

Reintroduction of kaka
(*Nestor meridionalis septentrionalis*)
to Mount Bruce Reserve,
Wairarapa, New Zealand

SCIENCE FOR CONSERVATION: 89

Raelene Berry

Published by
Department of Conservation
P.O. Box 10-420
Wellington, New Zealand

Science for Conservation presents the results of investigations by DoC staff, and by contracted science providers outside the Department of Conservation. Publications in this series are internally and externally peer reviewed

© June 1998, Department of Conservation

ISSN 1173-2946
ISBN 0-478-21732-3

This publication originated from work done under Department of Conservation contract 2350 carried out by Raelene Berry, Pori R.D. 6, Pahiatua. It was approved for publication by the Director, Science & Research Unit, Department of Conservation, Wellington.

Cataloguing-in-Publication data

Berry, Raelene.

Reintroduction of kaka (*Nestor meridionalis septentrionalis*) to Mount Bruce Reserve, Wairarapa, New Zealand / by Raelene Berry.
Wellington, N.Z. : Dept. of Conservation, 1998.

1 v. ; 30 cm. (Science for conservation, 1173-2946 ; 89.)

Includes bibliographical references.

ISBN 0478217323

1. Kaka o te Ika a Maui. 2. Kaka o te Ika a Maui--New Zealand--Mount Bruce Reserve. I Title. II. Series: Science for conservation (Wellington, N.Z.) ; 89.

598.710993 20

zbn98-054215

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Abstract

Two releases of North Island kaka occurred at Mount Bruce Reserve in 1996 and 1997 to investigate whether the release of juvenile kaka is a useful tool in the restoration of kaka to mainland ecosystems. Five wild-caught juvenile kaka and four hand-reared captive-bred juvenile kaka were released in 1996. Five parent-reared captive-bred juvenile kaka were released in June 1997. The suitability of each group for release was assessed by monitoring survival rates, dispersal from release site and behaviour of the kaka after release. Survival rates for all three groups were high after release, with 13 of the 14 kaka known to be alive at 30 November 1997. Site-fidelity was higher for captive-bred kaka than wild-caught kaka, although most kaka stayed within Mount Bruce Reserve after release. Captive-bred kaka also showed higher reliance on supplementary food. All the kaka adapted well to their new environment, feeding on a variety of natural foods and interacting with each other after release. Captive-bred kaka spent more time feeding on the ground, exposing them to a greater risk of predation. The results of this study suggest that it is possible to successfully reintroduce wild-caught and captive-bred juvenile kaka to a mainland site.

1. Introduction

1.1 KAKA POPULATIONS IN NEW ZEALAND

The kaka (*Nestor meridionalis*) is a forest-dwelling parrot endemic to New Zealand (Bull *et al.* 1985). There are two recognised sub-species: the North Island kaka (*N. meridionalis septentrionalis*) and the South Island kaka (*N. m. meridionalis*). The total number of kaka has been estimated at fewer than 10 000 birds, with the largest populations on offshore islands (Heather & Robertson 1996). There are relatively large and stable populations of North Island kaka on Kapiti Island, Little Barrier Island, Great Barrier Island, Hen and Chicken Islands and Mayor Island (Heather & Robertson 1996). Large populations of South Island kaka exist on Stewart Island and Codfish Island (O'Donnell & Rasch 1991). Localised flocks of kaka are also present in the large forest tracts of mainland New Zealand. In the North Island the largest and most stable populations are located at Pureora and Whirinaki. Populations of South Island kaka are present in the beech (*Nothofagus*) forests near Nelson lakes, and also in Westland forests. However, these mainland populations are thought to be declining (O'Donnell & Rasch 1991) because of habitat destruction, predation and competition from browsing mammals and wasps (Moorhouse 1990, Beggs & Wilson 1991, O'Donnell & Rasch 1991, Wilson *et al.* 1998).

1.2 THREATS TO KAKA POPULATIONS

Productivity of kaka is generally low and nesting is infrequent, only occurring in years when food supply is abundant (O'Donnell & Rasch 1991). The breeding success of South Island kaka in beech forest is linked to the mast seeding of beech trees (Wilson *et al.* 1998). Breeding success of North Island kaka on Kapiti Island, which lacks most of the introduced competitors present on the mainland, is also related to food abundance (Moorhouse 1990).

In addition to typically low productivity, kaka on the mainland also have to contend with introduced predators and competitors. Several aspects of kaka breeding behaviour make them particularly vulnerable to predators. They nest in deep cavities in tree trunks, making escape from predators difficult (O'Donnell 1996). They have long nestling periods and chicks often fledge before they can fly, sometimes spending several days on the ground (O'Donnell & Rasch 1991, Moorhouse & Greene 1995). These factors mean that nesting female kaka, eggs, chicks and fledglings are all at risk of predation (Moorhouse 1990, Beggs & Wilson 1991, O'Donnell & Rasch 1991, Wilson *et al.* 1998). Stoats (*Mustela erminea*) have been identified as a major threat to kaka. A study of kaka in the Nelson Lakes Region (Wilson *et al.* 1998) found that of 20 breeding attempts monitored over 11 years, only four fledglings survived to independence. Nine young kaka and four adult females were killed on the nest, most probably by stoats (Wilson *et al.* 1998).

Kaka are vulnerable to competition from brush-tailed possums (*Trichosurus vulpecula*) and introduced wasps (*Vespula germanica*, *V. vulgaris*) for food resources (Beggs & Wilson 1991, O'Donnell & Rasch 1991). There is considerable overlap between possum and kaka diets and selective browsing by possums can considerably alter forest composition (Cowan 1990, Owen & Norton 1995). Possum browsing has led to the local extinction of some kaka foods such as Loranthaceae mistletoes (Ogle & Wilson 1985), and can suppress the production of others such as hinau (*Elaeocarpus dentatus*) fruits (Cowan & Waddington 1990). In addition, possums may compete with kaka for nest holes (Wilson *et al.* 1998) and are potential predators of Kaka eggs and nestlings (Brown *et al.* 1993). Wasps are a problem in beech forests where they feed on honeydew, one of the few energy rich foods in this habitat, thus reducing the amount available to kaka (Beggs & Wilson 1991).

1.3 REINTRODUCTION AS A MANAGEMENT TOOL

In the future, mainland kaka populations will require intensive management to prevent their extinction. In addition to the necessary control of introduced predators and competitors (Wilson *et al.* 1998), reintroductions may play an important role in re-establishing kaka within parts of their former range and counter-acting the decline of existing populations. Reintroductions are being used increasingly in conservation efforts to save many rare and endangered species (e.g., Gipps 1991, Serena 1994). A reintroduction usually involves releasing translocated individuals from source populations (either wild or captive) into apparently suitable, vacant habitat within the species's historical range (Scott & Carpenter 1987, Griffith *et al.* 1989, Wolf *et al.* 1996).

Translocation has been used as a conservation management tool in New Zealand since at least the 1880s (Saunders 1994). Most translocations have been to offshore islands which are free of the threats present on the mainland, or where any threats can at least be effectively managed (Towns *et al.* 1990). Translocations of species into mainland habitat patches have been much less successful than those to islands (Saunders 1994) and have usually been avoided in favour of predator-free islands (Armstrong & McLean 1995). However, as techniques developed on islands to effectively control predators and competitors are applied to the management of species in 'island-type' situations on the mainland (Saunders 1990, 1994), reintroductions to mainland sites may become more common in the future. Reintroductions using captive-bred individuals, although having severe limitations (Derrickson & Snyder 1992, Snyder *et al.* 1996) can play a useful short-term role in species recovery, and may also be used more frequently in New Zealand in the future (Saunders 1994, Armstrong & McLean 1995).

1.4 BACKGROUND TO THE RELEASE OF KAKA AT MOUNT BRUCE RESERVE

Reintroductions in the past have often been attempted as 'last-ditch' efforts to save populations which have declined to extremely low numbers (Griffith *et al.* 1989, Saunders 1994). Griffith *et al.* (1989) suggested reintroduction techniques need to be developed as early as possible while a population is large or even increasing in numbers, in case these techniques are required in the future. Because each translocation project is unique, management techniques must be developed to suit each species, and the particular habitat conditions at the release site (Saunders 1994). Developing techniques for translocating wild kaka, and for releasing captive-bred kaka to the wild, have been identified as important areas of kaka research (Captive Breeding Specialist Group 1992). With this in mind, a proposal to investigate the feasibility of reintroducing juvenile kaka to Mount Bruce Reserve in the North Island was developed.

The success of a reintroduction can be influenced by factors such as habitat requirements, the size of the release area, the presence of animal pests/predators, the timing of translocations, the size and composition of the founder group and genetic issues (Armstrong & McLean 1995). In addition, the behavioural patterns specific to a species and to individuals within a species can determine whether a population survives after release (Lyles & May 1987, Kleiman 1989, Wiley *et al.* 1992, Snyder *et al.* 1994). Obviously it is advantageous to determine which individuals of a species are the most suitable release subjects before valuable time and expense is invested in further release attempts. Releases involving wild-caught individuals have generally been more successful than releases involving captive-bred individuals (Griffith *et al.* 1989, Snyder *et al.* 1994, Snyder *et al.* 1997, Wolf *et al.* 1996). The aim of this study was to investigate the suitability for release of wild-caught, captive-bred hand-reared (from now on referred to as hand-reared) and captive-bred parent-reared (parent-reared) juvenile kaka by monitoring their survival, movements and behaviour after release at Mount Bruce Reserve, and to investigate the techniques needed to successfully release kaka into a new habitat.

Three research objectives were identified:

1. To compare the post-release survival and movements of the three groups of kaka released at Mount Bruce Reserve using a soft release method (Lovegrove & Veitch 1994), in order to determine the reasons for success or failure of kaka reintroductions and help refine techniques for future releases of kaka.
2. To investigate the use of supplementary food by the kaka after release, to determine what positive and/or negative influences post-release feeding had on the natural behaviour of kaka and their transition to a new environment.
3. To investigate the post-release behaviour and foraging ecology of the kaka in order to learn how they adjust to their new surroundings and new food resources.

2. Study site

Mount Bruce Reserve is an area of podocarp-broadleaf forest east of the Tararua Ranges in the southern North Island. The north-western boundary of the reserve adjoins state highway 2 between Eketahuna and Masterton. Mount Bruce Reserve is approximately 1000 ha, and reaches an elevation of 710 m. Originally, it was part of an extensive podocarp forest known as the 'Forty mile bush'. Mount Bruce Reserve is the last remaining substantial remnant of this forest. Over the years, fires, fencing problems, stock trespass and noxious animals., particularly goats (*Capra hircus*), and brush-tailed possums, stoats and rats (*Rattus rattus*, *R. norvegicus*) have continued to degrade the forest. Ferrets (*Mustela furo*), weasels (*Mustela nivalis*), and feral cats (*Felis catus*) are also present. Periodic culling of goats within the reserve is undertaken by the Department of Conservation. The Manawatu/Wanganui Regional Council also carries out 1080 poison drops within the Reserve to control possums.

Mount Bruce Reserve contains many possible food sources for kaka (Appendix 1). Thirteen hectares of mixed exotic species were planted on the north-western side of the reserve in 1933, 1934 and 1951. These included *Cupressus lawsoniana*, Douglas fir (*Pseudotsuga menziesii*), California redwood (*Sequoia sempervirens*), Spruce (*Picea sitchensis*), Cedar (*Thuja plicata*) and Ponderosa pine (*Pinus ponderosa*).

The National Wildlife Centre (NWC) administered by the Department of Conservation is situated on the north-western boundary of the Reserve. The kaka were housed in aviaries at the centre prior to release. Feedstations were set up at the release site, situated at the NWC, to provide the kaka with supplementary food after release.

3. Release procedure and monitoring methods

A release involving five wild-caught and four hand-reared juvenile kaka was carried out in June 1996. A further group of 5 parent-reared juvenile kaka was released in June 1997. The kaka were all 6-8 months old at the time of release. At this age they were independent of their parents (Moorhouse & Greene 1995). The kaka were named, sexed, radio-tagged, and marked with individual coloured leg band combinations (Table 1).

A soft-release method was used, following techniques outlined in Lovegrove & Veitch (1994). The release procedure for each year is described below.

TABLE 1. IDENTIFICATION OF KAKA RELEASED AT MOUNT BRUCE IN 1996 AND 1997. NWC = NATIONAL WILDLIFE CENTRE. SEX: M = MALE, F = FEMALE. BAND COMBINATION: M = METAL BAND.

NAME	ORIGIN	SEX	BAND COMBINATION	YEAR RELEASED
Te mimi	wild-caught, Kapiti Island	M	Red/Black/White-M	1996
Kapiti	wild-caught, Kapiti Island	F	M-Red/White/Green	1996
Taepiro	wild-caught, Kapiti Island	M	Red/Blue/Yellow-M	1996
Rangatira	wild-caught, Kapiti Island	M	Red/Blue/Orange-M	1996
Te Rere	wild-caught, Kapiti Island	M	Red/Orange/Black-M	1996
Yakka	hand-reared, NWC	F	M-Yellow	1996
Bidi	hand-reared, NWC	F	M-Blue	1996
Mel	Hand-reared, Auckland Zoo	F	Black-M	1996
Burwood	Hand-reared, Auckland Zoo	M	Green-M	1996
Cleo	parent-reared, NWC	F	M-Yellow/Blue	1997
Eke	parent-reared, NWC	F	M-Yellow/White	1997
Monroe	Parent-reared, Auckland Zoo	M	Yellow/Black-M	1997
Mounty	Parent-reared, Auckland Zoo	F	M-Red	1997
Tua	Parent-reared, Auckland Zoo	F	M-Yellow/Green	1997

3.1 PREPARATIONS FOR 1996 RELEASE

3.1.1 Hand-reared captive-bred kaka

All four hand-reared kaka were artificially incubated and hand-reared by DOC staff in Te Anau then transferred to the NWC. Two of the kaka (Yakka and Bidi) arrived at the NWC on 5 February 1996, and the other two (Mel and Burwood) on 3 May 1996. All four kaka were held together in an aviary at the NWC and supplied with a standard captive diet. The aviary measured 16 m (l) x 9 m (w) x 4 m (h), which allowed enough space for short flights. The aviary was planted with native trees and shrubs representative of the area. An adult kaka already resident at the NWC was held in the aviary with the juveniles throughout their time in captivity to pass on learned feeding behaviour. While in captivity, the kaka were introduced to natural foods obtained from Mount Bruce Reserve. Yakka and Bidi were exposed to a wide range of fruits and berries, including *Coprosma*, pigeonwood (*Hedycarya arborea*), supplejack (*Ripogonum*

scandens), mahoe (*Meliccytus ramiflorus*) and kaikomako (*Pennantia corymbosa*) fruits, throughout the period they were in captivity from 5 February to 4 June 1996. Because Mel and Burwood arrived at the NWC in May when fewer natural foods were available, these two birds were exposed to a more limited range of natural foods before release.

3.1.2 Wild-caught kaka

The five wild-caught juvenile kaka were captured using cage traps and mist nets on Kapiti Island over a two week period from 6-17 May 1996. The five kaka were held in an aviary on Kapiti Island for two weeks. The aviary measured 4 m (l) x 2 m (w) x 2 m (h). Wooden perches, foliage, rotten logs and leaf-litter were put into the aviary to make it as natural as possible and to provide the kaka with some natural food sources. The roof of the aviary was covered in foliage to provide extra shelter. The kaka were provided with food *ad libitum* (corn, apple, pear, carrot, banana, dates, walnuts, cheese, wombaroo (nectar mix, wombaroo Food Products, Australia), and sugar water) in feedstations set up in the aviary. The five wild-caught kaka were transferred from Kapiti Island to the NWC on 17 May 1996. On the morning of the transfer the kaka were caught in the aviary using hand nets. The kaka were weighed, their transmitter harnesses were checked, and cloacal swabs and faecal samples were collected for disease screening, before they were put in wooden transport boxes. The boxes measured 550 mm (l) x 300 mm x 300 mm. Each box could house two kaka in separate compartments. The floor of each compartment was covered in leaves, and the kaka were supplied with apple and cheese cubes for the journey. Sugar water was supplied for a period of time, but removed from the boxes just before the journey. The birds were transported by boat and car. Upon arrival at the NWC, the wild-caught kaka were immediately released into aviaries with the captive-bred juveniles.

3.1.3 Holding period at the NWC

The nine kaka were held together in two aviaries at the NWC for two weeks prior to release. Five of the kaka (two hand-reared kaka and three wild-caught kaka) were held in the large aviary that the hand-reared kaka had been in since their arrival at the NWC, with the adult kaka. The other four kaka (two hand-reared kaka and two wild-caught kaka) were held in a small temporary aviary (6 m (l) x 2 m x 2 m) at the release site/feedstation area. Both aviaries contained natural foliage, leaf-litter, rotten logs and perches. Food (based on the diet given to captive kaka at the NWC) was supplied at feedstations in the aviaries. Natural foods obtained from Mt Bruce Reserve were also provided to the kaka during this time. During the two week holding period cloacal swabs and faecal samples were collected from all nine kaka for disease screening/quarantine purposes. The samples were screened for coccidia, listeria, salmonella, yersinia and egg counts. All tests from these samples, and from the samples taken previously on Kapiti Island, returned clear results.

3.2 PREPARATIONS FOR THE 1997 RELEASE

Five parent-reared kaka were released in 1997. Two of these kaka were reared by their parents at the NWC and three were parent-reared at Auckland Zoo. The kaka were reared on a captive diet and were also regularly provided with natural foods (rotten logs for invertebrates, foliage, berries) while in captivity. The three Auckland zoo kaka were transferred to the the NWC and all five kaka were then moved to the large aviary which had housed the hand-reared kaka before release in 1996 (see above). The kaka were quarantined/screened for disease while in captivity, and all tests returned clear results.

3.3 FEEDSTATIONS

Three feedstations were designed to be set up at the release site, situated on the public walkway at the NWC. Each feedstation consisted of an aluminium circular body divided into four separate feeding compartments (to minimize the chance of aggression between birds, or of one bird dominating a feedstation), and surrounded by pipe for the birds to perch on. Food was supplied in each compartment in bowls (solid foods) and 'hamster' water bottles (liquids). Trays in the bottom of each feedstation caught dropped food, and could be removed for cleaning. Each feedstation was secured 2 m off the ground at the top of a pole by a bolt running through the pole at the base of the feedstation. This minimised vulnerability of the kaka to ground/climbing predators while feeding. When the bolt was removed the feedstation could be lowered to the ground for re-stocking with food and for cleaning. Feedstations were set up in all three aviaries (at the NWC and on Kapiti island) that housed the kaka prior to release, so the kaka would become familiar with feeding from them. On the morning of the release in 1996, three feedstations were permanently set up at the release site at the NWC. The feedstations have been stocked on a daily basis, in the afternoons, from 4 June 1996. The supplementary food provided to the kaka is based on the captive kaka diet at the NWC and included walnuts, dates, cheese, apple, pear, sunflower seeds and jam-water (jam blended in water). Banana, carrot, orange and kiwifruit were initially provided in 1996, but were removed from the food supply after the kaka showed no interest in them.

3.4 TRANSMITTERS

Transmitters (supplied by Sirtrack Limited, New Zealand) were attached to each kaka using a cord harness. The transmitter used had a pulse rate of 30 beats per minute, with a mortality sensor doubling the pulse rate after a 9.1 hour period of no movement (indicating death or transmitter removed). The maximum lifetime of the transmitters was approximately 11.4 months. As part of a field trial to investigate methods of identifying individual birds (Moorhouse & Greene 1996), tags were attached to the aerials of some of the transmitters used in the 1996 release. These tags were either coloured aluminium discs or epoxy tubes with a three-colour combination.

3.5 RELEASE OF KAKA

Releases took place on 4 June 1996, and 24 June 1997. The release method was identical for both years. The kaka were caught the day before the release, weighed and fitted with transmitters. All the kaka spent the night before release in the temporary aviary at the release site (where the feedstations were set up at the NWC). At the time of the release the front mesh wall was removed from the temporary aviary, allowing the kaka to fly out. In 1996 the kaka were released in the morning to allow them some time to investigate their surroundings before nightfall. In 1997 the kaka were released at 4 pm in the afternoon. This is the time that the feedstations are re-stocked each day, and meant that the kaka released in 1996 were feeding from the feedstations at the release site when the parent-reared kaka were released from the aviary.

3.6 POST-RELEASE MONITORING

Data were collected on survival rate, movements and behaviour of the kaka (four hand-reared, five parent-reared, five wild-caught) during 6 month periods after each release. In 1996 the kaka were monitored on a daily basis; in 1997 monitoring was reduced to two days each week. Monitoring methods were identical for each year.

The survival and movement of each kaka within Mt Bruce reserve was determined by scanning all transmitter frequencies daily at the release site. An attempt was also made to track and locate each bird once every 7 days.

Supplementary feed station use was monitored daily by recording the number of kaka present at the feedstations during a 30 minute period after the feedstations were restocked. The feedstations were checked daily after the kaka had finished feeding to see which foods they were eating and how much food they had taken.

Behavioural data were collected for individual kaka during the day between 8 am and 5 pm, using an instantaneous sampling method (Martin & Bateson 1986) with a 1 minute sampling interval. Data were collected for all four hand-reared kaka and all five parent-reared kaka each month during their respective monitoring periods (June–November 1996 and June–November 1997). A maximum of five and a minimum of three wild-caught kaka were observed each month from June–November 1996. A total of 120 behavioural observations were collected from each bird each month. In June 1997, transmitters were re-attached to all the hand-reared kaka and one of the wild-caught kaka (Te Mimi) and data were collected on the foraging behaviour of these birds during July–November 1997, when they were > 18 months old. Behaviour was categorised as feeding, resting (including sitting, roosting and maintenance activities), investigating the environment (which included all movements not associated with feeding and resting), interactions with kaka and interactions with the observer. Foods the kaka fed on were categorised as invertebrates, fruits/seeds, flowers, foliage and sap.

4. Results

4.1 POST-RELEASE SURVIVAL

All five parent-reared kaka released in 1997 and eight of the nine kaka released in 1996 were known to be alive at 30 November 1997 (Table 2).

TABLE 2. STATUS AS AT 30 NOVEMBER 1997 OF KAKA RELEASED AT MOUNT BRUCE RESERVE IN 1996 AND 1997. HR-CB = HAND-REARED CAPTIVE-BRED, PR-CB = PARENT-REARED CAPTIVE-BRED, WC = WILD-CAUGHT. NWC = NATIONAL WILDLIFE CENTRE, AUCK ZOO = AUCKLAND ZOO. SEX: M = MALE, F = FEMALE.

BIRD	ORIGIN	DATE RELEASED	SEX	FEEDSTATION USE	STATUS AS AT 31 NOV. 1997
Yakka	HR-CB, NWC	4 June 1996	F	Yes	Alive, monitored regularly
Bidi	HR-CB, NWC	4 June 1996	F	Yes	Alive, monitored regularly
Mel	HR-CB, Auck zoo	4 June 1996	F	Yes	Alive, monitored regularly
Burwood	HR-CB, Auck zoo	4 June 1996	M	Yes	Alive, monitored regularly
Te Mimi	WC, Kapiti Island	4 June 1996	M	Yes	Alive, monitored regularly
Taepiro	WC, Kapiti Island	4 June 1996	M	Yes	Alive, monitored regularly
Kapiti	WC, Kapiti Island	4 June 1996	F	Yes	Unknown, last sighting 26 September 1996
Rangatira	WC, Kapiti Island	4 June 1996	M	No	Alive, sighted irregularly, last sighting 12 November 1997
Te Rere	WC, Kapiti Island	4 June 1996	M	No	Alive, sighted irregularly, last sighting 2 December 1997
Cleo	PR-CB, NWC	24 June 1997	F	Yes	Alive, monitored regularly
Eke	PR-CB, NWC	24 June 1997	F	Yes	Alive, monitored regularly
Monroe	PR-CB, Auck zoo	24 June 1997	M	Yes	Alive, monitored regularly
Mounty	PR-CB, Auck zoo	24 June 1997	F	Yes	Alive, monitored regularly
Tua	PR-CB, Auck zoo	24 June 1997	F	Yes	Alive, monitored regularly

Radio contact with one of the wild-caught kaka ('Kapiti') was lost on 26 September 1996, 114 days after release. Telemetry sweeps of the Mount Bruce Reserve and areas of the Tararua Ranges were unsuccessful in locating the bird, and its status at the present time is unknown.

4.2 POST-RELEASE MOVEMENTS

4.2.1 Hand-reared kaka

From the time of their release in June 1996, all four of the hand-reared kaka have always been located within 1 km of the release site/feedstation area, and they were often observed around aviaries at the NWC during the first 6 months they were monitored after release. One of the hand-reared kaka ('Bidi') spent time in captivity from 5-10 June 1997, while undergoing treatment for a damaged eye. She is now blind in her left eye.

4.2.2 Wild-caught kaka

After release in 1996, the wild-caught kaka immediately dispersed from the release site. One of the birds ('Kapiti') was located in a group of trees on a neighbouring farm 600 m north of Mount Bruce Reserve on 7 June 1996 (three

days after release). She returned to the reserve on 8 June and remained near the release site/feedstation area with the hand-reared kaka until late August. On 22 August Kapiti was again located on a neighbouring farm, 800 m north of the Reserve. She returned to Mt Bruce reserve the next day and remained within the Reserve, close to the release site/feedstation area during the first three weeks of September. Radio-contact with Kapiti was lost on 26 September and she has not been sighted since.

Te Mimi dispersed a short distance (700 m) from the release site immediately after release. He returned to the release site/feedstation area in the last week of June 1996, and has since remained within 1 km of the release site/feedstation area, associating with the hand-reared kaka.

During the first six months after release in 1996, two of the wild-caught kaka (Rangatira and Te Rere) were located in areas 500 m-3 km away from the release site, and these two birds were most often observed alone. Te Rere was first observed making contact with other kaka on 30 November when he returned to the release site/feedstation area. Rangatira was observed associating with other kaka for the first time on 22 November 1996. On 6 December 1996 both Te Rere and Rangatira were interacting with the hand-reared kaka at the release site/feedstation area, and there were further sightings of them at the release site/feedstation area throughout December. Te Rere and Rangatira have been sighted irregularly since January 1997. Because their transmitters died in May 1997 and we have been unable to catch them to replace their transmitters, monitoring them has been difficult. However, Te Rere was sighted on 3 January, 15 February, 5 March, 24 June, 2 July, 21 July, 20 August, 12 November and 2 December 1997. There were sightings of Rangatira on 3 February, 24 September, 26 September, 23 October and 12 November 1997. During all observations of Rangatira and Te Rere in 1997, they have been associating with other kaka.

Taepiro dropped his transmitter within three days of being released in 1996. There were no sightings of Taepiro in Mount Bruce Reserve throughout June. He was located at Hokio Beach on the west coast of the North Island (adjacent to Kapiti Island) in late June 1996 by a member of the public (Hokio Beach is 39 km directly west of Mount Bruce Reserve and 31 km directly north of Kapiti Island). Taepiro was recaptured, and returned to the NWC at Mt Bruce on 26 June 1996. He was kept in an aviary at the NWC from 26 June to 28 August 1996, then re-released. Since then, Taepiro has remained within Mount Bruce Reserve and has been regularly sighted. In late September 1997 Taepiro broke his left wing and was captured and taken into captivity on 26 September. The wing was bandaged and he recovered well. Taepiro was fitted with a transmitter and re-released back into the reserve in December 1997. He dropped his transmitter within weeks of being released but has been sighted regularly at the feedstations.

4.2.3 Parent-reared kaka

Four of the parent-reared kaka released on 24 June 1997 left the release aviary within 1 hour of the doors being opened. Monroe spent the night in the aviary, and flew out at 8 am the next morning. During the first week after release the parent-reared kaka spent a lot of time at the NWC kaka aviary, begging off the

adult pair and interacting with the two young kaka within the aviary. Contact and interactions with the kaka in the aviary declined over time, as the newly released kaka integrated into the group of kaka released in 1996. The parent-reared kaka were always observed within 1 km of the release site during the six month post-release monitoring period.

4.3 SUPPLEMENTARY FEEDING

Twelve of the 14 kaka (4/4 hand-reared, 5/5 parent-reared, 3/5 wild-caught) were observed using the feedstations (Table 2). There was a significant difference between the 3 cohorts in rates of feedstation use (Kruskal-wallis non-parametric ANOVA, $H = 9.9257$, $p < 0.01$). The hand-reared kaka had the highest rate of feedstation use, followed by the parent-reared kaka and then the wild-caught kaka. All four hand-reared kaka began using the feedstations on the day they were released (4 June 1996). Kapiti was the first wild-caught bird observed using the feedstations. She first fed from the feedstations on 13 June, ten days after release. Kapiti disappeared in September and was last observed at the feedstations on 26 September 1996. Te Mimi began feeding at the feedstations on 19 July 1996. After he was re-released on 27 August 1996, Taepiro began using the feedstations on 14 September 1996. Rangatira and Te Rere were never observed using the feedstations, although they were observed on a number of occasions at the release site/feedstation area interacting with the kaka using the feedstations. Tua was the first of the parent-reared kaka released on 24 June 1997 to use the feedstations. She was first observed at the feedstations at midday on 26 June, two days after release. The other four parent-reared kaka began using the feedstations on 27 June, three days after release.

Though the kaka were given a range of foods, they ate only the cheese, dates, walnuts and corncobs during the 30 minutes they were observed at the feedstations each day. The kaka consumed the total amount of all these food items that was provided each day (Table 3).

TABLE 3. FOODS PROVIDED AND CONSUMED BY KAKA AT THE SUPPLEMENTARY FEEDSTATIONS.

FOOD	AMOUNT PROVIDED/BIRD (g)	AMOUNT EATEN/BIRD (g)
Dates	10	10
Walnuts	10	10
Cheese	5	5
Corncoobs	30	30
Sunflower seeds	10	-
Pear	25	-
Apple	30	-
Jam (mixed in water)	5	5

4.4 POST-RELEASE BEHAVIOUR

4.4.1 Activity budgets

Feeding was the most commonly observed activity for all three cohorts, followed by resting, investigating the environment and interacting with other kaka (Table 4). Although the kaka were commonly observed in groups, interactions between kaka made up a small percentage of the activity budgets for each cohort. Interactions included allo-preening, touching beaks, play-fighting, chasing/displacing kaka and attempted mountings. Two of the hand-reared kaka (Yakka and Bidi) were the only kaka to interact with the observer (contact always tried to be avoided), and these interactions decreased over time.

TABLE 4. ACTIVITY BUDGETS OF KAKA MONITORED OVER 6 MONTHS AFTER RELEASE AT MOUNT BRUCE RESERVE. DATA PRESENTED AS THE MEAN PERCENTAGE OF OBSERVATION TIME SPENT IN EACH ACTIVITY BY HAND-REARED, PARENT-REARED AND WILD-CAUGHT KAKA (\pm STANDARD ERROR). SAMPLE SIZES IN BRACKETS. ACTIVITIES ARE FEEDING, INVESTIGATING THE ENVIRONMENT, RESTING, INTERACTING WITH KAKA, INTERACTING WITH THE OBSERVER. - = NO DATA COLLECTED. TOTAL NUMBER OF OBSERVATIONS FOR EACH COHORT: HAND-REARED = 2880, PARENT-REARED = 3600, WILD-CAUGHT = 2640.

	FEEDING	INVESTIGATING	RESTING	INTERACTING WITH KAKA	INTERACTING WITH OBSERVER
Hand-reared kaka (4)	45.9 \pm 2.1	25.0 \pm 1.2	24.4 \pm 3.7	3.8 \pm 0.5	1.0 \pm 0.6
Parent-reared kaka (5)	73.1 \pm 1.4	7.7 \pm 0.6	17.1 \pm 1.6	2.1 \pm 0.2	-
Wild-caught kaka (5)	61.3 \pm 6.6	11.6 \pm 0.4	25.4 \pm 6.0	1.8 \pm 0.4	-

FIGURE 1. MEAN FORAGING EFFICIENCY, AS THE RATIO OF TIME SPENT FEEDING TO TIME SPENT INVESTIGATING THE ENVIRONMENT, FOR EACH COHORT. DATA FOR HAND-REARED AND WILD-CAUGHT KAKA COLLECTED EACH MONTH FROM JUNE-NOVEMBER 1996 AND FOR PARENT-REARED KAKA FROM JUNE-NOVEMBER 1997.

Feeding and investigating the environment together accounted for the majority of each cohort's total time budget. The ratio of these two categories can thus express the relative 'foraging efficiency' of the different cohorts. Hand-reared kaka showed a lower foraging efficiency than the other cohorts. The amount of time they spent feeding was low, while the time they spent investigating the environment was relatively high (Table 4). However, the foraging efficiency of all three cohorts increased over time in that the amount of time spent feeding compared to investigating the environment increased (Figure 1).

4.4.2 Foraging ecology

The diets of all three cohorts after release were diverse, but all groups spent most time searching for and eating invertebrates found in the bark and wood of trees (Table 5).

TABLE 5. COMPONENTS IN THE NATURAL DIET OF KAKA RELEASED AT MOUNT BRUCE RESERVE IN 1996 AND 1997, MEASURED AS MEAN PERCENTAGE OF OBSERVATION TIME (\pm STANDARD ERROR) EACH COHORT SPENT FEEDING ON EACH FOOD TYPE. DATA FOR HAND-REARED AND WILD-CAUGHT KAKA COLLECTED FROM JUNE-NOVEMBER 1996, FOR PARENT-REARED BETWEEN JUNE-NOVEMBER 1997, AND FOR OLDER BIRDS BETWEEN JULY-NOVEMBER 1997. OLDER BIRDS CONSISTED OF FOUR HAND-REARED AND ONE WILD-CAUGHT KAKA RELEASED IN 1996. SAMPLE SIZES IN BRACKETS. TOTAL NUMBER OF FORAGING OBSERVATIONS FOR EACH COHORT: HAND-REARED = 1322, PARENT-REARED = 2632, WILD-CAUGHT = 1618.

FOOD TYPE	KAKA			
	HAND-REARED (4)	WILD-CAUGHT (5)	PARENT-REARED (5)	OLDER BIRDS (5)
Invertebrates	84.2 \pm 5.7	87.9 \pm 6.7	72.9 \pm 4.2	78.7 \pm 4.3
Fruits/seeds	6.0 \pm 3.3	9.9 \pm 6.7	15.8 \pm 4.0	4.0 \pm 1.5
Flowers	1.2 \pm 1.1	0.3 \pm 0.3	2.0 \pm 0.9	1.7 \pm 1.7
Foliage	8.4 \pm 3.2	2.0 \pm 1.2	2.5 \pm 1.0	0.1 \pm 0.1
Sap	0.0	0.0	6.7 \pm 3.9	15.3 \pm 5.6
Unidentified	0.1 \pm 0.2	0.0	0.2 \pm 0.2	0.3 \pm 0.3

Some caution needs to be taken when comparing the diet components of fruits/seeds and flowers between years. Observations of phenology suggested that flowering and fruiting was more abundant in 1997 than in the previous year, thus influencing the range of foods available to the kaka released in 1996. Hand-reared kaka spent a greater amount of time feeding on foliage than the other groups, although parent-reared and wild-caught kaka included foliage items in their diets at certain times of the year. Foliage items included ponga fronds, leaves, leaf stems, and epiphytes. In October 1997, 30 minutes was spent observing one of the parent-reared kaka, ('Eke'), scraping at the surfaces of koromiko (*Hebe stricta*) leaves and nibbling at the new shoots. During September and October 1997 the parent-reared kaka spent time feeding on tarata (*Pittosporum eugenioides*) flower buds. In October and November kaka from all three groups were seen feeding on tarata flowers, as well as the flowers of clematis and kowhai (*Sophora microphylla*).

During the post-release observation period in 1996, none of the kaka were observed feeding on sap. However, in August-September 1997, sap was a

considerable component of the diets of some of the older female kaka (Yakka, Bidi and Mel) released in 1996. They fed on the sap by using their lower mandible to prise off strips of bark, leaving rows of distinctive horizontal grooves in the tree trunk. The kaka would spend a considerable amount of time making these horizontal grooves, and would often return a number of times to lick at the grooves they had made earlier. The parent-reared kaka released in 1997 would often follow after the three older female kaka while they were sap-feeding, observing these birds and often licking at the grooves the older birds had made in the trees. However, the parent-reared kaka released in 1997 were never observed using the same horizontal grooving technique themselves. Parent-reared kaka did feed on sap in September–November 1997, obtaining it by a different technique. This involved peeling off large portions of bark and licking at the exposed surface of the tree trunk. At times the kaka would expose areas of a tree trunk up to 1 m long.

4.4.3 Foraging locations

Kaka fed on foods from a variety of tree species (Appendix 1) and also spent time on the ground, mainly feeding on dropped hinau berries (Table 6).

TABLE 6. PERCENTAGE OF OBSERVATION TIME JUVENILE KAKA SPENT FEEDING ON THE GROUND, AFTER RELEASE AT MOUNT BRUCE RESERVE.

COHORT	PERCENTAGE OF OBSERVATION TIME SPENT ON GROUND	
	MEAN (\pm SE)	RANGE
Hand-reared (n = 4)	3.3 \pm 0.48	2 - 4
Wild-caught (n = 5)	0.8 \pm 0.80	0 - 4
Parent-reared (n = 5)	5.0 \pm 0.84	3 - 7

5. Discussion

The results of this study suggest that it is possible to successfully reintroduce kaka to a mainland site. The high survival rates of all three groups of kaka released at Mount Bruce Reserve suggest that juvenile wild-caught kaka and, perhaps more importantly, juvenile captive-bred kaka, can survive on the mainland in the presence of predators, when assisted by post-release supplementary feeding and low-level predator control. Juvenile kaka are generally less susceptible to predation than kaka of other ages (adult females, chicks, fledglings) (Captive Breeding Specialist Group 1992), so this may be an ideal age at which to translocate kaka to new locations. Juvenile kaka also appear to display more behavioural plasticity than adults—juveniles were the first to learn to take supplementary food in Nelson (P. Wilson, pers. comm.)

While site-fidelity was higher for captive-bred kaka than for wild-caught kaka, most of the kaka moved a limited distance from the release site, and generally stayed within Mount Bruce Reserve. This suggests that translocated wild-caught juvenile kaka will stay near the liberation site if a delayed-release method is

used. A soft/delayed release method is more demanding in terms of time and resources than simply releasing animals immediately on arrival at the release site. However, the ability of kaka to fly great distances, and the actions of Taepiro after release at Mount Bruce Reserve, indicate that kaka probably require some time in captivity at the release site prior to release. The presence of kaka held in aviaries at the release site may also keep released kaka in the release area.

The kaka at Mount Bruce Reserve adapted well to their new environment, and formed a cohesive group after release. The parent-reared kaka readily assimilated into the established flock of kaka after their release in 1997. The captive-bred kaka in particular may have benefited from interactions with the wild-caught kaka after release. To survive, an individual must be skilled at avoiding predators, finding food, and interacting appropriately with the environment (Kleiman 1989, Clemmons & Buchholz 1997). For parrots in general, essential skills in foraging and predator-avoidance are acquired over time, and in some cases (e.g., kea, *Nestor notabilis*, Diamond & Bond 1991) by extensive and lengthy social contact (Wunderle 1991). Captive environments differ greatly from wild environments, and may limit the extent to which captive-bred birds can learn certain behaviours before release (Kleiman 1989, McLean 1997). Captive-bred birds may therefore be deficient at foraging (Snyder *et al.* 1994), or at avoiding predators (McLean 1997). At Mount Bruce Reserve, association with wild-caught kaka after release would have provided opportunities for the captive-bred kaka to learn such essential foraging and predator-avoidance skills, thus increasing their chance of survival.

Interactions between the juvenile kaka after release may also have been important in increasing social ties between the juveniles, as well as introducing and developing certain adult behaviours (Levinson 1980). Many attempted mountings were observed between the kaka released at Mount Bruce Reserve, and such sexual behaviours have also been observed between juvenile kea (Diamond & Bond 1991). Kaka do not reach sexual maturity until four years of age (Moorhouse & Greene 1995), but plans are underway to set up predator-proof nest-boxes at Mount Bruce Reserve in anticipation of future breeding activity.

The young age of the kaka when released may also have enabled them to quickly learn new skills to adapt to, and survive in, a new environment. All the kaka showed high levels of exploration of the environment immediately after release, with this exploration decreasing over time. It is usual for young birds to explore the environment by pecking at both appropriate and inappropriate potential food items (Wunderle 1991), and some young birds such as ravens (*Corvus corax*) show high levels of curiosity towards novel items (Heinrich 1995). Heinrich (1995) suggested that the initial interest shown by young ravens in all items allows them to learn the background elements of their environment so they can quickly locate new sources of food. This initial exploratory behaviour is also important when the ravens disperse from their parents to new environments. They can use previous experiences to quickly find appropriate food resources in their new surroundings (Heinrich 1995). The kaka at Mount Bruce Reserve exhibited similar initial intense curiosity in their new environment, and this was probably a way for them to become familiar with their new surroundings. The wild-caught and parent-reared kaka had

previous experience with wild habitats (Kapiti Island), or had had opportunities to learn certain foraging skills from their parents (wild-caught kaka on Kapiti Island and parent-reared kaka in captivity), so after release were able to become familiar with Mount Bruce Reserve more quickly than the hand-reared kaka. This highlights the importance of exposing captive-bred kaka to aspects of the natural environment, and learning from experienced adult birds prior to release.

The kaka fed on a variety of natural foods after release, and their diets were similar to those of wild populations of kaka (Beggs & Wilson 1987, O'Donnell & Dilks 1989, O'Donnell & Dilks 1994, Moorhouse 1996). While the kaka spent most time foraging for invertebrates, they also utilised a broad range of seasonal foods, e.g., tarata flower buds, fruits and seeds, sap, and foliage items. North Island kaka on Kapiti Island (Moorhouse 1996), South Island kaka in South Westland (O'Donnell & Dilks 1994) and other parrot species (Best 1984, Snyder *et al.* 1987, Garnett & Crowley 1995) change their diets frequently, generally dictated by the changing availability of individual foods. Foraging for certain types of invertebrates (such as deep wood borers) is relatively inefficient (Beggs & Wilson 1987) so it is sensible for kaka to switch to alternative food sources when they are available. It is encouraging that the captive-bred kaka recognized and fed on a variety of natural foods, even though they had had limited or no exposure to some natural food items prior to release.

The sap-feeding by the kaka at Mount Bruce Reserve is in accordance with observations from other areas of New Zealand (O'Donnell & Dilks 1989, O'Donnell & Dilks 1994, Beaven 1996). Kaka in South Westland (O'Donnell & Dilks 1989) and at Whirinaki (Beaven 1996) also 'tapped' sap from horizontal grooves in the trunks of trees, as well as stripping bark from a branch and licking at the exposed surface. While most sap-feeding observed in South Westland was concentrated on rata trees (O'Donnell & Dilks 1989), signs of sap-feeding have been observed on a variety of tree species and tree sizes at Mount Bruce Reserve (see Appendix 1). The fact that sap-feeding was greatest in August/September at Mount Bruce Reserve, and in August at South Westland (O'Donnell & Dilks 1989), indicates that sap is an important seasonal component of the kaka's diet. The fact that only female kaka have been observed feeding on sap at Mount Bruce Reserve, and only the older female kaka using the more specialised 'tapping' technique, suggests that sap-feeding is predominantly a female activity, and a learned skill which is acquired with age. This has been confirmed by other studies (Beaven 1996, Greene 1998).

The amount of time the released kaka spent feeding on the ground was relatively high compared to reports from other studies. O'Donnell & Dilks (1994) reported that South Island kaka spent 0.1% of total feeding observations feeding on the ground. It is rare for North Island kaka on Kapiti Island to spend time on the ground (R. Moorhouse pers. comm.). Wiley *et al.* (1992) identified the tendency of captive-reared Hispaniolan parrots (*Amazona ventralis*) to search for food on the ground as a risky foraging behaviour making these birds susceptible to predators. Predators have been identified as a major risk for adult and fledgling kaka in the wild (Wilson *et al.* 1998). Behaviours exhibited by predator-naïve captive-bred kaka, such as spending time on the ground, greatly increase their exposure to predators, and may be a significant factor in whether or not populations of captive-bred kaka can be established in the wild.

It is possible that because the released kaka feed on the ground they may be at risk to poisoning from 1080 baits. While the impact of aerial bait drops on wild kaka populations has been found to be minimal (Lloyd and Hackwell 1993, Greene 1998), captive-bred kaka which are already familiar with an artificial diet and investigate all novel food items that they encounter, may be especially vulnerable. Hickling (1997) found that captive kaka participating in a bait trial fed on both plain and treated baits. This fact should be taken into account when future 1080 drops are planned for Mount Bruce Reserve.

Supplementary feeding was valuable in the period after release to ease the birds' transition to a new environment, and may have played a part in keeping the birds close to the release site. The captive-bred kaka in particular seemed to rely heavily on supplementary food. However, supplementary feeding did not appear to alter the natural behaviour of the kaka. They still spent a considerable amount of time foraging for natural foods. Also, use of supplementary food does not necessarily mean that it is needed. Certainly, the fact that two of the wild-caught kaka released in 1996 have not yet been observed using the feedstations suggests that kaka can survive in Mount Bruce Reserve without food supplementation. While the NWC at Mount Bruce Reserve has the means to provide supplementary food to the released kaka indefinitely, future reintroductions of kaka may be to areas where there are no resources available for prolonged supplementary feeding. Therefore, a necessary component of the Mount Bruce Release project in the future should be to see whether the captive-bred kaka can revert totally to a wild situation, which includes no dependence on people for food. This could be determined by a controlled experiment where supplementary food is provided on and off over a period of time, and monitoring of kaka weights used as an indication of how well they cope without supplementary food. Such an experiment, in conjunction with phenology studies, could also determine whether the natural resources of Mount Bruce Reserve, without any food supplementation, are able to sustain a population of kaka. While it is important to determine whether captive-bred kaka can become independent in the wild, supplementary food may have to be provided in the future at certain times of the year, such as during the breeding season.

This study has been successful in terms of establishing juvenile kaka at Mount Bruce Reserve. It has shown that wild-caught, hand-reared and parent-reared captive-bred kaka are all suitable candidates for establishing kaka populations at mainland sites. Furthermore, the techniques used in this study can also be applied to situations where the aim is to augment an existing population, or move individuals between populations. However, as with most reintroductions, establishing individuals at a new site is only the first step towards achieving a viable population. Therefore, this project will ultimately only be successful when the released kaka breed in their new environment. Future research and management at Mount Bruce Reserve should now focus on achieving this objective.

6. Acknowledgements

A big thank you to staff and volunteers at the NWC for their help throughout this project. A special thank you to Alison Bendall who helped monitor kaka during 1996. Shaun O'Connor (NWC) wrote the initial release proposal, and carried out most of the planning for both releases. Thank you to the Kapiti Island Kaka Capture Crew: Ron Moorhouse, Terry Greene, Hilary Aikman, Ji Weihong, Shaun O'Connor and Jeff Ainge, who all managed to survive the experience unscathed and with all fingers intact. Thank you also to Raewyn Empson, Peter and Shona Daniels and Pim de Monchy for their help on Kapiti Island. The feedstations in this project were based on an original design suggested by Bernard Goetz. Telemetry equipment was loaned by S&R Division, DOC. Funding for the 1996 release was provided by the National Wildlife Centre Trust, DOC Women in Conservation Fund, Pacific Development and Conservation Trust, The Ornithological Society of New Zealand (Inc) and the Pharazyn Trust. The 1997 release was funded by the DOC S&R Division.

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Appendix 1

Plant species used as food sources by juvenile kaka released at Mount Bruce Reserve. Food types utilised by kaka were: I = invertebrates, FS = fruits/seeds, F = flowers, L = leaf, LS = leaf stem, E = epiphyte, PF = ponga frond, S = sap.

TREE SPECIES	FOOD TYPES							
	I	FS	F	L	LS	E	PF	S
<i>Aristotelia serrata</i> (wineberry)	I			L				S
<i>Beilschmiedia tawa</i> (tawa)	I			L	LS	E		
<i>Carpodetus serratus</i> (marbleleaf)	I	FS			LS			
<i>Coprosma</i> spp.	I	FS	F	L	LS	E		S
<i>Cordyline australis</i> (cabbage tree)	I			L				
<i>Cyathea</i> spp., <i>Dicksonia</i> spp.						E	PF	
<i>Dacrycarpus dacrydioides</i> (kahikatea)	I	FS			LS			
<i>Dacrydium cupressinum</i> (rimu)	I							
Dead trees	I							
<i>Elaeocarpus dentatus</i> (hinau)	I	FS				E		S
Exotics	I		F					S
<i>Knighitia excelsa</i> (rewarewa)	I		F					
<i>Melicytus ramiflorus</i> (mahoe)	I							S
<i>Myrsine australis</i> (mapou)	I							
<i>Metrosideros</i> spp. (rata vines)				L				S
<i>Nestegis cunninghamii</i> (maire)	I	FS	F	L	LS			
<i>Notofagus fusca</i> (red beech)	I					E		
<i>Pennantia corymbosa</i> (kaikomako)	I							
<i>Pbormium tenax</i> (flax)			F					
<i>Pittosporum eugenioides</i> (tarata)	I	FS		L	LS			
<i>Pittosporum tenuifolium</i>	I							
<i>Prumnopitys ferruginea</i> (miro)	I					E		
<i>Pseudopanax arboreus</i> (fivefinger)	I	FS			LS			S
<i>Ripogonum scandens</i> (supplejack)		FS		L	LS			
<i>Schefflera digitata</i> (pate)	I				LS			S
<i>Solanum aviculare</i> (poroporo)					LS			
<i>Weinmannia racemosa</i> (kamahi)	I					E		S