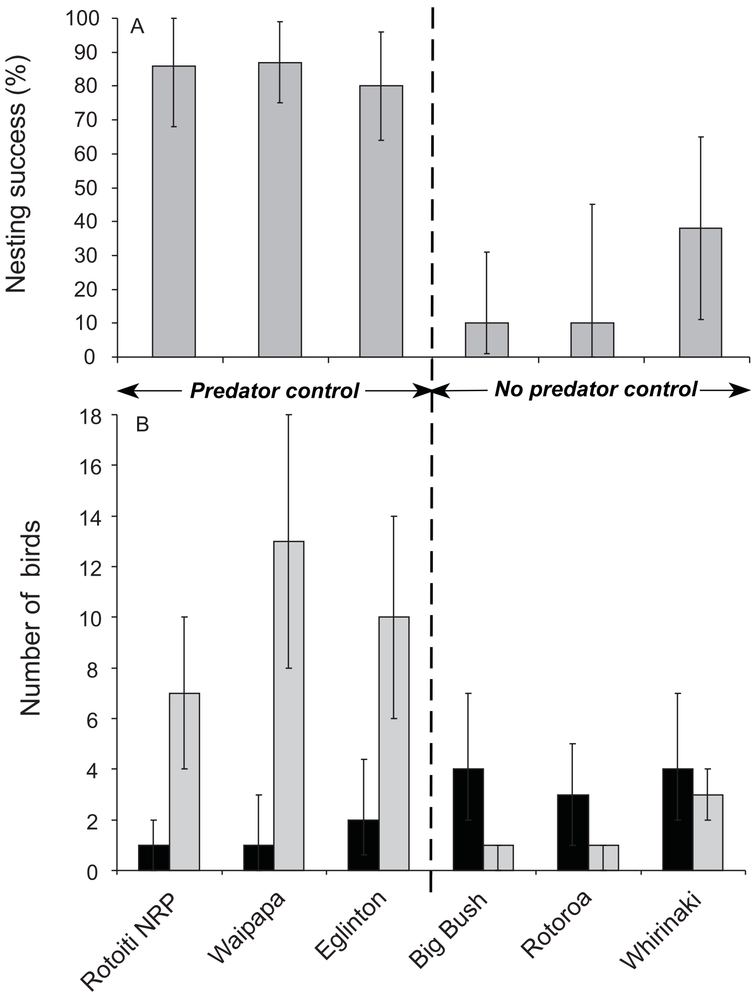
Waipapa Ecological Area and Nelson Lakes Mainland Island). It should also be noted, however, that we know of at least two kaka that appeared to have perished as a direct result (bait ingestion) of such pest control operations (Table 1; Moorhouse et al. 2003).

Two kaka populations have also been monitored during island rodent eradication operations using anticoagulant toxins (Pierce & Moorhouse 1994; Empson & Miskelly 1999). Although such eradications are expected to have a positive long-term impact on the resident kaka populations, a few deaths occurred as a direct result of the rodent eradication programme on Kapiti Island (Table 1). Although all 20 kaka monitored on Kapiti Island survived the first poison drop, four of these birds perished following the second follow-up operation four weeks later. None of the kaka monitored during kiore (*Rattus exulans*) eradication on Whatapuke Island are known to have perished.

No negative direct impacts have been recorded for kaka where stoats (*Mustela erminea*) and rats have been killed using Fenn traps and snap traps (Table 1). In some habitats (large linear valleys in the South Island), this has been a highly successful management regime, and a viable alternative to the use of toxins (Dilks et al. 2003). However, in areas where only rodents are trapped (e.g. Waipapa E.A.), we suspect that losses of kaka to stoats may still be important, as the latter shift their dietary preferences from rodents to other prey (Murphy et al. 1998). Kaka are known to have been captured in leg-hold traps targeted at possums, but this appears to be a problem associated only with high-density kaka populations, such as those found on offshore islands.

Given these results, it is likely that few, if any, kaka will be directly impacted by aerial or ground-based pest control operations using toxins or traps within mainland habitats. Explicit recommendations of appropriate control methods and/or targets for the significant predators of kaka (possums and mustelids) are problematic, particularly given the current dynamics of method selection (political, economic, experimental, etc.) and the coarse nature of the indices currently employed to measure predator abundance (particularly stoats) (Innes et al. 1999; C. Gillies pers. comm.). Appropriate predator control methods should be selected with reference to current DOC best-practice guidelines. Consistent application of chosen method(s) over several years and the monitoring of their impact would greatly assist future method selection. Rough guidelines for biodiversity managers of appropriate targets for predator control can be derived from our research. For stoats (and other mustelids), a target catch rate of < 0.5 animals per 100 trap nights or < 5% of tracking tunnels tracked should ensure minimal impact from this species. For possums, a target catch rate of < 5 animals per 100 trap nights should be sufficient to significantly reduce the impact of this species. The bottom line is that populations of both of these predators must be reduced as low as possible over considerable periods to ensure important benefits to the resident kaka population. For example, nesting success at the sites with predator control was much greater (> 80%) than those without it (< 38%, Fig. 1A) while predation on adult females was considerably less (5%, compared with 65%, Fig. 1B). The numbers of female kaka surviving to sexual maturity more than compensated for adult female mortality at three sites with intensive predator control (toxins and/or trapping), but not at three unmanaged sites (Fig. 1B) (Moorhouse et al. 2003).

Figure 1. A. Kaka nesting success at sites with and without predator control. Error bars are ± 95% confidence intervals. B. Adult female mortality (solid bars) and recruitment (shaded bars) at sites with and without predator control. Error bars are ± 77% (equals a 5% probability of overlap between mortality and recruitment). NRP = Nature Restoration Project.




## 2.2 IDENTIFICATION OF SIGNIFICANT THREATS

At the commencement of this research, evidence for the cause of kaka population decline was largely circumstantial. A combination of competitive and predation effects was viewed as the most likely cause of continuing decline or complete absence in areas of former habitat. Stoats and possums, in particular, were seen as major direct and/or indirect threats, particularly when current trends in kaka and these pest species' distributions were examined (Rose et al. unpubl. report 1990; Wilson et al. 1998; Veltman 2000).

Captures of kaka at several mainland sites in the last decade strongly suggested that mortality of adult females was much higher than that experienced by male birds (Moorhouse et al. 2003). Where predators were absent (offshore islands) or intensive pest management was occurring, population sex ratios were close to equal. However, in areas where there was no predator control, kaka populations were strongly skewed toward male birds (Table 2; Greene & Fraser 1998). The cavity nesting habit of kaka is the most likely explanation for this trend. Female kaka spend much longer in the nest cavity than males and are therefore more vulnerable to predation. Their exposure to potential predators, such as stoats, is therefore much higher than that of males. Our observations suggest that in areas where there is no effective predator control, nesting

TABLE 2. SEX RATIO ESTIMATES FOR KAKA POPULATIONS (FROM GREENE & FRASER 1998).

| LOCATION | PERIOD | ESTIMATION METHOD | SEX RATIO (female:male) | *n* | REFERENCE |
|---|---|---|---|---|---|
| Kapiti Island | 1988–91 | Mist net | 1:1.27 | 25 | R.J. Moorhouse pers. comm. |
| Little Barrier Island | 1989–93 | Cage-trap | 1:1.3 | 70 | DOC unpubl. data |
| South Westland | 1992 | Observation | 1:3.2 | 46* | C.F.J. O'Donnell pers. comm. |
| Nelson Lakes | 1984–89 | Mist net | 1:2 | 30 | P.R. Wilson pers. comm. |
| | 1989–91 | Mist net | 1:2.8 | 23 | P.R. Wilson pers. comm. |
| Waihaha Ecological | 1994 | Mist net | 1:6 | 21 | T.C. Greene unpubl. data |
| Area | 1995 | Observation | 1:3 | 14** | T.C. Greene unpubl. data |

* Number of confirmed sex sightings from a total of 325 observations

** Number of confirmed sex sightings from a total of 161 observations

females may suffer more than 80% mortality (Fig. 1B). Recent video evidence shows that some females are also prepared to enter nests and attempt to attack stoats that have recently killed their chicks. Undoubtedly this behaviour, if widespread, contributes to the low survival of breeding female kaka.

At all stages of the kaka breeding cycle, predation occurred at locations where these animals were not controlled, but outside this period, predation was much less frequent regardless of the pest status of the area (Fig 1B). In addition to deaths of adult females, evidence for predation of eggs, nestlings and fledglings up to 3–4 months of age was found. Post-mortem evidence largely confirmed stoats (or other mustelids) as the primary kaka predator in most forest habitats. This evidence included hairs in cavity nest material, puncture wounds on carcasses, and corpses cached in hollow logs and subterranean dens. Video cameras also confirmed this by recording stoats killing and caching kaka chicks in two nests.

More disturbing was evidence collected that showed that possums prey on kaka. Post-mortem evidence (Lyver 2000) for possum predation was recorded in all study areas in which possums occurred in reasonable numbers. Video footage of a possum killing and eating kaka chicks within a nest was also recorded. It seems likely that, in some forest types, particularly those capable of supporting high densities, possums are also a direct threat to kaka populations. For example, possums are thought to have been responsible for the failure of six of 13 kaka nests (46%) located in the podocarp forests of Whirinaki over a single breeding season. We also have evidence that possums have killed adult female kaka on at least three occasions. Other more indirect evidence for the effect of possums on kaka populations includes an apparent increase in kaka abundance following the eradication of possums from Kapiti Island (H.A. Robertson & A.J. Beauchamp pers. comm. in: Moorhouse & Greene 1998; Veltman 2000). Similarly, kaka abundance was much greater in West Coast forests with no possums, or where possums had been present for less than 10 years and were at low density compared to where possums had been present for 10 or more years and were at moderate to high density (Veltman 2000).

It should also be noted that there was considerable mortality of young kaka after fledging. Many of these birds are unable to fly and perch close to or on the ground. Some of this mortality is natural (starvation, weather, etc.), but predators also account for large numbers of fledglings. For example, within the Waimanoa Ecological Area, where there was no pest control over the 2001/02 kaka breeding season, 62% of chicks were killed within 2–3 days of fledging (T. Greene unpubl. data). For this reason it is simply not sufficient to focus protection at nests and/or cease pest control immediately following the fledging of any chicks. Pest control needs to be maintained over a considerable area for at least 3–4 months post-fledging in addition to that required over the nesting period (3–4 months).

## 2.3 METHODS OF ASSESSING POPULATION SIZE

An accurate understanding of population status is essential for effective conservation and management of kaka. Precise assessment of population size is, however, difficult due to the comparative rarity and extreme variability in diurnal and seasonal conspicuousness of the species. Traditional survey methods (such as 5-minute counts), which are particularly sensitive to such variations, have continued to be used, but provide only relatively crude indices of kaka abundance (Rose et al. 1990). Although these indices assume they are proportional to true abundance, there is no known reliable relationship between such an index and parameters of interest, such as density (Bibby et al. 2000; Thompson et al. 1998; Buckland et al. 2001). Even if a suitable index calibration function could be computed, some future conditions (e.g. beech mast) may well invalidate it (Thompson et al. 1998).

A pilot study assessing the density and abundance of the kaka population within the Waipapa Ecological Area using distance sampling methods has been conducted since October 2000 (T. Greene & A. Jones unpubl. data). Distance sampling provides an objective means of assessing population size by modelling the detectability of objects (in this case kaka) with increasing distance from a defined line or point (Buckland et al. 2001) provided that the method's assumptions are met (Hutto & Young 2003). By fine-tuning the field methods to best suit the species being counted (kaka and kereru) and to meet the assumptions, counts have been computed and short-term trends identified (Fig. 2). On the basis of these results, the method has since been adopted by the

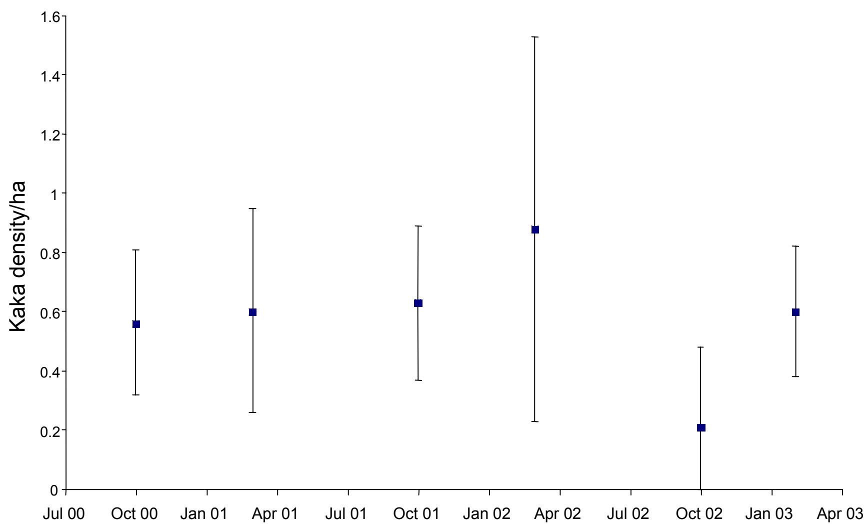



Figure 2. Kaka density estimates derived from distance sampling surveys within the Waipapa Ecological Area, Pureora. Error bars represent bootstrap estimates of the 95% confidence intervals.

Waikato Conservancy as a long-term standardised monitoring tool which appears to be robust, relatively simple, and capable of providing a relatively unbiased measure of density and abundance over temporal and spatial scales.

Unfortunately this does not mean that the method will suit all situations. This is particularly the case for those populations at low densities where the effort required to effectively model the detection probability may be too costly and lack precision. It should also be noted that monitoring methods, such as distance sampling, can tell us something only about the size and density of a population, and little, if anything, about the demographic structure. A population estimate by itself does not tell us whether demographic parameters, such as sex ratio, are highly skewed (see above). Other measurements are required (at least initially) to illuminate the larger picture and prevent us from drawing mistaken conclusions (e.g. a numerically strong but highly male-biased population may persist for years before rapidly disappearing). However, significant increases or decreases in population estimates imply related increases or decreases in productivity and a strong indication of the effectiveness of predator management techniques. Although an obvious downward trend would suggest the need for immediate intervention, decreases in the precision of population estimates (e.g. increasing width of confidence intervals) can also be used as an indicator of the impending need for intervention. Monitoring effort can, therefore, be adapted to various levels of intensity dependent on observed changes in density or changes in the variability of density estimates as a result of factors influencing population parameters (e.g. sex ratio, birth rate, etc.) (Smit 2003).

## 2.4 GENERAL ECOLOGY

Although we know that kaka attempt to breed in beech forests only in years of high seed production (Wilson et al. 1998), very little information on what triggers breeding within podocarp forests was available prior to this study. Considerable efforts were, therefore, made to examine phenology and diet and their relationship to kaka breeding during research at Pureora and Whirinaki.

Significant differences in the food types used by male and female kaka were recorded (T. Greene unpubl. data; R. Powlesland unpubl. data). Males generally ate more fruit and burrowing invertebrates whereas females preferred nectar, sap, and surface-dwelling invertebrates. Sap feeding was particularly important to females and an important difference between the sexes. Seeds were eaten by both sexes, as were invertebrates, seeds, and sap sourced from plantations of exotic tree species. Seasonal variation in diet (generally and between sexes) was also marked and closely linked to food plant phenology. Of the approximately 30 species of plants used by kaka, only a relatively small group of 8–10 species were important components of their diet. Although substantial differences in the importance of various foods were recorded between seasons, between years and between the two locations, the only consistent trend linking diet with productive breeding seasons was the mast fruiting of kahikatea (*Dacrycarpus dacrydioides*), rimu (*Dacrydium cupressinum*), and to a lesser extent matai (*Prumnopitys taxifolia*) and miro (*Prumnopitys ferruginea*) (T. Greene unpubl. data; R. Powlesland unpubl. data).

Kaka can, therefore, be described as episodic breeders regardless of habitat, with timing of reproduction closely linked to mast production of seeds and fruit. For this reason, the monitoring of productivity (timing and quantity) of important forest plant species is essential to understanding the reproductive cycles of all animals (including rodents, etc.) utilising these resources. Because of its importance in regulating many of the ecological processes we observe, regular and objective measurement of phenology over sufficient timeframes should be an integral part of kaka (and other species) management. For example, the appearance of large numbers of rimu pollen cones in late 2000 at Pureora and Whirinaki was used to successfully predict that the 2001/02 breeding season would be a good one (T. Greene unpubl. data; R. Powlesland unpubl. data). Whether phenology data could be used to successfully predict the timing of pest control for a given year is uncertain.

A considerable amount of information has now been collected on the breeding biology of kaka throughout New Zealand. This includes information on the physical parameters of nest sites used, site occupancy and fidelity, breeding season, periodicity, number of breeding attempts per season, clutch size, incubation and nestling period, fledging success and post-fledging survival. Video cameras used within nest cavities have also provided information on the behaviour of both the adult female and offspring which would otherwise be impossible to observe.

A method has also been developed to sex nestling kaka using measurements calibrated against genetic sex determination methods (A. Jones unpubl. data). This has important implications for determining aspects of dispersal and recruitment (i.e. which individuals are fitted with transmitters), particularly if the fate of females is critical. This method is sufficiently robust to be able to predict sex with about 90% accuracy provided that a reasonable estimate of age or tail length is available.

A preliminary assessment of home range data collected from radio-tagged kaka has been attempted. Data suggest that there are sexual and seasonal differences between kaka, and that these also vary between the study sites at Pureora and Whirinaki. Generally speaking, adult kaka have relatively small home ranges, but will, on occasion, make substantial excursions before returning to a core area. Of greater interest are the movements (in some instances > 30 km) of recently fledged birds which do not tend to settle for some time. The movement of these birds (and to some extent adults as well) has huge implications for the success of protected areas within mainland forests. If the designated areas are too small, very little or no recruitment into protected areas may occur, compromising the long-term sustainability of residual kaka populations.

## 2.5 RE-ESTABLISHMENT OF KAKA POPULATIONS

During the course of the research programme on populations of wild kaka, staff at the Mt Bruce National Wildlife Centre attempted to re-establish a wild kaka population within the adjacent Mt Bruce reserve by releasing wild-caught and captive-reared birds. This project has been reasonably successful (K. Barlow pers. comm.). The majority of the birds stayed within the reserve (no doubt encouraged by the availability of supplementary food), and a good proportion of these have attempted to breed. Mortality of breeding birds and their offspring within the reserve was, however, similar to that in other mainland areas with inadequate predator control and unlikely to be sustainable. The development of a 'stoat-proof' nest box for kaka (Greene & Jones 2003) has provided some relief, but post-fledging and adult mortality remains high. A sustainable kaka population is likely only if the intensive pest control being implemented throughout the reserve succeeds. A second reintroduction programme within the Karori Sanctuary in Wellington city using the methods developed at Mt Bruce has also been initiated.

# 3. Monitoring options for kaka populations

We now know predator control can be beneficial for kaka populations (Moorhouse et al. 2003). However, careful measurement of the responses to this management can yield additional information which will allow future work to be more efficient. The appropriate level of investment in monitoring kaka populations by managers will be a function of the available management options, their feasibility, cost of alternative monitoring practices, the current perceived state of the population, and ultimately the available funding (Smit 2003). Without some base level of monitoring, little idea of the scale of improvement (if any) will be available (particularly over the short to medium term) nor will we have the information to determine at which point(s) monitoring, research and/or management may need to be intensified. Monitoring of the gains achieved at some predetermined level therefore remains essential.

In an attempt to balance the competing demands (in terms of resources) of management (predator control) and monitoring we recommend adopting an adaptive monitoring strategy similar to that suggested by Smit (2003). This strategy suggests that if the trend for the parameter being measured (e.g. productivity, density, etc.) is stable or increasing and the variability of the estimate is small, monitoring intensity can be reduced. However, if the trend is downward and/or variability is increasing (reflecting an increasing probability of local extinction) monitoring should be intensified and, if necessary, management actions reassessed and further research considered. For example, if kaka density estimates within the Waipapa E.A. continue to slowly increase and estimated variability remains low over a 3- to 4-year period, monitoring could be reduced from annual to triennial counts. If the pest control regime was to change or a change in trend/variability of the density estimate was to occur, monitoring intensity should be increased again to an annual regime. Continued density declines and poor precision should spark a review of current management and appropriate research.

To assist with this process we recommend the following options as general guidelines for various sites and circumstances. These have been ranked from the least to the most resource intensive and informative.

## 3.1 OPTION 1: COMMENCE RECOMMENDED PEST CONTROL

The bottom line for pest control targeted at increasing kaka productivity is consistent and effective control of stoats and possums using the most efficient methods available. Table 1 summarises the type of pest control shown to be successful in raising the productivity of kaka in several different habitats at a limited number of sites. The impact of these methods (or any others) when applied to different areas/habitats (e.g. North Island beech forest, mixed beech/ podocarp forest), however, remains uncertain, and these kaka populations should be monitored accordingly.

## 3.2 OPTION 2: CONDUCT REGULAR POPULATION COUNTS OF KAKA

Regular population surveys targeted specifically at kaka or as part of general forest bird population surveys (the kaka and kereru combination works well) will enable temporal trends to be monitored and the impact of pest control and other kaka management strategies to be assessed. Distance sampling methods using point counts have been successfully trialled on the kaka population within the Waipapa E.A. (Greene & Jones in prep.) as a means of estimating relatively unbiased measures of density and abundance rather than more biased 'abundance' results derived from relative indices (5-minute bird counts).

It is recommended that points (no less than 300 m apart) are arranged systematically on a randomly placed grid and permanently marked in the area of interest. This ensures that all habitats within the area are sampled representatively and there is potential to stratify the analysis accordingly. Each point is visited at least once, and the radial distance is measured from the point to all birds seen and heard over a 10-minute period. A sample of about 80 detections is required over the sample period. Points may be visited more than once to achieve this. Preliminary results using this method are encouraging but also suggest that effort required to achieve an accurate result is considerably higher than for relative measures (minimum of 10 person days in good conditions). The sample size required may also make the application of the method unsuited to areas where kaka are scarce. Relatively crude measures of encounter rates using similar methods may be useful in these instances (T. Greene unpubl. data).

Whatever the survey method chosen, counts must be conducted at regular intervals and at similar times of year. We recommend that, at a minimum, counts be conducted in two consecutive years every five years—the more frequent the better. As kaka tend to be more conspicuous early in the morning and immediately prior to the breeding season, we recommend that counts be conducted in October and November (at the latest) and prior to 1100 hours (NZ Standard Time).

Specific sites should become priority areas for the regular application of count methods. Based on the importance of specific sites to the overall mainland kaka population, and the history of research and management within them, obvious candidates include the Waipapa Ecological Area, Whirinaki, Eglinton Valley, and Lake Rotoiti, although the latter site may be compromised by the low numbers of birds currently resident in the area. Other sites in which regular monitoring of kaka numbers would be of interest include the Hurunui, Haast, and Waitutu regions, and anywhere there are kaka populations and large-scale pest control is about to be initiated (see below).

## 3.3 OPTION 3: CONDUCT REGULAR COUNTS IN CONJUNCTION WITH ASSESSMENTS OF DEMOGRAPHY

Although numeric surveys are required to detect trends in the population size over time, these results, if viewed in isolation, can obscure important aspects of population health and compromise interpretation of trends. It is now known that populations of kaka exposed to predators are highly biased towards male birds (Greene & Fraser 1998). The assumption (strongly supported by observations) is that this has resulted from disproportionate predation of nesting females. As kaka are long-lived and difficult to sex by observation in the field, such biases are unlikely to be detected using numeric counts alone, particularly over the short term. An apparently static low- to moderate-density population of kaka dominated by long-lived male birds and relatively few breeding females is clearly not a healthy one. In such situations, transfer of additional female kaka in conjunction with intensive pest control may be required to resuscitate the population (see Section 4).

A practical and reliable approach to quantifying this issue has been difficult to devise. Recent attempts have used the proportion of radio-tagged males that are accompanying females just prior to breeding (Greene & Fraser 1998). Other suggestions include the periodic capture of a sample of kaka (30 birds once every 5 years?), and examining the sex ratio of those captured. Unfortunately all of these methods are resource-intensive and likely to be biased in some way. Further investigations of suitable methods are required.

## 3.4 OPTION 4: EXAMINE OCCUPANCY OF KNOWN KAKA NESTS

This option is only applicable to those areas where sufficient nests have been previously located. For example, if 20 nests are known from an area and their occupancy declines over time, some statement about the health of the population or need for improved pest control could be made. Unfortunately this option is not particularly practical. It is dependent on previous expensive monitoring, requiring the use of radio-tagged birds to find sufficient nests. Even if this is done, current experience points to a low level of nest re-use in subsequent years. This may reflect the large number of potential nest sites that are available and the relatively low numbers of kaka left in some forests. Even if the number of kaka was to increase rapidly, with the majority of potential holes being occupied in any given year, old hollows are constantly degenerating and others being formed, resulting in the turnover of marked nest sites used over time. Thus, this option is likely to be useful for relatively few years after many occupied sites have been located.

## 3.5 OPTION 5: DETERMINE REPRODUCTIVE OUTPUT AND DISPERSAL OF KAKA POPULATIONS

Although the resource requirements for this option are high, the potential gains are likely to be far greater than for any of the previously mentioned options. To monitor reproductive output sufficiently, a minimum of 10 adult female kaka need to be captured and fitted with radio-transmitters prior to a breeding season and monitored over 30 breeding attempts to provide an adequate sample size. In addition, at least two cohorts of juveniles, each cohort consisting of similar numbers of birds, would need to be tagged to provide information on dispersal and recruitment. Ideally, monitoring kaka populations using this type of approach should be applied to two core areas in both the North Island and South Island—obvious candidates are Waipapa, Whirinaki, Lake Rotoiti, and the Eglinton Valley (see below). This would be particularly valuable if any alteration to current pest control regimes (starting, stopping, pulsing, and reduction of effort) was being contemplated. Any monitoring initiated in additional areas would be a bonus.

The nests of these birds could then be located (if they breed) and productivity measured. Any mortality would also be detected and its cause(s) identified. Females could be monitored for up to three consecutive breeding seasons in the North Island and four or more in the South Island, thereby spreading the cost of bird capture and transmitter purchase over several years. Differences in the operational life of transmitters between the two areas/subspecies are related to the need for different-sized transmitter packages (i.e. smaller 7PN packages for female North Island kaka).

Priority to monitor productivity in this way should be given to those sites where:

- New pest control methodologies are to be used, particularly over large areas
- There is an opportunity to assess kaka productivity before as well as after intensive predator control
- Intensive predator control is to be implemented in habitats different from those previously examined
- There is replication of work in habitats previously studied
- Resources are available to radio-tag and follow fledglings.

# 4. Translocation and re-establishment of kaka

Experience at Mt Bruce National Wildlife Centre has indicated that the establishment of new kaka populations derived from captive-reared or birds transferred from other populations is possible (K. Barlow pers. comm.). However, the resources required to make a success of such a management programme are considerable, and such projects should not be undertaken lightly. For these reasons we strongly endorse the approach and techniques developed by staff at Mount Bruce to maximise the chances of success.

When considering a site for the establishment of a new population, a number of prerequisites should be met:

- Kaka should be extinct within the area or very rare to prevent resident birds luring them away from protected sites, particularly if they are contiguous with much larger areas of potential habitat.
- Supplementary foods should be provided throughout the establishment phase to entice the birds to stay in the area.
- Areas into which birds are to be released should be relatively large (c. 1000 hectares, depending on the type of forest) so that the population can expand and become self-sustaining over time.
- Effective pest control should be established in the area and maintained long-term.
- Artificial nest boxes should only be used where large numbers can be provided and natural sites are relatively few. A recommended predator-proof design should be used (e.g. Greene & Jones 2003).
- Sufficient resources must be available over several years to maximise the chances of success. This includes money for holding aviaries, disease screening, transmitters, food stations, food supplements, and staff time to monitor progress.
- Maximum numbers of birds to be released and the total number of releases should be capped prior to project initiation. Regular audits of progress should be conducted, and if these limits are about to be exceeded without reasonable prospects for successful establishment, the project should be abandoned.

# 5. Priority areas for conservation of kaka and recommended actions

Obvious starting points for monitoring kaka include current Mainland Island areas, kiwi sanctuaries, or any other monitored site where intensive pest control is occurring (or may be about to occur) and kaka are still present. There is a need to monitor kaka populations in a variety of different forest habitats, given that most recent work has been conducted in either South Island beech or North Island virgin podocarp forest.

Where possible, regular population estimates (Option 2) should be conducted at some sites so that trends in population size can be measured from a robust baseline over time. If possible, periodic assessments of demographic parameters (Option 3) should be carried out in tandem with these numeric estimates to provide an accurate picture of overall population health. Where appropriate resources exist, periodic assessments of kaka productivity should also be carried out (Option 5).

## 5.1 WAIPAPA ECOLOGICAL AREA, PUREORA FOREST PARK, WAIKATO

### *Maintain/initiate effective stoat and possum control (Option 1)*

Both stoats and possums pose a direct threat to nesting adult females, eggs, chicks and fledglings (Moorhouse et al. 2003). Effective pest control is therefore vital to the continuing recovery of the kaka population in the Waipapa E.A.). However, there is a case for examining the impact of using rat snap-traps as the only method of pest control (which appear to have less impact on mustelid populations than toxins). Previous experience suggests aerial 1080 operations are only useful in certain conditions and for limited times (Section 2.1).

### *Continue annual/biennial population counts using defined distance sampling methodology (Option 2)*

Results of the pilot study over the preceding three years within Waipapa E.A. suggest that this is a useful method of measuring population trends and should be continued accordingly.

### *Monitor ongoing reproductive output (Option 5)*

This is possible only if a sufficient sample of females are radio-tagged (minimum of 10) so that their nests can be located. Current estimates of the operational life of transmitters on females within the Waipapa E.A. suggest there will be eight radio-tagged birds in the 2004/05 breeding season. The number of nests located might be able to be supplemented by visiting known nests used previously (Option 4) and/or regularly adding a few new females to the radio-tagged population (such operations may provide information on demography – Option 3). Monitoring the reproductive output of kaka and the post-fledging survival and dispersal of juveniles within the Waipapa E.A. (and elsewhere for that matter) is particularly important if there are to be material changes in the pest control regime. It indicates what type of pest control works, how intensive it has to be, and over what area it needs to be sustained.

Additionally, while kaka within the Waipapa E.A. continue to carry operational transmitters it is important that their survival be monitored on a regular basis, as we still have a very limited idea of lifespan and age at first breeding. Any juveniles with transmitters (currently three juvenile females with transmitters operational until after the 2006/07 breeding season) must be monitored on a regular basis (monthly) to check their status (alive, dead, breeding).

## 5.2 WAIMANOA ECOLOGICAL AREA, PUREORA FOREST PARK, WAIKATO

Like other areas where there is no ongoing intensive pest control, the Waimanoa kaka population is faring badly, with about 50% of nesting females and 60% of the few fledglings produced being killed by predators. Although the long-term prognosis of this population is not bright, kaka continue to persist in low numbers, possibly as a result of immigration and periodic 1080 operations coinciding with good breeding years. We reluctantly recommended that nothing further be done in this area other than periodic checks on the remaining radio-tagged birds (four adult females and four juveniles from the 2001/02 season). If future resource allocations allow, consideration should be given to intensive predator control (Option 1) or rigorous population assessments using distance sampling as part of a wider non-treatment comparison with Waipapa E.A. (Option 2).

## 5.3 WAIHAHA ECOLOGICAL AREA, PUREORA FOREST PARK, WAIKATO

After the Waipapa E.A. this is the second most important kaka population within the Pureora Forest Park. However, like Waimanoa, the only pest control in the area involves aerial 1080 control operations at 5- to 6-year intervals. Although the kaka population persists in the area, we know that there is a significant sex bias towards male birds—a sure sign of a population in decline (Greene & Fraser 1998).

### *Commence recommended pest control (Option 1)*

Although the operational difficulties of implementing intensive pest control in this area are considerable, a periodic pulsed-management regime timed to coincide with major mast fruiting events would be of benefit to the kaka population. The priority here should be to stabilise the current population and rectify the imbalance in the sex ratio.

### *Conduct regular population counts (Option 2)*

Population surveys before (for at least two years) and after (ongoing) any planned pest control should be carried out.

## 5.4 WHIRINAKI FOREST PARK, BAY OF PLENTY

### *Commence recommended pest control (Option 1)*

The Whirinaki Forest Park kaka population is the only North Island kaka population outside Pureora Forest Park of any significance and as such is deserving of protection. Current pest control usually involves the periodic control of possums, which is insufficient to protect the resident kaka population. Future pest control must be long-term and of sufficient intensity to effectively control both stoats and possums over a minimum area of 750 ha, irrespective of the method(s) used.

### *Conduct regular population counts (Option 2)*

Population counts based on distance sampling should be instituted as soon as possible within any management area. Baseline densities of kaka prior to (preferably) or at the start of intensive pest management will provide a useful point of comparison for measuring the effectiveness of pest control.

### *Monitor ongoing reproductive output of kaka population (Option 5)*

This is only possible if there is a sufficient sample of radio-tagged females (minimum of 10) whose nests can be located. The number of adult females carrying operating transmitters needs to be increased accordingly. The number of nests located might be able to be supplemented by visiting known nests used previously (Option 4).

Monitoring the survival of adult kaka and fledglings, as well as the dispersal of juveniles, at Whirinaki is also important. A regular monitoring programme based on a sufficient sample size is required (see notes on Waipapa E.A. above).

## 5.5 RANGATAUA AND KARIOI RAHUI, TONGARIRO/TAUPO

The monitoring of kaka at Rangataua has suffered as a result of resource issues. The transmitters on birds failed following the 2002/03 breeding season, and the birds were outside the proposed management area. Intensive possum and stoat control is planned for the adjacent Karioi Rahui area of around 1500 ha. Kaka have been suggested as a suitable species for monitoring the outcome of the pest control.

### *Maintain current possum control and introduce effective mustelid control (Option 1)*

This will be possible only if sufficient funding is acquired to control mustelids. If this does not occur it will still be of interest to monitor kaka productivity in the absence of possums and the presence of stoats.

### *Conduct regular population counts (Option 2)*

Population surveys based on the current distance sampling methodology (assuming adequate numbers of birds) should be instituted as soon as possible within the planned study area. Baseline densities of kaka prior to (preferably) or at the start of intensive pest management will provide a useful point of comparison for measuring future trends.

### *Determine reproductive output of kaka population (Option 5)*

Measurements of reproductive output from a suitable sample of radio-tagged female kaka will provide an effective means of assessing the efficacy of pest control. Capture of birds for radio-tagging may give some overview of the demographic structure of the population (Option 3). If funds allow, some attempt should be made to examine juvenile survival, dispersal and recruitment.

## 5.6 MT BRUCE NATIONAL WILDLIFE CENTRE, WAIRARAPA

The reintroduction of kaka into the Mt Bruce scenic reserve has been a qualified success. The mechanics of rearing, releasing, establishing, and getting birds to breed have been successful. Unfortunately, survival of adults and fledglings is still too low to support a self-sustaining population of kaka. This realisation has, in part, resulted in predators being intensively controlled over an area of 950 hectares encompassing much of the Mt Bruce reserve (Option 1).

### *Continue to monitor the reproductive output of kaka within the Mt Bruce reserve (Option 5)*

To achieve this the following steps were recommended:

- Maintain transmitters on a minimum of 10 females
- Regularly monitor all tagged females
- Remove transmitters from males as opportunity arises
- Continue to radio-tag at least one female fledgling per nest
- Continue to erect more predator-proof nest boxes
- Institute protection at natural nests where feasible
- Provide secure nest sites for as many females as possible in the 2002/03 breeding season. Begin to withdraw protection after this so that pest control measures can be tested.

### *Continue establishment of kaka population at Mt Bruce (Section 4)*

Birds should continue to be released, if necessary, to maintain a core population of 10 breeding pairs while the pest control regime is established.

## 5.7 LAKE ROTOITI MAINLAND ISLAND, NELSON/MARLBOROUGH

### *Maintain effective pest control (Option 1)*

The establishment of new areas of pest control within Big Bush adjacent to the original mainland island area immediately prior to the start of the 2001/02 breeding season demonstrated the importance of the lag between initiation of trapping and attainment of effective pest control. This was disastrous for kaka choosing to breed within Big Bush, as all seven adult females that used unprotected nest sites were killed by predators. Clearly pest control should commence considerably in advance of the anticipated start of breeding by hole-nesting birds, such as kaka. Despite the removal of toxins from the original core of the mainland island and the move to traps, predation of birds in this area was able to be maintained at the low levels experienced in previous years. However, there is justification for maintaining the trigger for more intensive pest control about nests (particularly given the setback at Big Bush) whilst the number of females is low.

### *Conduct regular population counts (Option 2)*

This is not practical at the moment, given that so few kaka inhabit the area. Surveys should, however, be considered in future years, assuming numbers continue to increase.

### *Continue to examine the reproductive output of the kaka population (Option 5)*

The St Arnaud area office has undertaken to continue the intensive monitoring of radio-tagged female kaka for the foreseeable future. This includes maintaining operating transmitters on a minimum of 10 females and tagging up to 10 female fledglings in each breeding season. Nest location and productivity of each nesting attempt is to be monitored in detail. In addition, dispersal and recruitment of juveniles is to be followed intensively with a view to determining the optimal size of protected areas.

## 5.8 WEST COAST

The West Coast Conservancy should attempt to identify two priority sites for the management of kaka populations. Suitable sites might include areas in which intensive pest control is currently occurring or is planned.

### *Conduct regular population counts (Option 2)*

Following the identification of suitable sites (preferably where kaka are still moderately common) regular surveys using distance sampling should be instituted so that trends can be measured. A demographic ‘health-check’ of these populations would also be desirable before any long-term commitments to pest control were made (Option 3). More intensive monitoring (Option 5) would be useful if resources were available.

## 5.9 HURUNUI MAINLAND ISLAND, CANTERBURY

Current intensive possum, mustelid, and rodent control should continue (***Option 1***) to maintain increasing kaka numbers, according to anecdotal reports (A. Grant pers. comm.).

### *Conduct regular population counts (Option 2)*

Regular surveys using developed distance sampling protocols should be instituted so that trends can be measured (providing kaka are common enough). This would also provide some feedback regarding the success (or otherwise) of current stoat and possum control. Periodic demographic 'health-checks' of the population would also be desirable (Option 3). More intensive monitoring of reproductive output, as well as fledgling survival and recruitment (Option 5), would also be useful if resources were available.

## 5.10 EGLINTON VALLEY, SOUTHLAND

### *Trial population count methods (Option 2)*

Numbers of kaka within the Eglinton Valley during certain times of year seem sufficient to warrant trialling counts using distance sampling and some other potential methods. If this is the case, regular surveys should be undertaken to assess trends for this population in an area of relatively low-intensity pest control.

### *Continue monitoring reproductive output of kaka population (Option 5)*

If resources allow, radio-tags should be maintained on 10 female kaka to determine breeding frequency, reproductive success, and the continued effectiveness of the current stoat control regime. There is a need to tag more juveniles (minimum of 10) so that juvenile dispersal and recruitment can be examined. Juvenile dispersal is particularly important in assessing the effectiveness (or otherwise) of current pest control regimes at a population level. If juveniles suffer disproportionate mortality or move outside protected areas, the intensity and spatial scale at which predator control is conducted will require reassessment.

## 5.11 WAITUTU/HAUROKO, SOUTHLAND

### *Conduct regular population counts (Option 2)*

The podocarp–hardwood forests of Waitutu are thought to harbour reasonable kaka populations, but there is very little information to confirm this and even less (if any) on which to make any informed comment on current trends. Current information suggests that possum numbers are still relatively low, although increasing within Waitutu (particularly east of the Waitutu River). This is of particular concern, given results that suggest that around 40% of nest failures could be due to predation by possums and that recent declines of kaka populations in southern South Westland have followed invasion by possums

(Veltman 2000). A demographic 'health-check' of this population would, therefore, also be highly desirable (Option 3), as would more intensive monitoring (Option 5) if resources permitted.

### 5.12 OTHER NORTH ISLAND AND SOUTH ISLAND SITES

Baseline monitoring of the size of both kaka and kereru populations, using distance sampling, should be encouraged wherever there are reasonable numbers of these birds and there is interest in long-term population trends. This is particularly important in areas where long-term pest control is about to commence. Useful areas might include Great Barrier Island, Moehau, Haast kiwi sanctuary, Stewart Island, and the Otamatuna mainland island. More intensive monitoring would be useful to determine kaka demography where resources allow. It should also be emphasised that kereru are equally able to be counted using distance sampling methods and should wherever possible be counted simultaneously.

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