Monitoring and management of kereru *(Hemiphaga novaeseelandiae)*

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Abstract

The endemic kereru (*Hemiphaga novaeseelandiae)* (also known as kuku, kukupa or New Zealand pigeon, but henceforth referred to as kereru) and the Chatham Island subspecies, parea (*Hemiphaga novaeseelandiae chathamensis*), are the only extant representatives of the genus *Hemiphaga.* A programme has been set up to monitor kereru populations. The aim of this monitoring programme is to provide a clearer picture of medium- to long-term trends in kereru populations at key sites (e.g., mainland "island" management sites and their paired non-treatment sites), and to document the responses of kereru populations to management actions. This report sets out the requirements for monitoring kereru at key sites as part of a national programme. In addition, it is intended to be used as a practical guide for anyone (e.g., iwi, conservation groups, school groups) planning to initiate a kereru monitoring project. The most efficient way of detecting and interpreting kereru population trends is considered to be by undertaking 5-minute counts with distance estimates in conjunction with phenology monitoring and display flight monitoring. It is therefore recommended that others use these methods wherever possible. A section on other techniques is included to cover situations where 5-minute counts may not be practicable. Wherever possible, kereru monitoring should be integrated into existing Department of Conservation bird monitoring and management programmes, rather than requiring the initiation of new projects. Iwi, conservation groups and interested members of the public will be encouraged to participate in kereru monitoring and conservation management. Annual results from each site should be forwarded to the programme co-ordinator, who will review and collate the data, and prepare an annual report for distribution to all participants and interested parties. Explanation of the programme, relevant aspects of kereru ecology, and background information are provided in the main text. Descriptions of the actual methods are given in the appendices.

1. Introduction

The endemic kereru (*Hemiphaga novaeseelandiae)* (also known as kuku, kukupa or New Zealand pigeon, but henceforth referred to as kereru) and the Chatham Island subspecies, parea (*Hemiphaga novaeseelandiae chathamensis*), are the only extant representatives of the genus *Hemiphaga.* The development and implementation of reliable and sensitive methods for monitoring kereru populations will enable us to determine whether management actions are required to protect local kereru populations and to assess the effectiveness of management programmes. This is an important conservation issue because:

1. The kereru is one of the most important seed dispersing bird species in New Zealand because of its widespread distribution, mobility and the wide range

of fruit it eats (at least 70 species). No other common bird is capable of swallowing fruits greater than 12 mm diameter and dispersing their seeds intact. Seed dispersal of large-fruited species, such as karaka *(Corynocarpus laevigatus)*, tawa *(Beilschmiedia tawa)*, taraire *(Beilschmiedia taraire)* and puriri *(Vitex lucens),* is virtually dependent on kereru (Clout and Hay 1989). Kereru can therefore be regarded as a keystone species vital to the health of mixed podocarp-broad-leaf forests. Local extirpations of kereru would lead to disruption of ecological processes and, in the long term, would almost certainly alter forest composition. For example, large-fruited species dispersed only by kereru would generally be absent from forest patches regenerating after clearance or fire. Since miro seedling survival in mixed podocarp-broad-leaf forest is relatively poor beneath the canopy of the parent tree and greatest 30–40 m away (Clout, unpublished data), the relative abundance and distribution of species, such as miro, may decline even within structurally intact forest. As evidence of this prediction, there is a clumped distribution of several tree species and their seedlings on the Three Kings and Poor Knights Island groups, the former lacking kereru and kereru having only recently been seen at the latter (I.A.E. Atkinson pers. comm.).

2. kereru's life history traits (relatively low reproductive rate and potential longevity) and its vulnerability to predation by introduced mammals are typical of many of New Zealand's more critically endangered species. It is therefore a useful indicator species whose population trends could be monitored as part of an assessment of the effectiveness of mainland "island" management programmes and smaller restoration projects, such as of privately-owned forest remnants.

3. Kereru populations are known to be rapidly declining in Taitokerau (Northland), where the bird is known as kukupa, and are widely perceived to be declining in some other parts of the country. However, more quantitative data are needed to confirm whether these widespread concerns, based on anecdotal reports, reflect real population trends in areas other than Taitokerau.

4. Illegal harvesting of kereru continues in some areas and is considered to be a factor in the decline (or suspected decline) of populations. Debates over whether customary use of kereru (currently not permitted under the Wildlife Act) is still appropriate cannot be satisfactorily resolved without, among other issues, a clear understanding of population trends.

5. Management targeted specifically at enhancing kereru populations demands a monitoring technique that enables as high a level of precision as possible.

The development and implementation of a nationally coordinated monitoring programme is a necessary first step in the development of a kereru conservation strategy which will link into a number of mainland "island" management programmes.

2. Kereru

2.1 TAXONOMY

The endemic kereru (*Hemiphaga novaeseelandiae novaeseelandiae*) and the Chatham Island subspecies, parea (*Hemiphaga novaeseelandiae chathamensis*), are the only extant representatives of the genus *Hemiphaga.* The genus formerly included subspecies on Norfolk Island and Raoul Island. *Hemiphaga* has probably been isolated in the New Zealand archipelago since the mid to late Tertiary (James 1995).

2.2 APPEARANCE

Male and female kereru look alike. The head, nape, hind neck, throat and chest are green, often with an intense metallic green and bronze iridescence. The mantle, and lesser and median wing coverts are maroon, but with brown-orange and green tones towards the margins. The rump and upper tail coverts are a pastel blue-green, with a faint green and bronze iridescence. On perched birds the exposed portions of the primaries and secondaries are black with a dull green sheen. The upper surface of the tail is black, but having an extensive brown tip. The under tail coverts are white, except with occasional grey patches on the outer coverts. The breast and belly are white. In the nesting season, the eyes, eye rings, beak and feet are crimson, the claws black. Occasionally the tip of the beak is paler than the rest, and may be orangey in some regions.

Kereru have only 12 tail feathers, fewer than most other fruit pigeons. Weighing from 550 to 850 g when adult, the kereru is also heavier than most fruit pigeons.

During the first few weeks after fledging, several features can sometimes be used to distinguish juveniles from adults (Table 1). Note that bill colour is the most reliable and persistent indicator (recognisable for 3–6 months after fledging). The other features are less persistent (1–3 weeks only) or are not present on all individuals.

2.3 HOME RANGE AND MOVEMENTS

In areas with a year-round food supply and suitable nesting habitat, adult kereru tend to be relatively sedentary. For example, Bell (1996) found that radio-tagged breeding birds at Wenderholm Regional Park occupied home ranges of 20–30 ha over the entire year within which their core areas (defined as 60% of fixes, and including all nests) were only 1–2 ha. Juvenile home ranges were much bigger (up to 109 ha) as were their core ranges. In other areas, where seasonal feeding sites are distant from each other, kereru may occupy a succession of home ranges through the year. For example, about half of the kereru radio-tagged at Pelorus Bridge subsequently followed an extensive but **traditional** circuit of seasonal home ranges, which were spread over distances of up to 18–20 km (Clout *et al.* 1991).

TABLE 1. DISTINGUISHING FEATURES OF JUVENILE KERERU COMPARED WITH ADULTS.

CHARACTERISTIC	JUVENILE	ADULT
Bill Colour	Brown	Crimson
Unfeathered skin	Eye ring and feet relatively dull brown-pink	Eye ring and feet crimson
Feathering	• May have sparse feathering around base of bill (i.e., forehead and cheeks), giving the bill an elongated and dorso-ventrally flattened appearance. • May have tassels of yellow down persisting, especially on the head. • Some individuals have bands or spots of grey or brown feathers on upper part of the breast. Most of the feathers which appear white from a distance are actually $^2/_3$ grey with white tips. • Tail feathers of even length but initially a little shorter than adults.	• Dense feathers cover the base of upper bill. • No down present. • Breast completely white when viewed from a distance. The basal part ($^1/_3$ or less) of some breast feathers may be grey but this is not visible unless you have the bird in your hand. • At least some tail feathers full length. (When moulting, only a few tail feathers are undergoing replacement at any one time.)
Size	Initially lighter (c. 400 g at fledging)	Heavier (550 to 850 g)
Vocalisation	Prior to their "voice breaking" at c. three months of age, the only vocalisation is a high pitched squeaking/whining noise, usually heard in a begging context.	A range of ascending, descending, short and long "coos" depending on context: contact, alarm, courtship.
Behaviour	Fed by male parent for at least two weeks after leaving nest. Begging consists of "wing paddling" and squeaking.	Adults do not feed their mates, and do not squeak or "wing paddle".

2.4 DIET

Whereas most fruit pigeons are tropical species feeding exclusively on fruits, the New Zealand species inhabits temperate forests, where the fruit supply is often discontinuous due to a cooler climate and where more recently podocarps have been removed for timber. Kereru feed on fruits whenever possible. In some northern forests there is a continuous succession of fruits available throughout most years (Pierce 1993). However, in many parts of New Zealand, kereru are forced to subsist on foliage, particularly of leguminous and deciduous plants, during much of winter and spring; e.g., kereru at Nelson Lakes fed almost exclusively on leaves from June to January (Clout *et al.* 1986). Introduced legumes and deciduous species are now important winter and spring foods in some areas, e.g., tree lucerne (*Chamaecytisus palmensis*) from May to September at Mohi Bush (Langham 1991), and willows, elms and poplars from July to December at Pelorus Bridge, Nelson (Clout *et al.* 1991).

Kereru can survive for several months on a diet of foliage and buds. M.C. Clout (pers. comm.) found no significant difference between the spring bodyweights of kereru captured at Pelorus Bridge immediately prior to good breeding seasons versus poor breeding seasons. However, they breed apparently only when a good supply of fruit is available (Powlesland *et al.* 1997); breeding activity commences at the beginning of the fruiting season, which varies

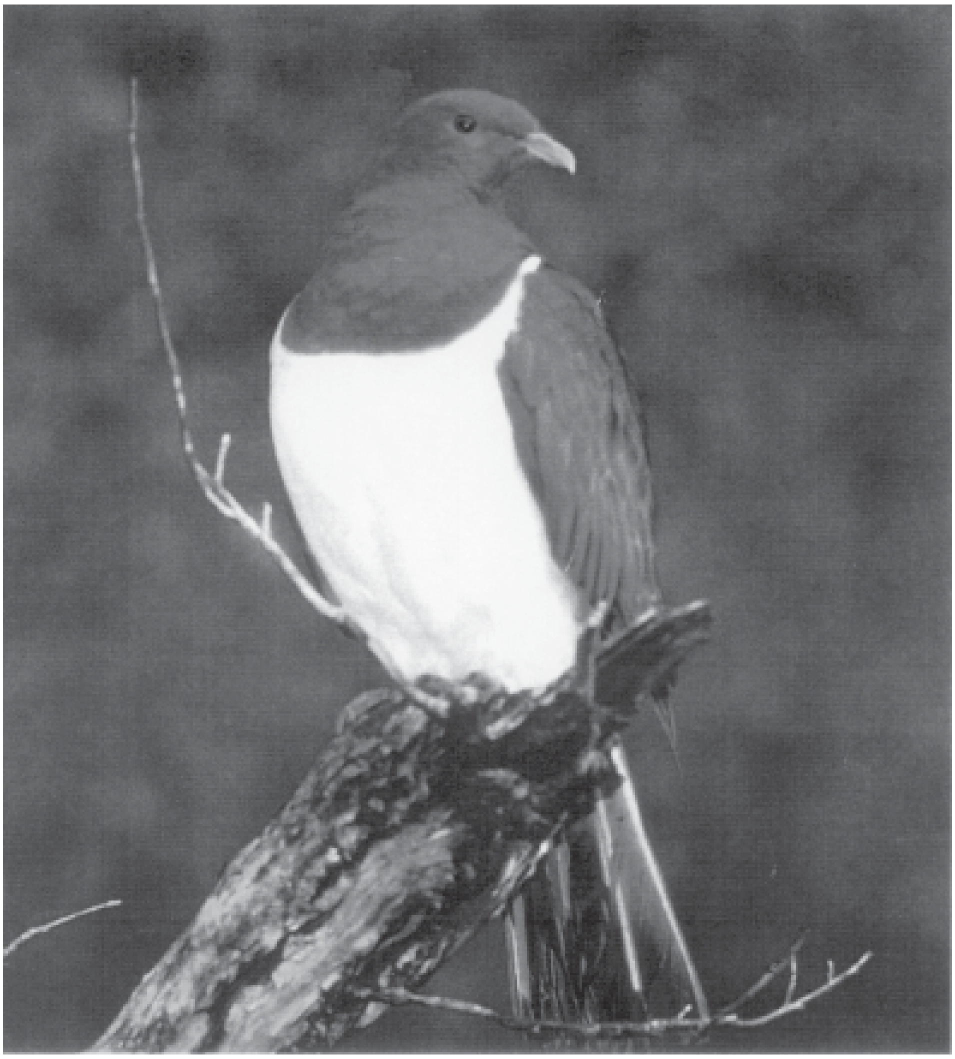

FIGURE 1. ADULT KERERU. (Photo J. Kendrick)

FIGURE 2. JUVENILE KERERU. (Photo D. Mudge)

between areas. For example, egg laying generally commences during December–January at Pelorus Bridge, Nelson (Clout *et al.* 1995), whereas Taitokerau (Northland) birds may breed at any time, except when moulting during March–May (James 1995; Pierce and Graham 1995). In good fruiting years, a relatively large proportion of the kereru population will attempt to breed and the breeding season will be of longer duration, with some pairs making up to four breeding attempts. In poor fruiting years, few kereru attempt to breed at all (Clout *et al.* 1995). While the correlation between good breeding years and good fruiting years is obvious, it is not clear which particular foods are important for bringing kereru into breeding condition in each area.

2.5 BREEDING

Kereru are seen undertaking paired flights and chasing for up to two months prior to nesting. Display flights (described in Appendix 1) are apparently performed only by males in breeding condition and are most common prior to laying and immediately following nest failure. Males associated with nests during the incubation and chick-rearing stages very seldom perform display flights (James 1995). The first display flights of the season are usually noted only one to two weeks before the first nests are found. The onset of display flights therefore provides a fairly accurate indication of the onset of breeding.

A single egg is laid in a nest consisting of a platform of twigs and is incubated for 28 to 30 days. The male incubates during most of the day with the female taking over from early evening to mid-morning. The chick is brooded continuously for the first few days and is then left unattended for much of the time. The chick is generally fed only two to three times each day, initially on crop milk then increasing proportions of regurgitated foods. The duration of the nestling stage apparently depends on the quality of the food supply: about four to five weeks under favorable conditions in Northland, whereas a chick hatched outside the main breeding (and fruiting) season at the same site took at least seven weeks to fledge (James 1995). Chicks fledge at about 400 g (approximately two thirds adult weight) (Clout 1990) and are fed by a parent (often the male) for at least a week after leaving the nest (James 1995).

Nestling survival apparently depends on regular feeding by both parents; cases have been reported where one parent has died while supporting a nestling and its surviving mate has failed to rear the chick alone (Clout *et al.* 1995). Although kereru are slow breeders, taking two to three months from laying to fledging, pairs which lose an egg during incubation are able to re-lay within eight days (Clout *et al.* 1995). Also, when fruit is readily available during the nesting season pairs occasionally have overlapping clutches—beginning incubating a second egg on a second nest while still feeding but not brooding a large chick in a previous nest (Clout *et al.* 1988).

3. History of decline

Faced with habitat loss, introduced browsing and predatory mammals, and hunting with guns, kereru declined rapidly after European settlement. Concern over the obvious decline of this and other species led to the passing of the Wild Birds Protection Act 1864. Section III stated that "No wild duck, paradise duck or pigeon indigenous to the colony shall be hunted, taken or killed except during the months of April, May, June and July of any year". Further restrictions were imposed under The Animal Protection Act 1908: the hunting season was shortened to May to July and every third season was closed. However, these measures did not halt the decline of kereru. Absolute protection of kereru, along with most native birds, was finally conferred under the Animals Protection and Game Act 1921–22, s3(1).

Anecdotal reports suggest that kereru numbers subsequently stabilised or recovered in some areas. However, further declines were inevitable in areas where the kereru's mixed podocarp forest habitat was destroyed or degraded by logging and land clearance.

In recent times, many people have expressed concerns that kereru are apparently continuing to decline in areas such as Taitokerau, Te Urewera, Wanganui and West Coast, where large-scale habitat destruction is no longer occurring. In most cases it seems that quantitative monitoring programmes have not been put in place to test whether these perceived trends are real. However, the suspected decline of kereru has been confirmed in Taitokerau (Pierce *et al*. 1993).

When Pierce *et al.* (1993) repeated 5-minute bird counts in six Taitokerau forests initially surveyed in 1979 by the Wildlife Service (Moynihan 1980), their 1993 kereru counts averaged only 50% of the 1979 numbers. While increasing possum numbers may have been a contributing factor, the greatest declines (3 to 5 fold) were recorded from the forests experiencing high hunting pressure—Russell, Raetea and Omahuta forests. Whereas much possum sign was recorded from Russell and Omahuta forests, the kereru population had also crashed at Raetea where possum densities were lower than in any other forest surveyed. The highest kereru count was obtained from an unhunted reserve which had a moderate density of possums. In some areas at least, it appears that kereru may be able to coexist with moderate densities of possums, but cannot sustain hunting pressure as well.

The mortality and productivity data from a number of other kereru studies (see following section) indicate that kereru are also declining elsewhere.

4. Review of population studies

Kereru have been intensively studied at four mainland sites. All four populations appear to be declining because adult mortality rates in each population apparently exceed reproductive output.

Clout *et al.* (1995) summarised research over seven seasons at Pelorus Bridge and three seasons at Mohi Bush and Wenderholm Regional Park. At Pelorus Bridge, only 10 young were fledged from 45 known nesting attempts. Of the 30 which failed at the egg stage, at least six losses were attributed to rat predation, as was the death of at least one of the five chicks. Annual nesting success ranged from 0 to 0.6 fledglings per pair per season, with a mean reproductive output of 0.24 fledglings per pair per season (0.12/bird/season). At Mohi Bush all of the nine known nests failed. Of the seven eggs lost, two were attributed to rat predation and one to stoat predation; one chick was preyed upon by a rat, and stoat predation of the other chick was suspected. At Wenderholm Regional Park, none of the 20 monitored nests was successful. All losses were at the egg stage, including at least 12 predations of which three were attributed to rats and four to stoats.

Clout *et al.* (1995) also recorded particularly high adult mortality at Wenderholm, where the two deaths among 11 radio-tagged birds were attributed to hunters, and at Mohi Bush where half of the radio-tagged birds died within two to six months. This included six cases attributed to exposure/starvation of birds which had been browsing tree lucerne for several months, one probable cat predation of a bird feeding on tree lucerne, and one unknown. At Pelorus Bridge, 10 deaths were recorded from 19,321 radio-transmitter bird days: one bird was killed by a stoat while feeding in the canopy, five birds were almost certainly killed by stoats while feeding on broom (*Cytisus scoparius*), two were hit by cars and two died of unknown causes. The mean life expectancy of pigeons at this site was estimated at 5.4 years. Clout *et al.* (1995) predict the Mohi Bush and Wenderholm populations will decline rapidly unless supplemented by immigration, and that even the Pelorus Bridge population is not quite replacing itself.

Pierce and Graham (1995) studied kukupa at Maungatapere, near Whangarei, and on the Chickens Islands (free of introduced mammals except for the kiore (*Rattus exulans*)). Of 31 unprotected mainland nests, only six (19%) succeeded to the late nestling stage, compared with 10 of the 16 nests (63%) monitored on the Chickens Islands. All mainland nest failures occurred at the egg stage, including two cases of possum predation, 10 cases of small mammal predation and two cases where nests were probably partially destroyed by a large animal (possum, cat or harrier). One fledged chick was later killed by a stoat. Adult mortality was also very high at Pierce and Graham's Maungatapere site. Out of 11 kukupa fitted with radio-transmitters, five died or disappeared within three months: one crashed into a window, two were almost certainly killed by hunters and the other two were suspected of being killed by hunters. This population clearly cannot sustain such a high mortality rate in combination with low reproductive success.

5. Perceived threats

5.1 PREDATION

Adult kereru are vulnerable to predation by cats and stoats, especially when feeding on or near the ground (Clout *et al*. 1995, Grant *et al*. 1997).

In addition to the recorded predation of eggs and nestlings by rats, possums, stoats and cats, harriers are also suspected to take eggs and nestlings. Egg predation by rats, possums and stoats seems to be the most common cause of nest failure (see “Population Studies” section).

James (1995) recorded 19 incidents of other vertebrates on or near kereru nests videoed at Wenderholm Regional Park. These included 12 recordings of possums (one of which was almost certainly responsible for an egg predation) and three ship rat visitations, none of which elicited any obvious response from the incubating kereru. Mammals ventured only on to the two nests studied which were positioned against the main trunk of the nest tree.

James (1995) also compared nesting success at Wenderholm Regional Park (where rats were intensively controlled during the breeding season using a 100 m x 50 m grid of Talon baits in Novacoil stations) with that in nearby forest patches (non-treatment areas where rats were not poisoned). Snap-trapping indices confirmed that poisoning had substantially reduced rat numbers at Wenderholm and that rat densities there were lower than in the non-treatment areas. Egg predation at real kereru nests and artificial nests (baskets baited with *Columba livia* eggs) was significantly lower at Wenderholm, but due to a higher incidence of desertion there, fledging success was not significantly higher. However, the nesting success at Wenderholm (nine chicks fledged from 38 monitored nests) had increased markedly compared with nil success during the previous 1988–1990 study there (Clout *et al.* 1995). James cautions that the increased productivity cannot be entirely attributed to the reduction in rat numbers because possum numbers had also been reduced since 1990. He considers that possums may be a more important nest predator than previously thought.

Common mynas (*Acridotheres tristis*) may kill young pigeon chicks and probably also take eggs (T. Wilson pers. comm. in Clout *et al*. 1995).

5.2 LOSS AND DEGRADATION OF LOWLAND FOREST HABITAT

Kereru productivity may be reduced if possums and rats deplete fruit supplies needed to trigger and sustain breeding. That is, the removal of flower buds or fruits by these mammals may result in a higher frequency of non-breeding years for kereru, fewer opportunities for re-nesting during “good” breeding years, and increased chick mortality through predation. Poor nutrition extends the nestling period and hence the risk of predation.

Any cause of habitat degradation which leads to reduced fruit availability may also increase adult mortality. For example, at Mohi Bush (an isolated forest remnant from which podocarps had been logged), kereru fed on foliage and flowers, principally of tree lucerne, from May through to September/October (Langham 1991). Such extended periods of subsistence foraging may place kereru under nutritional stress. Langham (1991) suspected that starvation and/or exposure was the cause of death of six adults during late spring. Apparent starvation of kereru in spring has been noted at other sites (e.g., Te Anau and near Murchison (Clout *et al*. 1995) and Northland (Pierce & Graham 1995)) which have a relatively low diversity of fruiting plants and a short fruiting season.

In the longer-term, introduced browsers, including ungulates, can degrade kereru habitat by inducing changes in forest composition, thereby reducing the relative abundance of important food species.

5.3 ILLEGAL HUNTING

Kereru population declines and suspected declines seem to be more pronounced in areas where hunting is known to be a problem, for example in the Hunua Ranges near Auckland and in Puketi, Russell, Raetea and Omahuta forests in Northland (Pierce *et al*. 1993).

5.4 COLLISIONS WITH MOTOR VEHICLES AND WINDOWS

Collisions with motor vehicles and windows of buildings may be significant causes of death in some areas. For example, two of the 10 known deaths among radio-tagged kereru at Pelorus Bridge were the result of collisions with motor vehicles (Clout *et al*. 1995); one of five kereru deaths during Pierce and Graham's (1995) Taitokerau study was a window casualty, as were 22 kereru cases (c. 30%) processed by Whangarei Bird Rescue Group during 1992–93 (Pierce and Graham 1995). Since January 1995, the Department of Conservation Dunedin Field Centre has collected 28 kereru injured or killed as a result of window strike (32% of all kereru collected). The majority of the Dunedin cases involved young birds in autumn. The pattern is repeated in other urban areas inhabited by kereru. While it is understandable that window strike would be a commonly observed cause of death, it is not clear how significant such accidents are at the population level. The Dunedin kereru population appears to be increasing and extending its distribution, despite these accidental deaths.

5.5 HARASSMENT

There are records of magpies attacking and apparently killing kereru in the Waikato region (Barrington 1996).

5.6 DISTURBANCE

Kereru disturbed by people or other animals during the early stages of their nesting cycle are likely to abandon potential nest sites or accidentally tip eggs out of nests. The birds are most likely to be startled when nests are relatively close to the ground, as is often the case in regenerating forest patches where few, if any, high nest sites are available.

6. The National Kereru Monitoring Programme

6.1 OBJECTIVES

1. To measure medium- to long-term trends in kereru populations at key sites and distributed throughout New Zealand; and
2. To document the responses of kereru populations to management actions.

6.2 DUTIES OF THE NATIONAL CO-ORDINATOR

The national co-ordinator is:

Ralph Powlesland
Science and Research Unit, STIS
Department of Conservation
58 Tory Street
P.O. Box 10 420
WELLINGTON

Phone 04 4710 726
Fax 04 4713 279

The co-ordinator will maintain the network between kereru workers based in conservancies and other agencies.

By April of each year, the person responsible for overseeing monitoring and research of kereru at each key site should have provided the co-ordinator with a copy of their results.

The co-ordinator will then collate and review these data, providing a national overview of regional patterns. By July of each year, the co-ordinator will prepare an annual report to be published by the Department of Conservation as an internal report. This will be distributed to participants in the programme and made available to other interested parties (e.g., iwi and conservation groups involved in kereru conservation programmes at other sites), ensuring minimal delay in the sharing and use of recent information.

6.3 OUTPUTS

Annual reports and periodic scientific publications.

6.4 RELATIONSHIPS WITH OTHER PROGRAMMES

The kereru monitoring programme needs to be properly integrated with other aspects of monitoring at mainland “island” management sites. For example, kereru food plants **must** be included in phenological monitoring programmes at key sites because interpretation of kereru population trends and breeding patterns **depends** on effective and consistent phenological monitoring at each site.

7. Key sites for monitoring

Where appropriate, existing data sets will be used as a baseline for repeat surveys and/or regular monitoring. During the 1970s, DSIR Ecology Division and the NZ Wildlife Service Fauna Survey Unit carried out 5-minute counts along transects in many areas. It is important to collate these existing data sets as part of the site selection process. For example, Mick Clout's 5-minute counts at Wenderholm in the 1980s, prior to any rodent control there, provides a potential baseline for demonstrating population change as a result of management. While this historical information is a bonus, such sites will not be selected as key sites for ongoing monitoring unless they meet the programme's key site requirements:

- Representative of a particular forest type in each ecological district, or nationally important.
- Vegetation along transects or grids must be representative of that in the area, and the transects or grids must be user-friendly, i.e., stations should be positioned and marked so that each observer can complete counts at at least 20 stations per day. In some cases, the original surveys were not sufficiently user-friendly to be repeated on an annual basis.
- Relatively large habitat areas will need to be selected in preference to small isolated forest patches. Each area should be able to accommodate at least 50 count stations.

Whenever possible, sites should be selected that are already being monitored and/or managed as part of a mainland "island" habitat management programme. These may be Department of Conservation, iwi or other conservation group initiatives. Involvement by iwi and other community groups will make it feasible to have more replicates. The operation at Motatau Forest, Northland, is an excellent example of how local people, interest groups and agencies can combine to bring about the survival and enhancement of a kereru population (Pullman & Pullman 1997). The 350 ha forest ecosystem has been ravaged by possums, rats, cats, stoats, goats, pigs and people. The initiator of this project is Kevin Prime, a Ngati Hine elder. Kevin's energy and commitment to Motatau Forest has resulted in the Department of Conservation (overseeing and assisting with pest control), Ngati Hine (providing the vision and pest control workers), Landcare Research (monitoring the impact of the management), Education Training Support Agency (providing funding for and trainees for pest control around the edge of the forest and in adjacent pine forests), and Lottery Grants Board New Zealand (providing funds for mustelid control), working together, starting in 1996. The results being obtained at Motatau Forest are being compared with observations at nearby Okaroro Forest (325 ha) where no pest control is being carried out.

The following types of situations will be monitored:

1. **Islands free of introduced mammals**

   e.g., Lady Alice
   Red Mercury
   Kapiti Island
   Codfish Island once kiore have been eradicated

2. **Mainland "island" management** sites (where introduced mammals are subject to intensive control) **with a paired non-treatment area for each** so that the effects of management can bemeasured; these areas will have existing or planned monitoring programmes for a range of species

   e.g., Trounson, Northland
   Motatau, Northland (Maori land where DoC is helping with pest control)
   Wenderholm, Auckland (Auckland Regional Council)
   Mapara, Waikato
   Pureora, Waikato
   Te Urewera, Bay of Plenty
   Boundary Stream, East Coast/Hawkes Bay
   Lake Rotoroa, Nelson/Marlborough
   Hurunui, Canterbury
   Okarito and another South Westland site, West Coast
   One or two sites in Southland

3. **"Standard" management sites**: e.g., several sites where 1080 possum control is done on a three- to five-year cycle and several sites where there is sustained control of possums but no other pest control.

4. **Other islands**, such as Little Barrier Island, which have a restricted range of introduced mammalian pests.

In addition, kereru should be monitored at **urban sites**. The Department should facilitate the setting up of urban monitoring programmes. However, others (e.g., Regional Council and Local Authority staff, University students, OSNZ and other volunteer conservation groups) would be encouraged to actually collect the data and provide it for collation in the national programme.

8. Monitoring methods

8.1 GENERAL POINTS

Any index of abundance, for example, 5-minute counts and display flight counts, is affected by the birds' conspicuousness, which varies with factors such as the weather conditions, habitat type, seasonal vegetation changes, and changes in bird status (e.g., more conspicuous prior to breeding than during moult). Additional variation in an index of abundance can arise from changes in an observer's skill level and differences between observers' in their ability to detect a particular species of bird.

To minimise extraneous sources of variation in detectability of kereru over time at each site, it is important to carry out monitoring under similar weather conditions each year, at the same time of day and on approximately the same calendar dates. Annual monitoring of relative abundance (e.g., 5-minute counts) should be completed over as short a time period as possible (preferably within two weeks) to minimise the influence of seasonal changes. Where possible, the same observers should be used each year. Any new observers should be trained and checked by experienced observers previously involved in the programme. This can be done by a pair of observers, one experienced, undertaking the first set of counts simultaneously and cross-checking their results at the end of each sample. Also, all observers must spend equal time in the treatment and non-treatment areas.

Avoid indexing kereru abundance at times of day when their activity patterns (hence conspicuousness) are likely to be changing rapidly; i.e., counts should not be undertaken near dawn, dusk or nest change-over times (within four hours of sunrise and four hours of sunset; see Appendix 2). During these periods, all non-incubating and non-brooding birds tend to be actively foraging, which can involve several flights. Breeding males, which are quite territorial about the nest, often respond to the foraging flights of neighbours or those passing over the territory by giving display flights. The frequency of display flights tends to be minimal from mid-morning to late afternoon, while males are attending their nests, but increases again once they are relieved of incubating or brooding duties in the evening. Extremes of weather should also be avoided; e.g., counts undertaken during strong wind and/or rain are likely to under-estimate relative abundance. Thus, the best times for indexing kereru abundance is from mid-morning to mid-afternoon on days when the weather is dry and relatively calm.

Because the proportion of kereru detected will be strongly affected by habitat type, one must be very cautious of directly comparing 5-minute counts (or any other relative abundance index) of kereru in different areas unless forest types and topography are very similar.

As the objective of regular monitoring is to detect medium- to long-term population trends in each area, it is vital that the most appropriate method for each site is selected at the outset and is not subsequently modified from year to year unless the methods are fully compatible.

8.2 MONITORING PROTOCOL

Monitoring at key sites will consist of 5-minute counts undertaken annually during the peak breeding season, which may range from November in Northland to January in South Island areas. In the first two to three seasons of monitoring at each site, display flight monitoring starting prior to breeding and continuing during the early part of the breeding season should be carried out to establish the correct timing for 5-minute counts. Counts during the breeding season will provide the best indication of trends in the number of birds present despite the variance arising from year-to-year differences in the proportion of birds on nests. At other times of year, kereru may live in seasonal home ranges distant from their breeding area.

Ongoing display flight monitoring and phenological monitoring of kereru food plants should be used to help interpret 5-minute count data. A robust and consistent method of phenology monitoring will be mandatory at all sites where kereru are monitored as part of the national programme.

8.3 PREFERRED MONITORING METHODS

8.3.1 Five-minute counts with distance estimates

Purpose

To obtain an index of relative abundance of kereru in both treatment and non-treatment areas with which to monitor medium- to long-term population trends.

Method

Each observer records the number of kereru seen and heard during a 5-minute period within a 200 m radius of each count station. Refer to Appendix 3 for full instructions on how to carry out 5-minute counts, as outlined by Dawson and Bull (1975). For each record during the count period an estimate is also made of the distance to the individual bird recorded.

Advantages

Five-minute counts were selected as the preferred method because:

- Five-minute counts are more reliable than walking transects. Dawson and Bull (1975) demonstrated that a stationary observer based at a count station detected a higher and more consistent proportion of birds than a walking observer did. The walking observers' ability to detect birds is compromised by the noise generated by walking, which varies with weather and habitat conditions (e.g., dry litter is noisier than wet litter; dense vegetation is noisier than sparse vegetation; wet conditions are noisier than dry conditions). Detection rates will be further reduced if the observer is walking through unfamiliar or difficult terrain. Proponents of walking transects point out that the walking observer is likely to observe more birds over a given time because no observation time is lost while moving between count stations. However, the benefit of increased reliability of the 5-minute count data outweighs the costs of reduced observation time and area sampled by this method.
- Compared with walking transects, 5-minute counts are subject to relatively little variation between observers, particularly if only one distinctive species, like kereru, is being monitored. Differences between observers are further reduced if counts are statistically analysed on the basis of presence/absence.
- The method is not excessively labour intensive. With experienced observers and sensibly placed (but representative) count stations, each observer should be able to complete at least 20 counts per day. Thus, the expected annual quota of 100 counts per study site could be completed in 5 person-days of fine weather.
- Since the 1970s, the 5-minute count has been the most commonly used method for monitoring diurnal birds in New Zealand. Where possible, 5-minute counts of kereru will be carried out in conjunction with ongoing monitoring of other diurnal species. This is the most cost-effective approach to kereru monitoring as extra resources will be required only for the monitoring of display flights. In some situations, however, it will be necessary to count kereru specifically. For example, where the timing of general bird counts conflicts with the kereru monitoring protocol, and in privately-owned forests where kereru may be the sole focus of monitoring and management.

- Some existing data sets may be used as a baseline for comparison with future monitoring, provided that the original surveys were carried out at sites that fit the criteria of the monitoring programme, and the transects can be relocated and re-surveyed without excessive effort or time.

Disadvantages

Unfortunately, given the relatively low kereru counts obtained in most mainland situations (generally ≤0.3 birds/count (Dawson *et al.* 1978, Clout and Gaze 1984, Pierce *et al.*1993, Wilson *et al.* 1988)), 5-minute counts are unlikely to be sensitive enough to detect 20–30% changes in kereru abundance within very small forest patches where fewer than 25 stations can be accommodated. In an ideal situation, where location of stations is not constrained by topography, etc., the placement of 25 stations on a 200 m x 200 m grid where no station is less than 200 m from the forest edge, would require a minimum area of 1.2 km x 1.2 . Refer to "Other Methods" section for suggestions on how to monitor kereru in areas too small for 5-minute counts.

Sample Size

Pilot surveys should be carried out at each site to determine the number of stations and counts required to allow detection of a 20–30% change over a two- to three-year period where $P \leq 0.05$. It is preferable to count from the required number of stations once only rather than count from a smaller number of stations several times. At least 100 counts will be needed at most mainland sites, although it may be possible to reduce sample size in areas where kereru are exceptionally abundant (i.e., mean count of >0.5 birds/station). Wherever possible, at least 50 stations should be counted no more than twice each. In small or difficult areas where it is not possible to have 50 stations, 25 stations may be counted four times but this approach should be considered a last resort.

Statistical Analysis

There is a variety of statistical techniques which can be used to compare the results from the treatment and non-treatment areas, each with advantages and disadvantages. If the data are normally distributed, then a simple one-way analysis of variance is possible. With index counts of birds this is very rarely the case though, so either the data need to be transformed prior to analysis or an analysis technique used which takes account of non-normal data. Of particular note is the fact that there are generally many zero counts.

The method most commonly used for the analysis of multi-species 5-minute counts in the past (Dawson & Bull 1975) has been the chi-square test on square root transformed data. However, a more robust alternative is the Kruskall-Wallace test which is a non-parametric one-way analysis of variance. An alternative, if only kereru are being counted, is to use the binomial test on presence-absence data. This provides a robust result, and has the advantage that the observer only needs to count until a kereru is detected within the five-minute period. However, this results in the loss of potentially valuable data, particularly when kereru are relatively abundant.

Recent years have seen the growth of distance sampling (Buckland *et al.* 1993). The critical feature of this technique is that each observation of a bird must be accompanied by an accurate estimate of its distance from the observer. Distance sampling may be employed using transect or point counts. For some species, the detection rate for individuals is such that it can be assumed that all birds very close to the observer, and most others within the sampling area, are being recorded. From the data for these species it is possible to calculate a density estimate. However, for most species, particularly kereru, it may be assumed that an unknown proportion of birds is not being detected. Therefore, even if distance from the observer is calculated, an actual density estimate cannot be calculated. Notwithstanding this, distance measurement does facilitate calculation of the effective sampling area in different habitats and allows corrections to be made between areas where birds are more easily observed than others. It is important that distances are estimated accurately, which is not always easy to do, particularly when detections are based on calls.

Distance sampling for kereru consists of normal 5-minute counts, with estimates assigned to 20 m intervals up to 100 m and then to two further intervals between 100 and 150 m, and between 150 and 200 m. Records from greater than 200 m distance may be recorded but would not be used in analysis. It is emphasised that data gathered in this way can still be analysed using the normal 5-minute count procedures and will hence enable comparisons to be made with data gathered previously.

Analysis of distance is undertaken using the programme Distance (Buckland *et al*. 1993). Initially this programme will be used by Science & Research Unit for the analysis of kereru data. As familiarity with its use grows, it will be made more generally available Data input is made via Excel files which categorise data according to site, study block, date, time and the number of birds recorded at each distance interval at each station.

8.3.2 Display flight monitoring from vantage points

Purpose

To obtain an index of breeding activity in order to estimate the onset, peak and intensity of breeding each season.

Method

During five separate 10-minute sessions each week during the pre-breeding to early breeding season, the observer records the number of display flights and number of "general" flights seen. Refer to Appendix 4 for full instructions on how to monitor display flights.

8.4 OTHER MONITORING METHODS

8.4.1 Census Counts from Vantage Points

Purpose

- To obtain a minimum estimate of the actual number of kereru currently using the observed area. In addition, the number of kereru performing display flights may provide an estimate of the minimum number of males in breeding condition. This method was used by Grant *et al.* (1997) to determine the number of breeding pairs of parea in various valleys of southern Chatham Island. (Note: this statistic will over-estimate the number of resident breeding pairs if the observations include displays by unpaired males, and the number of resident breeding pairs will be under-estimated if some males are already involved in incubation or chick rearing (when they do not usually perform display flights)).

- To monitor population changes within small, isolated forest patches (number of breeding pairs present each year over several years), where 5-minute counts are unlikely to be sensitive enough to detect a 20–30% change in population size (see Section on "5-Minute Counts—Disadvantages").
- Census counts will not be a core part of the national monitoring programme but may be used at some sites, in conjunction with display flight monitoring and 5-minute counts, to assess the extent and sources of variance in these indices. (See "Research" section.)

Method

The approach is similar to display flight monitoring (Appendix 4), except that:

- The emphasis is on keeping track of individual birds, in order to determine the minimum number of separate individuals seen (and possibly the minimum number of individuals involved in display flights).
- Census counts require longer observation periods. To have a reasonable chance of detecting all individuals currently inhabiting an area, you would generally need to watch for at least four hours, including either the mid-morning nest changeover period or the late afternoon changeover period.
- More than one observer is required unless the area is particularly small, isolated and used by only a few kereru. Most censuses require a team of observers in radio contact.

Advantages

- Of the methods described in this manual, this is the only one which provides a minimum estimate of actual population size rather than an index of relative abundance. But note that census counts are not a requirement of the national monitoring programme.
- A census, as long as it is reasonably accurate, is a more sensitive way of detecting population trends than are 5-minute counts and transects, which only provide an index of the population.

Disadvantages

- Requires one or more vantage points, natural or man-made.
- Labour intensive and logistically difficult; requires a number of people to be stationed on different vantage points for relatively long periods and in radio contact with each other.
- Difficult to apply in large areas, where the terrain is relatively flat, or where more than 20 birds are present. Under these circumstances, it becomes increasingly difficult to keep track of individuals and so not count the same bird more than once.

8.4.2 Transect counts

Walking Transects

When carrying out 5-minute counts, many people also record less common species (e.g., kaka, kereru, falcon) encountered between stations. Those involved in 5-minute counts as part of the kereru monitoring programme are encouraged to also count kereru encountered between stations. These observations should be recorded separately as the number of kereru seen and heard per hour, excluding time spent at count stations As explained in "5-minute counts—Advantages", data obtained from walking transects is less reliable than 5-minute count data and may not be suitable for statistical analysis. However, provided it can be collected without compromising or prolonging the core monitoring work, the extra information might provide additional clues on population trends.

Roadside Transect Counts of Kereru Congregating on a Seasonal Food Source

The method is best described by an example. Since 1991, Wanganui conservancy staff have been monitoring kereru numbers from a moving vehicle along a 14 km stretch of highway, where the birds congregate to feed on buds of willows and poplars. These kereru are counted at the same time of day on 14 consecutive days during the same calendar dates in August and September by the driver and one observer travelling at a steady rate of c. 35 kph; recounts are unlikely because stopping is not allowed. On each occasion, the following data are recorded: wind, rain, cloud, observer, driver, start time, finish time and number of kereru (minimum number of separate birds) seen per run. Although no particular trend was apparent from 1991 to 1994, the counts dropped markedly in 1995 when almost no kereru were seen on the northern part of the transect. It was suspected that birds may have been killed while feeding in this area.

Clout *et al.* (pers. comm.) carried out similar counts of kereru feeding in spring on roadside trees at Pelorus Bridge, Marlborough. This data set could be used as a baseline for future counts along the same transect.

This approach does have limitations. Such counts of kereru feeding on seasonal food sources outside their normal habitat provide less specific information because the birds are likely to have come from a number of different areas and their origins cannot be determined, except by re-sighting of jessed birds or following of radio-tagged birds. Short-term changes in these counts do not necessarily reflect real trends in the source population(s). For example, low counts in a single year might simply mean that a better food source (e.g., an unusually persistent miro fruit crop) is available elsewhere. Steadily increasing counts are not necessarily a good sign. This trend could indicate declining habitat quality in the birds' source area (i.e., the population's use of the seasonal food source is increasing in response to increasing nutritional stress) rather than an increasing kereru population.

Despite these limitations, the roadside transect counts done by Wanganui conservancy staff and at Pelorus Bridge are worth continuing because:

1. Detection of a sustained downward trend in counts over several seasons would suggest that the "population" is declining. (A less likely explanation

is that habitat quality in their source areas, which probably are not known, is improving markedly). Declining transect counts may provide justification for finding out where the birds are coming from and undertaking more intensive monitoring in those areas.
2. The technique is not labour-intensive.

Roadside transects may be a worthwhile approach in some situations where 5-minute counts are not appropriate (e.g., they could provide clues on habitat use and population trends in urban areas) or cannot be justified (e.g., in areas where it is suspected that kereru may be declining but all available resources are committed to higher priority projects).

Helicopter flushing

This method consists of flying a helicopter along a transect and counting kereru as they take flight. This approach would be expensive and would have to be done very carefully outside the breeding season to avoid the risk of nests being destroyed by downdrafts or frightening incubating birds causing them to dislodge eggs from nests. It is possible that helicopter disturbance of nests during the live deer recovery era may have contributed to kereru declines in some areas.

8.5 OPTIONS FOR MONITORING KERERU IN VERY SMALL FOREST PATCHES

Members of the public may seek advice on how to monitor kereru in this situation. Where one or more suitable vantage points are available, census counts would be the preferred method. Where this is not possible, other less precise options include counting the maximum number of birds seen together at one time, or the number of birds seen over a particular time frame.

9. Research

It is **essential** to test the reliability and sensitivity of the preferred methods for indexing kereru abundance and breeding activity. At certain key sites where good estimates can be made of actual population size, a series of 5-minute counts should be carried out in conjunction with census counts and display flight monitoring from a vantage point. These data should be collected over several seasons so that records are available from both good and poor breeding years. The following questions need to be answered through analysis of four data sets:
1. Are 5-minute counts in general closely correlated with census counts?
2. Are 5-minute counts strongly affected by the proportion of birds attempting to nest in a particular year, as estimated from display flight monitoring? For example, do 5-minute counts seriously under-estimate relative abundance during seasons when a high proportion of the population is nesting? Is this

bias overcome when 5-minute count data are reduced to presence/absence data for statistical analysis?

3. Are 5-minute counts strongly affected by changes in the birds' conspicuousness relating to year-to-year variation in food availability? For example, are 5-minute counts substantially lower, in relation to census counts, in poor fruiting years when the birds are eating foliage and buds rather than fruit?
4. Is it necessary to continue early season display flight monitoring at all sites in order to interpret 5-minute counts?
5. Can monitoring of display flights be used as a measure of habitat quality/response to management? i.e., is there close correlation between the availability of certain foods (as estimated through phenology records) and the proportion of birds observed performing display flights?
6. The hypothesis that monitoring of display flights can be used as an index of nest failure could also be tested if nest monitoring is also being done at particular key sites; i.e., does the regular sighting of display flights throughout the season indicate a high incidence of nest failure?

The following research topics are **not** urgent and are **not** essential to the kereru monitoring/management programme but would be supportive because the results would help interpret kereru monitoring data and refine management responses.

1. Identify which predator species are important causes of kereru nest failure. In order to do so further infra-red video monitoring at kereru nests would be required. This information could be supplemented by extrapolation with information obtained by infra-red video monitoring at kokako nests.
2. Quantify the influence of introduced mammals on fruit availability and how this affects bird productivity. This investigation could be undertaken under the mainland "sland" management programmes for the benefit of a range of species; i.e., it is **not** dependent on the kereru programme specifically.
3. Assess movements between populations to evaluate whether measured population trends are being strongly influenced by emigration/immigration as well as mortality/productivity.
4. Gain a better understanding of the relationship between fruit abundance and kereru breeding. For example, which particular fruits in each area are important for bringing kereru into breeding condition? This information will eventually be obtained through the national monitoring programme, provided that robust and consistent prescriptions for phenology recording are followed at each site. Once these specific food-breeding relationships have been identified, managers will be able to predict good breeding years through phenology monitoring of key food species, and then initiate predator control when and if required. The information could also be used to refine ecological damage thresholds for pest control programmes (e.g., when assessing the effectiveness of possum control in a managed area, at least in part, for kereru conservation, plant damage measurements must include species which are key food species for kereru and are also targeted by possums) and to guide replanting programmes whose goals include habitat restoration/enhancement for kereru.

Even if the four preceding research projects are not carried out, monitoring of kereru populations in mainland "island" management sites will provide a coarse measure of the net benefits to the population given by each management regime, provided that the methods of indexing pest and food abundance, and kereru abundance and breeding intensity, are sensitive and reliable, and that apparent population trends are not strongly influenced by immigration/emigration.

5. Investigate post-fledging behaviour, movements and survival, and age at first breeding. This investigation, which would involve further studies of kereru radio-tagged as nestlings, would assist interpretation of mortality/productivity data and identification of vulnerable periods when management could most effectively enhance survival or productivity.
6. Investigate the causes of death of emaciated and non-emaciated kereru dying in spring. Is this an important factor limiting some kereru populations? If so, and if the birds are succumbing to opportunistic infections as a result of nutritional and/or climatic stress, then the best management option will probably be habitat enhancement to improve the nutritional status of the birds' diet during critical periods. This will require a good knowledge of the birds' feeding ecology.
7. Investigate the nutrient and toxic status of food plants. Captive kereru could be used during feeding trials to determine their energy requirements by the technique of injecting doubly-labelled water (Tatner and Bryant 1989). This would help managers to select plant species for replanting programmes those most likely to benefit kereru, and to predict the effects on kereru of removing particular food sources (e.g., exotics and weeds). This experimental approach could supplement, but **not** substitute, information obtained through study of the birds' feeding ecology.
8. Gain a better understanding of the role of kereru as a seed disperser, by: (i) following radio-tagged birds, (ii) comparing germination rates of seeds with and without passage through kereru, and (iii) comparing regeneration patterns (i.e., distribution of large-fruited species at sites with and without kereru). Further research in this field would need to complement that carried out at Pelorus Bridge (Clout & Tilley 1992).
9. Document kereru population trends in cities. Are city kereru populations self-sustaining? Identify factors important for sustaining kereru populations in cities. Are window and vehicle collisions a significant cause of mortality? (Mortality rates could be better estimated if all rehabilitated kereru are banded/jessed prior to release.)

10. Management options

Management priorities at each key site will be determined in response to the results of the monitoring programme. However, potential management options available to the Department, iwi and other conservation groups and individuals fall into the following categories:

1. Minimising nest predation through predator trapping and poisoning, or exclusion from isolated nest trees.
2. Increasing productivity and survival through improved food supplies by:
   - sustained control of possums and rats where these species are suspected of competing for fruits;
   - fencing of forest habitat for protection from domestic and feral stock;
   - planting (this could involve a combination of exotics (to supply short-term needs) and natives (more appropriate to supply foods in long-term but often relatively slow to bear fruit));
   - protection of seasonally important food sources, including introduced deciduous trees and legumes that provide important spring forage.
3. Reducing human-associated sources of mortality (e.g., illegal hunting, collisions with windows and vehicles) through general advocacy and education.

11. Other aspects

Ultimately, this report should be used to develop a national kereru monitoring/ management strategy. Such a strategy can be justified in terms of the species' endemism, role as a keystone species, and as a focus of cultural interest to both Maori and Pakeha.

Because of the particular interest of Maori in kereru, there is a need to foster the involvement of Maori in monitoring and management programmes of kereru populations.

The kereru monitoring programme also needs to be properly integrated with other aspects of monitoring at mainland island management sites. For example, kereru food plants **must** be included in phenological monitoring programmes at key sites because interpretation of kereru population trends and breeding patterns **depends** on effective and consistent phenological monitoring at each site.

Public awareness of and involvement in kereru management needs to be encouraged. One way would be through the production of advocacy brochures which outline the kereru's conservation values, status and threats, and explain how members of the public can help kereru conservation. Brochures could be targeted at particular groups. For example:

- for private forest owners—provide tips on predator control and habitat enhancement;

- for city dweller—suggest kereru food plants suitable for backyard plantings, strategies for reducing accidents (e.g., window ornaments or curtains to prevent collisions), and what people should do if they find an injured kereru;
- for tree croppers and orchardists—strategies for protecting susceptible trees and their fruit crops from over-exploitation by kereru; possibilities might include scaring devices, decoy crops (although this may just encourage more kereru to use the area), or netting of trees (seldom cost-effective).

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Appendix 1: Display flight of the kereru

(from James 1995)

The display flight of the New Zealand pigeon is very distinctive. The bird gains altitude with noisy, deep, increasingly rapid wingbeats, soars briefly and then stalls, with its body vertical and its wings and tail spread, exposing its white ventral plumage. It then tilts forwards or sometimes sideways to glide silently down again with its wings still fully spread. There may be a single vertical stall in flight, or several successive stalls. The flight may be performed along a circular path which returns the bird to its original, or another nearby perch. Alternatively, the bird may perform its display then fly off somewhere else.

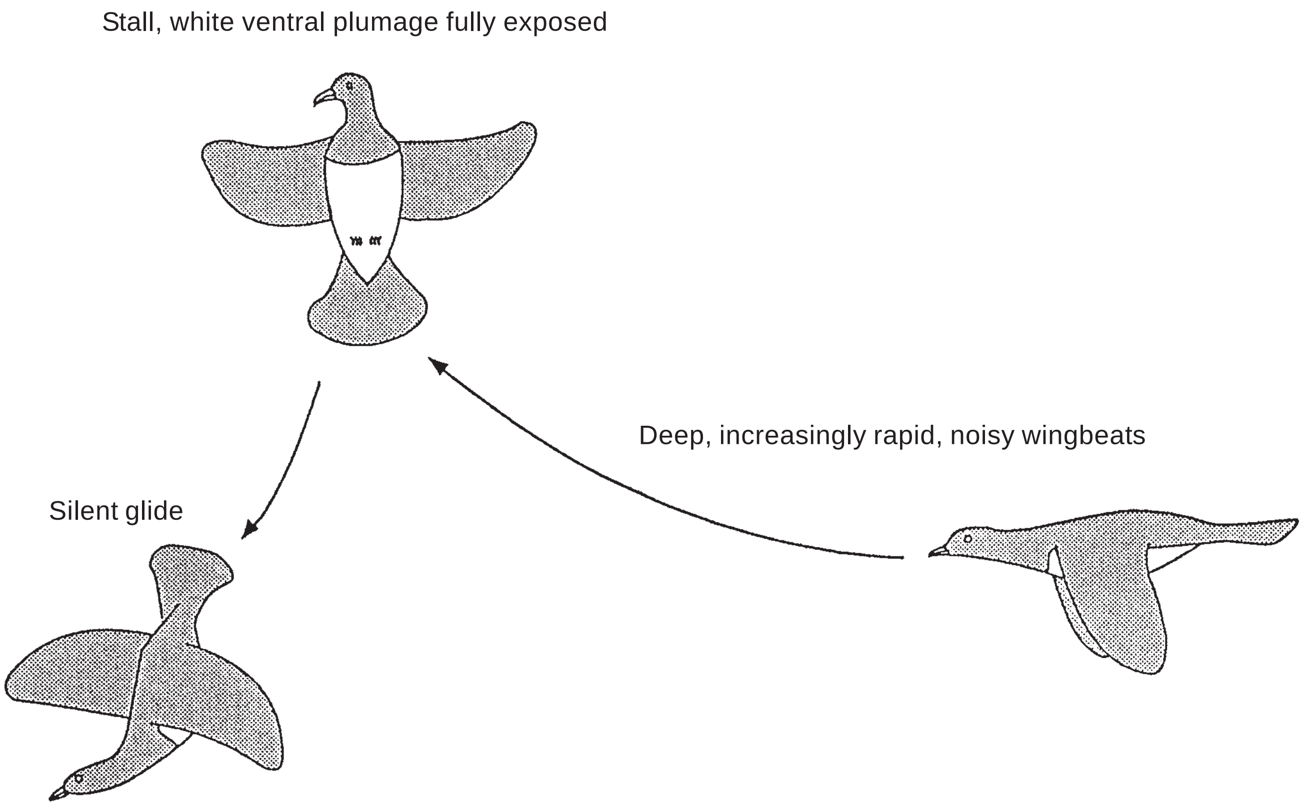


FIGURE A1. DISPLAY FLIGHT OF THE KERERU.

Appendix 2:
How to find kereru nests

(from James 1995)

INTRODUCTION

This guide is intended for persons who have not had much experience with the species and who are faced with the task of monitoring the nesting of kereru. It is intended to be of practical rather than of academic worth. Each section deals with different clues to the location of nests, several of which have been discussed more formally in the text of James's thesis.

DISPLAY FLIGHTS

A pigeon flies from its **perch**, glides up to a vertical stall and then glides down to return to the original perch or fly off somewhere else. The perch from which the kereru flies gives the best indication of the general location of its nest. At Wenderholm, nests were within a c. 50 m radius of the display flight perch.

Territorial display flights are most frequently performed by males prior to nesting. You should bear in mind that **single males** also perform display flights, but obviously there will be no nest nearby the perch of such a bird.

During the day, display flights are most consistently performed **immediately before and up to ½ an hour after sunrise**. An early start is useful for planning where to search.

COURTSHIP

This consists of a **male** puffing out his white chest feathers, **bouncing up and down**, turning around every now and then, hopping from side to side and performing a ritualised preening movement with its head over its shoulder to "preen" behind its wing. However, note that this may also constitute aggressive behaviour. Sometimes it is followed by copulation, which indicates that the female will be laying within a week. Try to follow the female when she flies off as she may go to the nest site.

Courtship seems to occur within 50 m of the eventual nest site. During courtship, a rising **ooO** is often heard.

NEST BUILDING BEHAVIOUR

The twigs used for building nests at Wenderholm are mostly kanuka, although totara and macrocarpa have also been seen to be used. The birds collect twigs off the trees, pulling them off with a light twist of their beak. This delicate method means that they often try a few twigs before they finally detach one. The twigs are generally about 30 cm long, so are quite conspicuous in the bird's beak.

If you see this behaviour, **watch the bird very carefully and follow it to its nest!!**

The general pattern is that the male brings twigs to the female at the nest, the female doing the construction. When the male arrives, a **growling coo** or a **quiet, rising ooO** may be heard.

The **growling coo** is sometimes heard when the birds appear to be **prospecting** for nest sites. They sit together, usually **one above the other**, frantically **billing** in short bursts.

Not every nest has eggs laid in it. Often the birds decide to build a nest in a different site after building one or two "trial" nests. Keep monitoring the nest for a few weeks before giving up on it as a trial nest.

A pair may renovate an old nest, or build a fresh one. The nest is a spartan, but usually solidly constructed, **platform of twigs** about the **size of a dinner plate**. It may be bulky, or so thin as to be barely visible.

NEST SITES

The only consistent pattern appears to be **dense canopy cover**. This is probably related to the kereru's well-developed fear of harriers.

A variety of trees are used: puriri, karaka, tawapou, tawa, taraire, supplejack thickets, clumps of the epiphytic kahakaha (*Collospermum*), the base of nikau fronds, and totara. Totara seems to be particularly popular although targeting it creates bias in your results (if you're a scientific purist).

Nest height ranges from 2 to 20 m.

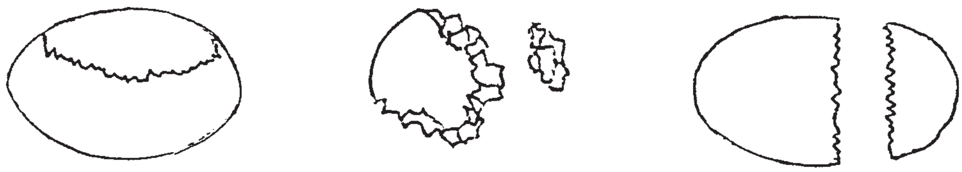
Do not try to climb the nest tree while the adult is sitting. If the adult exhibits anxiety (head-jerking) while you are nearby, it is best to retire to a spot further away from the nest. **Remember, you stink**. Anywhere you go, a stoat, cat, rat or maybe even a possum, can follow you several hours later by following your scent trail. Bear that in mind when checking for chicks. A mirror on a pole comes in handy.

NEST ROUTINE

The general rule for **incubation** is that the male incubates during the day, the female at night**. Nest changeovers** generally occur between **10 am–12 noon** (male on), and **4 pm-dusk** (male off). If you see a bird fly out of or into a non-food tree, especially if it is flying quietly, it is worth checking out (carefully). Pigeons are quite noisy fliers, except when approaching or departing their nest.

The egg is incubated for about **28 days. "Hatch sign"** is when you find the shell on the ground, in two "halves".

If the egg is broken into small, jagged-edged fragments or chewed longitudinally, suspect **rat** predation. If you find shell fragments which look crushed, suspect **possum** predation. Look for mammal faeces under the nest, or in a failed nest. (See Figure A2).



Rat sign Possum sign Hatch sign

FIGURE A2. SHELL REMAINS USED TO ASSIGN FATE OF EGG. IF REMAINS DO NOT MATCH ANY OF THESE CATEGORIES, THEY ARE CLASSIFIED AS INKNOWN PREDATOR.

Shell fragments on the ground are another good way of **finding nests**, as are the accumulated **piles of seeds**. Check seeds for freshness (have a feel, take a whiff, but tasting is not recommended), especially in relation to what you've noticed the pigeons feeding on at the time. Shells are reasonably recent if the **membrane** is still present. If you find these things, look up to search the canopy above, as the nest may be well hidden.

Once the egg has hatched, the parents **brood the chick during the day** for about the next **ten days**. From then on it is **left alone during the day**, and only brooded at night.

When the **adult is sitting**, the nest is at **its most visible**, and the instant assumption is that it is on an egg (though the ground beneath should be checked for shell in case it is brooding a young chick. When the **young chick is alone** in the nest, it can be **very hard to see**. If you find a nest with fresh pigeon faeces underneath, or hatch sign, try to see into the nest (*without* climbing the nest tree), or continue to monitor the nest for a couple of weeks, by which time the chick should have grown sufficiently to see from below.

Chick feeding is regularly in the **early morning**, sometimes in the late morning and often at **dusk**.

Chicks generally **fledge** at about 45 days (although this can range from 30–60 days), and will be dependent on their parents for about another month after that. **Dependent fledglings** will be seen begging (wing-paddling) for food from a parent. Their bill is brown and the top of it flat and unfeathered. Some tassels of yellow 'down' may be visible on the plumage.

Appendix 3: Five-minute bird counts

(from Dawson & Bull 1975)

The observer stops and stands quietly for five minutes every 200 m (approximately 250 paces). If possible, the counting route should be through reasonably homogeneous vegetation, and further than 200 m from its edge. At each stop all the birds seen or heard are recorded. In regularly counted areas these stations are best marked so that the counts are made from the same point each time. Each count is treated as an entity so that, even if it is thought that an individual bird was included in a previous count, it is counted again. Within each count, no bird is knowingly counted twice*, nor are birds assumed to be present without some visual or auditory clue to their presence (e.g., a flock of silvereyes is noted as the number heard calling rather than the number the observer guesses such a frequency of calling would represent; if a bird calls in one place and later one of the same species calls some distance away, they are taken as two individuals unless there is evidence that the first bird moved to the second place).

Each set of counts includes the following information:

Locality (including map reference, altitude, aspect, vegetation, etc. if not a regularly counted area);
Date (day, month, year);
Observer:
Temperature: in °C or:

1	freezing	<0°C
2	cold	0–5
3	cool	5–11
4	mild	11–16
5	warm	16–22
6	hot	>22

Showers: a note of any rain in the hour before the counts;

And for each count:

Sun: (0–5) Record the approximate duration, in minutes, of bright sun on the canopy immediately overhead
Wind: The average for each minute count on a modified Beaufort scale:

0 Leaves still or move without noise (Beaufort 0 and 1)
1 Leaves rustle (2)
2 Leaves and branches in constant motion (3 and 4)
3 Branches or trees sway (5, 6 and 7);

Other noise: (water, cicadas, traffic, chain saws etc.): the average for the five minutes on the following scale:

0 Not important,
1 Moderate,
2 Loud;

Precipitation: the average for each count

Mist -- M, Rain -- R, Hail -- H, Snow -- S, on a scale as follows:

0 None,
1 Dripping foliage,
2 Drizzle,
3 Light,
4 Moderate,
5 Heavy;

Time: 24-hour clock time at beginning of each count.

[* To reduce confusion as to whether particular birds have already been recorded within a count, the observer may wish to record additional details of each observation. Ray Pierce (pers. comm.) suggests taking a separate sheet of graph paper for each count station, marking the count station/observer at its centre, drawing a direction arrow or adding a landmark for orientation purposes, and then plotting the direction and estimated distance of each bird seen or heard, noting species and number in each case. Note that this additional information is **not** used in analysis of the data so these maps can be discarded once the counts have been recorded on the standard form.]

Extremes of weather are best avoided. [The authors also suggested avoiding counts near dusk and dawn because of the change in the birds' conspicuousness which occurs at those times.]

Birds which were identified by sound only are noted as heard (h), the rest are seen (s).

Distance—if a bird is judged to be more than 200 m away then exclude it from the list (this is the distance between successive counts and can be checked whenever the bird is near one counting point and audible from the next). Birds flying overhead and judged not to belong to that vegetation type should be recorded, but the record may be circled to indicate this.

Five - Minute Bird Counts	P.B.1 Fletchers Ck
	Date: 20-4-74
	Observer: P.D.G

Counts

	1	2	3	4	5	6	7	8	9	10	
Temp °C	12·5	—	—	—	—	—	—	—	—	14·0	
Time	0952	1003	1015	1027	1038	1050	1101	1121	1132	1145	
Sun	0	0	0	3	3	2	1	0	1	0	
Wind	0	0	0	0	0	1	1	2	0	0	
Other Noise	0	0	0	0	0	0	0	0	1	0	
Precipitation	0	1	0	0	0	0	0	1	1	2	
Species	S/H	S/H	S/H	S/H	S/H	S/H	S/H	S/H	S/H	S/H	Total
Silvereye	/8			3/3	1/4	2/4	1/9	/4	4/8	3/1	47
Fantail	1/1	/1		1/1	2/		1/2			1/	11
Bellbird	/2	/2	1/2	1/1	/4	1/4	1/3	2/1	1/2	/2	31
Tit	1/	/2	3/		1/2	1/1	/2	/2		/1	15
Warbler	/1	/1			1/	/1	1/				5
N.Z. Pigeon	/2				/1	/1	1/		1/	/2	8
Robin		/1	/1	3/		/2		1/1	3/	1/2	13
Song Thrush				/1					/1		2
Redpoll					/1						1
Tui				/1			1/				2
Blackbird						/2	/1			/2	5
Parakeet sp.							/1				1
Chaffinch								/1		1/1	3
Weka									/1		1

Remarks:
2 Kakas seen in N. fusca between counts 3-4

FIGURE A3. RECORD SHEET USED IN WESTLAND WITH AN EXAMPLE OF THE DATA RECORDED.

Appendix 4: Display flight monitoring method and protocol

Select suitable vantage points that overlook representative samples of your study area. Key sites will be far too large to be observed properly from a single location.

Define your search area before starting observations. If the viewed area is not obviously defined by natural topographical features, pick landmarks beyond which any kereru will be ignored. You want to sample an area sufficiently large or well populated to collect enough data to establish patterns. But do not try to watch areas that are so large or awkward (e.g., long and narrow) that you cannot be confident of detecting all kereru movements. If the search area is long, narrow and sparsely populated, then two or more observers may be required. Make a clear record of the landmarks bordering your search area in case other observers are given the task of continuing these observations in subsequent years.

Use a range of vantage points if available but make sure that the same set of vantage points is used from week to week and year to year. If no natural vantage points are available, consider whether the construction of an observation tower may be justified.

Plan to carry out at least five 10-minute observations per day on one day per week. 10-minute observation periods should **not** be consecutive. Even though it may be more labour intensive to make repeated visits to a vantage point, it is important that observations are independent of each other. Do not carry out these observations at times of day when the birds' activity level is likely to be rapidly changing; e.g., close to dawn, dusk, and nest change-over times. It is preferable to watch during the middle of the day. Also avoid very wet windy conditions.

- During each 10-minute time slot, record:
- observer's name;
- date;
- time;
- weather conditions (use the same method as in 5-minute counts; see Appendix 3);
- the number of display flights (see Appendix 1);
- the number of "general" flights
  (defined as all flights of 10 metres or more but excluding panic flights initiated by passing harriers).

If the search area is relatively small and/or used by relatively few kereru, you may be tempted to also keep track of individual birds in order to determine the minimum number of separate individuals seen and the minimum number of individuals involved. However, be careful not to focus too closely on particular individuals as this could result in missed observations of other kereru.

Remember that your objective is to obtain an **index of breeding activity** (the proportion of general flights that are display flights). You are **not** attempting to count the actual number of males in breeding condition or the number of kereru in the area (which would require much longer observation periods).

Display flight monitoring will initially be used to determine the peak breeding season of kereru in your study area; i.e., to establish calendar dates for undertaking annual 5-minute counts. Start observations about a month before nesting is expected. Continue these weekly observations until you see a drop in the proportion of flights that are display flights. This suggests that many pairs are now nesting and 5-minute counts should be started as soon as possible. If display flights have not been observed by mid-December in the North Island or early January in the South Island, then you should start 5-minute counts anyway. Assume that the birds are experiencing a poor fruiting year and are unlikely to breed that season. This pre-season to early-season monitoring of display flights should be repeated for two or three seasons to check that the onset of nesting is reasonably consistent from year to year (in those years when breeding occurs). If the first season was not typical, it may be necessary to change the calendar dates initially selected for 5-minute counts to ensure that they consistently fall within the peak breeding season. Once the optimum timing has been established, however, these dates should not be changed.

In situations where the birds have a good food supply but experience a particularly high incidence of early nest failure (e.g., if high levels of predation hold the population well below the carrying capacity of its habitat), a high proportion of birds might continue doing display flights through the season as they repeatedly attempt to re-nest. Under these circumstances, the peak and subsequent drop off in the proportion of flights that are display flights may be less distinct.

Where work schedules permit, display flight monitoring should be continued each year beyond the first few years, as the results will help interpretation of 5-minute counts. For example, consider the following scenarios:

- If any display flights were observed at the beginning of the season, then it is likely that at least some kereru will attempt to breed.
- If pre-nesting display flight indices are low and 5-minute counts (during the breeding season) are lower than expected, then either there are fewer birds in the area or they are less conspicuous (e.g., foliage feeding). If phenology observations indicate good fruit availability that year, then it is probable that the population has declined.
- If display flight and 5-minute count indices are both high, then the population has probably increased. This increase may include immigrants, especially if phenology records indicate improved fruit availability in the area.