



Project Kākā: Tararua Nature Recovery

Project background and progress report
covering July 2010 to June 2011

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Department of Conservation
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Cover: A silver beech on the lower slopes of Mount Holdsworth. Photo: Jeremy Rolfe.

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ISBN 978-0-478-14934-0 (printed copy)

ISBN 978-0-478-14935-7 (web PDF)

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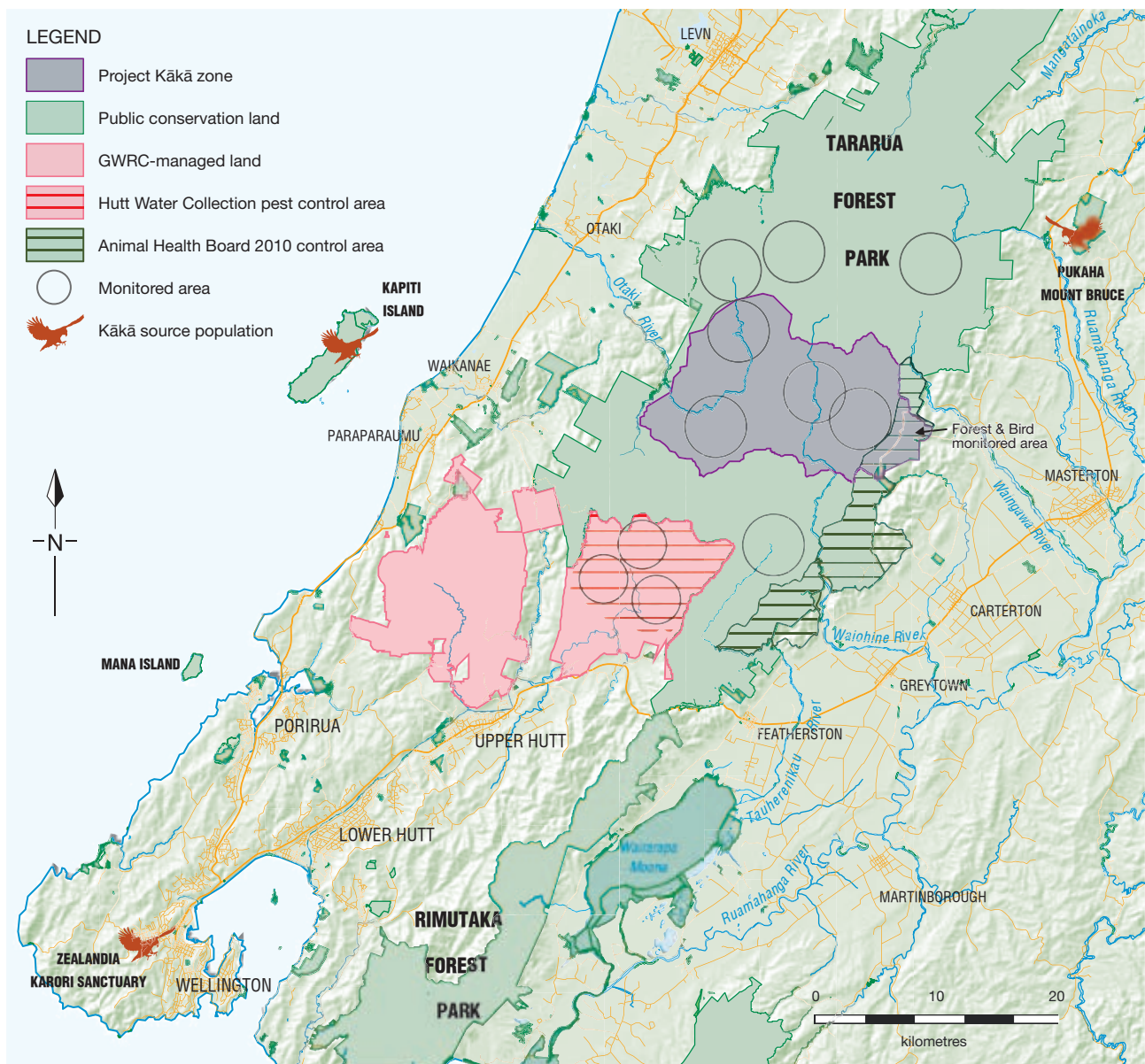


Figure 1. Map showing the location of the Project Kākā area within the Tararua Forest Park and other sites mentioned in the text.

Acknowledgements

Many people from different agencies have contributed to Project Kākā during its start-up phase. These range from the Department of Conservation Area Managers and other members of the Project Kākā Steering Committee, to James Griffiths who developed the DOC monitoring programme, Philippa Crisp at Greater Wellington Regional Council who is responsible for the Hutt Water Collection Area monitoring programme and a number of staff at the Animal Health Board. Wendy Ruscoe and Mandy Barron have been the principle scientists involved from Landcare Research. Last but not least, mention needs to be made of the people who toiled in the Tararua Range laying out monitoring lines, recording birdsong and collecting trapping information often in difficult and challenging places.

1. Summary



N.I. Kākā.
Photo:
Fiona Cunliffe

This report explains the background rationale for a new 10-year conservation initiative by the Wellington Hawkes Bay Conservancy, Department of Conservation (DOC) and summarises the results of the first two year's activities. In 2009, the decision was taken to substantially change the focus of pest management in the Tararua Forest Park (Fig.

- 1). Operating within the same overall budget, the conservation effort shifted from 6-yearly cycles of possum control that aimed to protect forest canopy to a broader, more comprehensive restoration project. The new objective is the ecological restoration of forest and wildlife values over 22,000 hectares in the Tararua Forest Park.

New advances in pest control—pre-feeding of non-toxic baits followed by biodegradable 1080 baits spread aerially—can dramatically reduce populations of possums, rats and stoats. Since these are the major predators of native birds and other wildlife their removal should provide at least one year when chick survival is increased. By shortening the control cycle to 3 years bird populations should increase over the long-term. Although many plant and animal species should benefit, kākā have been chosen as the flagship species for this project. Kākā face extinction on the mainland due to stoat and possum predation. Wellington is in the unique situation, however, of having three locations where kākā are thriving, particularly on Kapiti Island, and maintaining low predator numbers in the Tararua Range would provide another place and opportunity for the once plentiful kākā to recover.

As well as its restoration component Project Kākā also has two other major objectives:

- to improve our understanding of the value, safety and efficacy of large-scale pest control over three 3-year cycles of aerial 1080 and ground control through a comprehensive research and monitoring programme; and
- to increase the public's engagement with, and awareness of, conservation issues and the benefits and costs of different approaches to conservation management.

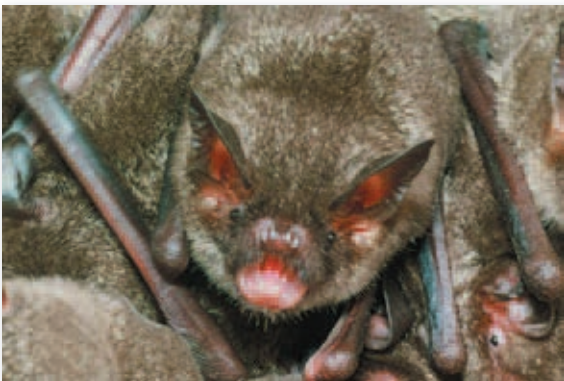
Monitoring was undertaken both before and after the first control cycle in November 2010 and showed that possum, rat, mouse and stoat populations were all reduced to almost zero across the Project Kākā treatment area. We anticipate that bird numbers have probably increased within the Project Kākā area, however the evidence for this will only be available

after the next bird monitoring is undertaken. This monitoring is programmed for late 2011. We should not expect major gains to be evident until further control cycles have been completed. Several major research projects are now in place by DOC and Landcare Research scientists. There have been efficiency gains made by the Department working closely with the Animal Health Board and Greater Wellington Regional Council on various monitoring and control activities.

2. Background

The Tararua Forest Park is Wellington's most visited forest park, a magnet for trampers of all ages and capabilities, although its rugged and unforgiving interior is only for the very fit and experienced. Hunters stalk its deer and families picnic on its gentler lowlands whether at Otaki Forks or its eastern slopes below the shadow of Mt Holdsworth. Author Chris MacLean described it as follows: "*With its axial spine and shoulders pushing the sky upwards, this dramatic range has a powerful presence and influence on those who dwell in its proximity.*"¹

For centuries before weekend recreationalists walked its tracks, the Tararua Range sustained generations of Māori who named its rivers and peaks and used its forests for food and fibre. Those generations experienced a richness of plant and animal life, especially bird life, which has sadly gone forever. In 1903, the last huia to be seen alive in New Zealand was sighted on the track to Mt Holdsworth. Since then, kokako, kiwi, blue duck (whio) and the North Island robin (toutouwai) have followed the huia and disappeared from the Tararua



Short-tailed bat. Photo: Brian Lloyd, DOC.

Range. The introduced predators—rats, stoats, possums, feral cats—that eliminated these birds continue to prey heavily on surviving forest birds, bats and invertebrates. Yet despite the impacts that predators have had for over a century, the 'southern' subspecies of the lesser short-tailed bat still roosts at Deep Creek in the Waiohine catchment of the Tararua Range—its only recorded location in the North Island. Since its discovery 10 years ago the Department of Conservation (DOC) and volunteers have been trapping rats and stoats to protect bats around their known roosting sites within the 300 hectare area.

In addition to introduced predators, deer and goats have reduced the abundance of many palatable plant species in the diverse forest ecosystems. Meanwhile, up in the canopy, possums feed nightly on a wide range of palatable plant species. They have killed many of their preferred foods, such as fuchsia, while denying native birds the abundance of flowers and fruits they used to rely on. Possums have also all but wiped out populations of once-flourishing mistletoe on the eastern Tararua Range. Less than 50 mistletoe plants survive around Holdsworth, Atiwhakatu and Blue Range. These are being monitored and a number of host trees have been banded to protect the mistletoe plants from possums.

Overall, the outcome has been loss of native species and a steady decline in the health of the forest ecosystems that are Tane's living cloak in the Tararua Forest Park.

1 Tararua: the story of a mountain range. 1994. Chris MacLean, Whitcombe Press, Wellington.

3. Making the hard management decisions

The Tararua Forest Park covers 116,535 hectares, the largest conservation park managed by the Department of Conservation in the North Island, and the protection of its native biodiversity values has long been an important priority for DOC. Its complex forests and other ecosystems contain at least 739 indigenous plants, almost 30% of the New Zealand indigenous flora. Between 1994 and 2006, the main focus for DOC was possum management with some goat control. During this period possums were controlled on a 6–7 year cycle over an area of about 70,000 hectares in the central region of the park using biodegradable 1080 (sodium fluoroacetate) applied from the air. This control protected forest canopy species, as demonstrated by the recovery of fuchsia (*Fuchsia excorticata*; kotukutuku) (a favourite possum food) in upland forests. Unfortunately, the 6–7-year rotation and nature of the operations meant any impacts on other pests (rats and other predators) would have been ephemeral and unlikely to protect vulnerable bird, lizard and invertebrate species. Anecdotal records suggest there has been a gradual deterioration in forest wildlife and forest health.

In 2006, the 7-year rotation was cut to 6 years and one area—the “Otaki Biodiversity Zone”—was put onto a 3-year rotation. The total area under control was reduced to 57,000 hectares to meet the costs of this changed approach. One reason for this decision was the significant advances in aerial control techniques for predators, thanks to new research in pest management. Aerial 1080 operations had been unreliable in reducing ship rat populations. As a consequence, control of stoats and rats was dependent on ground-based control (traps and toxins) that were more expensive and covered relatively small areas with limited effectiveness. The break-through (less than 10 years ago) was research showing that aerial pre-feeding with non-toxic cereal baits not only improved possum control, but also significantly reduced bait-avoidance behaviour by rats. Pre-feeding followed by toxic baits resulted in consistently high rat kills which also led to high kill rates of stoats since they fed on the poisoned rats. A review of aerial 1080 operations in 2005 concluded: “*Regular three-yearly operations using pre-feed, 12 gram cereal baits and 0.15% toxic loading is likely to be of benefit to forest structure, forest birds, vulnerable plants, and other biodiversity.*”²

This advance in control techniques coincided with research demonstrating that predation is the major factor responsible for the continuing decline of native wildlife, from snails and invertebrates to bats and forest birds. Rats, mice, mustelids (particularly stoats, but also ferrets and weasels) and possums are the major predators of forest wildlife. Remote video cameras had shown that possums were also major predators of kākā (second only to stoats), killing both chicks and nesting females.³

In summary, a single aerial application of biodegradable 1080, following a pre-feed of non-toxic baits, can reduce populations of the three major predators—rats, stoats and possums—to very low densities. The other major gain is that this “triple-hit” on predators can be achieved over very large areas in a few days. Control over large areas is needed to give native animals a 1–2 year ‘window’ with much better chances of nesting success and survival of nesting females before pests re-invade from outside areas and again build up to high numbers. These ‘windows’ mean much higher survival rates in the nesting and fledgling stages when birds are most vulnerable to predators.

2 Aerial 1080 operations to maximise biodiversity protection. 2005. K.P. Brown & S.C. Ulrich. DOC Research & Development Series 216. Department of Conservation, Wellington.

3 Research summary and options for conservation of kākā (*Nestor meridionalis*). 2004. T.C. Greene, R.G. Powlesland, P.J. Dilks and L. Moran. DOC Science Internal Series 178. Department of Conservation.

The recognition of the seriousness of predation, coupled with the opportunity to significantly reduce three major predators (possums, rats and stoats) with a single aerial 1080 application, led DOC to a major re-assessment of its pest management regime in the Tararua Range in 2009. The outcome of this re-assessment was Project Kākā.

4. Ecological restoration focus

The Wellington Hawkes Bay Conservancy decided to move from a single focus on protecting forest canopy to a more ambitious ecological restoration of forest and wildlife values in the Tararua Forest Park. The goal is to increase bird populations and invertebrates as well as protecting forest plants over a substantial area of the Park. This focus on wider ecosystem protection is now possible with the pre-feed and toxic bait approach of aerial 1080 operations. The pest focus expanded from just reducing possums to also targeting rats and stoats—a triple-hit on the major predators.

To work within the same pest control budget, an area of 22,000 hectares was identified that straddles the Tararua Range from Otaki Forks to the Holdsworth road end that will be treated every three years, starting in spring 2010. There will be three treatment cycles over 9 years with monitoring and a reassessment of the whole Project within a 10 year period. Spring operations (aerial operations are often in winter) will maximise the benefits to birds by reducing predator numbers during the vulnerable nesting period. Figure 1 shows the area covered by Project Kākā. This area was chosen because it includes the Otaki Biodiversity Zone, where more intensive control started in 2006, and covers the highest recreational use areas so that many park users can experience the expected increases in bird life and improvements in forest condition. It includes a diversity of forest types including fertile river valleys, kamahi and fuchsia forests and high altitude beech within the Otaki, Waiohine, Waingawa and Atiwhakatu catchments. The area also includes all of the Penn Creek and Totara Creek Ecological Areas that are representative examples of natural forest ecosystems. As Fig. 1 shows, this zone is also directly east of Kapiti Island, a nationally important island refuge for many threatened bird species including kākā.

5. Why ‘Project Kākā’?

Regarded as the rangatira of all forest birds by Māori, kākā, along with kea and kākāpo, are a highly distinctive and ancient group of parrots, unique to New Zealand. Unfortunately, they are also declining steadily under stoat, rat and possum predation. Kākā face a dismal future on the mainland. Although they have strongholds in some central North Island forests, populations are shrinking there as well. Most populations are skewed towards male birds since females are often killed while nesting. Ron Moorhouse, a kākā expert, has gloomily concluded “...without intensive control of introduced predators, mainland kākā populations are heading for extinction.”⁴

Fortunately, the kākā population is thriving on Kapiti Island in the absence of predators. Kapiti is therefore a long-term source of kākā as well as other strong fliers—kererū

4 Kākā. R. Moorhouse. 2004. In *Restoring Kapiti. Nature's second chance*. Edited by K. Brown. University of Otago Press. P. 65.

and kākāriki. In the absence of predators kākā numbers have also steadily increased in two other sanctuaries in the Wellington region. In the Wairarapa, at Pukaha Mt Bruce, kākā numbers have risen to over 100 birds since 9 birds were introduced in 1996. At Zealandia, the fenced wildlife sanctuary in Wellington city, kākā numbers have also increased. This provides the Tararua Forest Park with three natural sources of kākā, of which Kapiti Island is clearly the most important. When Kapiti Island reaches its carrying capacity for kākā, Ron Moorhouse expects more mixing of the Kapiti and Tararua populations, which will benefit the survival of the species. Hence the importance and value of establishing a large area with few predators in the Tararua Forest Park.⁵ Kākā are very strong fliers. A young bird banded at Zealandia was recorded at Pukaha Mt Bruce and turned up again at Zealandia some time later, a straight-line distance of over 100km. The geographical relationships between these three sources of kākā and Project Kākā are shown in Fig. 1.

Kākā can lay 4–5 eggs in good food years, but few attempt breeding if food levels are low. Given that kākā can live for 20–30 years and start breeding at age 4, providing ‘breeding windows’ by reducing predator numbers could substantially benefit populations and reverse population declines for a number of years.

For all these reasons kākā were chosen as the flagship species for the larger ecological restoration initiative over the 22,000 hectares area in the Tararua Forest Park, although many other native species are also expected to benefit from Project Kākā, hence the full title: ‘Project Kākā: Tararua Nature Recovery’. The long-term goal of restoring richer, healthier forest ecosystems for their own sake and for our enjoyment is well captured by the Māori proverb:

E koekoe te tūi, e ketekete te kākā, e kuku te kererū.
The tūi sings, the kākā chatters, the pigeon coos.



6. Other objectives of Project Kākā

Biodiversity conservation is only the first of three important objectives for Project Kākā. The second is a comprehensive research and monitoring programme to study the outcomes of the pest control programme and the safety of the pest management practices. Rigorously measuring what effects the pest control has over the initial 10-year life of the Project is a key objective. Pest control is expensive and assessing the outcomes for conservation gains is a key part of making the most effective use of limited funds. The third objective is to increase the public’s engagement with conservation management and improve the public’s understanding of the relevance and importance of biodiversity to New Zealand and the threats it faces.

Monitoring is also closely linked to research initiatives, both by DOC and Landcare Research scientists. The first-year results of the monitoring and public engagement are described later in this report. Both the monitoring and the research will help to guide and improve future management practice for Project Kākā and elsewhere in New Zealand.

The Wellington Hawkes Bay Conservancy also has two second-level goals for Project Kākā. The immediate goal is to actively develop synergies with other agencies and communities that could team up with DOC to improve the biodiversity and restoration outcomes. This

⁵ For comparative purposes, Project Kākā at 22,000 hectares is over eleven times larger than Kapiti Island at under 2,000 hectares.

has already been successful through collaboration with both the Animal Health Board (AHB) and the Greater Wellington Regional Council (GWRC). The AHB has an active programme of reducing Tb levels along the eastern margins of the Tararua Range while GRWC has been controlling possum numbers south of the Project Kākā area around its Hutt Water Collection Area. The AHB had scheduled its next aerial control operation along the Tararua Range foothills for late 2010/early 2011 but agreed to bring it forward and co-ordinate with the timing of the 2010 Project Kākā operation. Other initiatives are underway with community groups to be involved in monitoring activities and complementary pest control on the periphery of the project area.

The second goal is a longer term aspiration. If the control of key predators can be successfully achieved then it may be feasible to re-introduce species that are now locally extinct. Long-term monitoring will guide decisions on whether this is realistic. If it is, we could see whio back in Tararua streams, kiwi probing the forest floor at night, and North Island robin entertaining daytime trampers along the tracks.

7. The monitoring plan

Through extensive discussion with technical and management staff, as well as researchers, a detailed monitoring plan was developed that covers short-term operational aspects as well as results, or outcome aspects. Technical aspects of the monitoring programme are covered in the Annex and summarised here.

7.1. Operational monitoring

Monitoring certain aspects of the aerial operation is part of the standard requirements of the resource consent that sets out conditions to be met as well as being part of best practice. The things that are covered under the operational monitoring include bait quality/strength, flight paths of helicopters and water quality monitoring in all public water supply catchments.

The Project Kākā zone includes the public water supply catchments of the Masterton, Carterton and South Wairarapa Districts. To cover all these areas water samples were taken at Kaipatangata (Carterton), Taits Creek, Greytown intake (both South Wairarapa) and Waingawa River (Masterton). At sites (non-treatment and treatment) selected in collaboration with key stakeholders (hunting groups/iwi/Tararua Tramping club, etc) water monitoring was undertaken approximately two, four and six hours after the 1080 bait application. Water monitoring samples were collected by Bioworks and sent away to Landcare Research for analysis.

7.2. Results monitoring: research questions

The results monitoring regime for Project Kākā is much more extensive than that used for most aerial 1080 operations and is aimed at improving our knowledge about the effects of such operations as well as the interactions between pest animals and native plant and animal communities. The monitoring programme aims to answer the following questions:


1. What is the magnitude and persistence of the effect of 3-yearly aerial 1080 application with pre-feed (non-toxic cereal baits) and toxic 1080 baits, sown at 2 kg/ha, on the abundance and distribution of target pest species (possums, rats, stoats) and non-target pests (mice, deer)?
2. What is the effect of stopping 6-yearly aerial 1080 control on the abundance and distribution of these target and non-target pest species? (Referred to as the 'non-treatment' or 'control' area.)
3. Do changes in the abundance and distribution of these target and non-target pest species lead to changes in the abundance and distribution of vulnerable native animal species?
4. Do changes in the abundance and distribution of these target and non-target pest species lead to changes in the structure and composition of the dominant forest plant communities in the Tararua Range?
5. Is the abundance and distribution of target pest species (rats and possums) and breeding of fruit-feeding birds (kākā, kākārīki, etc) correlated with changes in seed-fall rates? (Seeds from rimu and beech trees are major foods for birds and rats and can trigger population explosions during heavy fruiting (mast) years.)

There may also be some subsequent research into whether Project Kākā has changed the perceptions of key stakeholders on the value, efficacy and safety of large-scale aerial 1080 operations. In the summer of 2009-10, extensive pre-treatment monitoring of pest, wildlife and vegetation was done in the treatment and non-treatment areas.

8. Additional research initiatives

The 10-year Project Kākā has also attracted the interest of other DOC and Landcare Research scientists who see the value of using it to answer additional research questions by piggy-backing on its comprehensive monitoring programme. Project Kākā is contributing to an important national study run by DOC's Science and Technical Group which aims to improve the efficiency of pest control across the country. About twenty sites across New Zealand are part of this national study. They have in common the goal of protecting native forests and species from rats, stoats and possums over large areas on the mainland. Many of the sites use aerial 1080 as a primary means of predator control, but some use bait stations and others have stoat trapping as well as aerial 1080 treatment.

The Project Kākā site is valuable within this greater study because predator numbers are measured in both treatment and non-treatment areas along with seedfall by the beech and rimu trees that dominate the area. The study aims to produce a site-specific computer simulation model of predator populations in the Tararua Forest Park which may improve the efficiency with which the Project achieves its goals.




"Ultimately, the information will help people protecting other sites to design new projects and improve the efficiency of existing projects. We will all see better biodiversity outcomes as a result. Conversely, data from other sites will help improve the efficiency of Project Kākā. Being part of a network of sites doing predator control on a similar scale and monitoring it in similar ways is a good place to be."

Josh Kemp, Science and Technical Group

An additional Science and Technical Group study led by DOC scientist Graeme Elliot is investigating the response of rifleman (*Acanthisitta chloris*) at several sites around New Zealand, including the Tararua Ranges. Rifleman survival and productivity is being monitored closely at two sites, one near Cone Hut in the non-treatment block, and one on the Mt Holdsworth track in the Operation Kākā block.

As part of a larger Invasive Mammal Impacts programme Landcare Research scientists have set up a complementary monitoring regime to test whether the actual area protected by the aerial pest control is larger or smaller than the area that is treated with aerial 1080 (a 'halo effect' versus 'core effect'). A related study is to investigate if the size of the area protected from pests varies for different species (such as weta) and for native vegetation. Other Landcare Research studies will examine the feeding behaviour of possums, why and how do they feed on particular trees or tree species and the impact that this feeding has on individual tree survival and, ultimately, on forest health.

For the Landcare studies two monitoring lines have been set up along river valleys perpendicular to the Project Kākā treatment boundary. Each line extends 2.5 kilometres into and out of the Project Kākā treatment area; one on the eastern side and one on the western side of the Tararua Range. The relative abundance of rats, mice, stoats and possums will be measured along the monitoring lines and sampled four times annually (February, May, August and November) using the methods described in the Annex. Tree and cave weta will be monitored using tracking tunnels and 'weta houses' fixed to kamahi trees. Seedfall will also be monitored and more extensive sampling of invertebrates will be made using pitfall traps at specific sites along the monitoring lines. Tree health (of kamahi, toro and rimu) will also be measured to see if the benefits of pest control change with increasing distance into and out from the treatment area. Monitoring will be repeated over the next 3–6 years to find out how quickly pest populations re-invade or recover to the levels that existed before the aerial 1080 control.



'Rifleman are likely to be responsive to improved pest control because they are hole nesters that are prone to predation while on the nest, but are still common enough to be easily monitored. These days they are mostly confined to high altitudes where there are lower predator densities—if predator control is effective they can be expected to become more common at low altitudes. During the summer of 2010–11 31 birds were individually colour banded in the Operation Kākā block, and 29 in the non-treatment block. 12 nests were monitored in the Operation Kākā block and 7 in the non-treatment block—all were successful. With only one year's data we can make no inferences about the effect of 1080 use on rifleman survival and productivity.'

Graeme Elliot, Science and Technical Group



"Teaming up with DOC has enabled Landcare Research to take advantage of a 'management scale' experimental manipulation of invasive mammal populations. By pooling our resources and data we can achieve a greater understanding of how best to manage multiple invasive species and demonstrate the benefits of pest control for native plants and animals."

Mandy Barron & Wendy Ruscoe, Landcare Research

9. Synergies with Greater Wellington

Understanding the complex interactions between pest and prey species along with influences of varying food supplies, location and climate, and how they are all affected by pest control is not rocket science—it is much more difficult! So, as well as the additional studies by DOC and Landcare Research, a close working relationship has been established with the Greater Wellington Regional Council (GWRC). For several years GWRC has been controlling possums on its own lands to protect the health of water supply catchments and to care for the ecological values of these areas. GWRC is also involved in regional possum control to reduce the number of Tb infected cattle and deer herds. Not far south of Project Kākā lies the Hutt Water Collection Area (see Fig. 1) where the latest possum control was done in August 2009. For the aerial control component, non-toxic cereal baits were spread followed by 2 kg per hectare of toxic baits, the same regime as in Project Kākā (detailed in next section). This provides a second treatment area of about 10,000 hectares in which aerial 1080 possum control operations will continue on a 6-year cycle. GWRC staff are using identical monitoring methods to those in Project Kākā to track pest and bird responses. Greater Wellington undertakes control every 5–6 years (compared to every 3 years in Project Kākā), so their involvement will provide valuable comparable information on the effectiveness of different approaches to control. It will help answer an important management question: What are the pros and cons of 3-year versus 6-year cycles of aerial 1080 use? Some initial comparative results from the Hutt Water Collection Area are given alongside Project Kākā results (see Section 11).

10. 2010 pest control operation

Although the aerial part of control operations using biodegradable 1080 is often completed in a day or two it is preceded by months of planning, consultation and paperwork. The extensive pre-operation consultations and discussions with iwi, communities and groups are elaborated below (Section 12). The necessary resource consents from the GWRC and consents from the Medical Officer of Health, based on details of the operational plan and how relevant water bodies would be protected, were granted.

A valuable synergy was the coordination of Animal Health Board operations in Wairarapa along the eastern edges of the Park with the timing of the Project Kākā aerial operation. This benefited both AHB and DOC objectives in two ways. There were efficiency gains for both agencies in shared messages and consultations with landowners and communities as well as other operational savings. A single operation in one year instead of two in 2 years meant less impact on Park users. There were also greater benefits for both biodiversity and Tb reduction since by treating a larger area the reinvasion rates of rats, stoats and possums into the Project Kākā treatment area will be reduced (Fig. 1). Within the Project Kākā boundary the AHB paid for the treatment of an additional 1824 hectares as part of the Tb eradication programme.



"It was really great to work with DOC. Tb is bad in the Wairarapa and by working with DOC we were able to knock out a much greater chunk of the possum reservoir, plus we were able to make sure we maximised benefits to biodiversity as well."

Alan Innes, Programme Manager,
Animal Health Board

The first ground and aerial treatment for Project Kākā was successfully completed during October/November 2010. The cereal, non-toxic baits used for the pre-feed weighed 6 grams with cinnamon lure added and were sown on 4 and 23 October. These were followed by 12-gram, toxic cereal baits sown on 8 and 9 November. Toxic baits were dyed green (making them less attractive to birds) and also had cinnamon lure added to attract possums and rats. Roughly 10,000 hectares were treated each day with helicopters using GPS to accurately track flight paths.

The smaller, non-toxic baits were spread at the rate of 1.4 kg/hectare which is equivalent to six baits on an area the size of a doubles tennis court. By comparison, the larger toxic baits were spread at 2.0 kg/hectare, equivalent to 4 baits on a doubles tennis court. Using smaller, more numerous non-toxic baits increases the likelihood that rats and possums will find them while keeping the operational cost down. The toxic baits had the standard loading of biodegradable 1080 at 1.5g/kg meaning that 99.85% of the weight of each bait was cereal. The amount of 1080 applied per hectare was 3 gram, roughly the weight of a Brazil nut. The costs associated with buying and spreading both non-toxic and toxic baits over the Project Kākā treatment area was \$15.54 per hectare.⁶

The operation took place in fine weather with light winds and was followed by several fine days without rain which is ideal for maximum uptake of toxic baits by possums and rats. Research has shown that over 80% of toxic baits are found and eaten by possums or eaten/stored by rats in the first 2–3 days after aerial operations.

11. Treatment and monitoring results to July 2011

This section summarises the results of monitoring undertaken to date. The results fall into two categories:

1. Indices of pest animal abundance, showing the impact of the aerial 1080 operation on possum, stoat, rat, and deer/goat populations; and
2. Indices of bird abundance, which provide a baseline for bird populations and indicate whether there were any declines due to the pest operation. Note that no direct benefits will be observed until at least summer 2011.

Although bird monitoring results are given it will be some years before the full benefits for bird populations will be clearly evident. There are two reasons for this. First, the primary aim of the pest control operation is to increase breeding success, and any increased survival of newborn birds will not be detectable until at least 1 year post treatment, once they have fledged and joined the adult population. Secondly, the bird populations in the Tararua have steadily decreased over many decades because of predation and it is likely to take them some time to recover. The baseline information for the extensive vegetation monitoring (see Annex) has also been collected, but vegetation responses will not be measured for some years yet and will be reported on subsequently.

⁶ In 2009, Greater Wellington estimated that treating 11,000 hectares in the Hutt Water Collection Area using only bait stations would have taken 15 staff 46 weeks to complete at a cost of \$145/ hectare and would have been less effective at reducing possum density than a single aerial operation. Media release, posted 7 August 2009, Greater Wellington Regional Council.

11.1. Impacts on pests

Every DOC pest control operation sets ‘result targets’. The 2010 result targets for Project Kākā were a reduction of the wax tag index for possums to less than 10% and the same reduction (< 10%) for the rodent tracking index. By comparison, the pre-treatment index for possums was 42% and 21% for rats in the treatment area. No result target was set for the stoat tracking monitoring.



A possum and a rat raid a bird's nest.
Photo: David Mudge.

The post-treatment result for possums was a low wax tag index of 2%, while possum numbers did not drop in the non-treatment area (Fig. 2). Figure 2 also shows that possum numbers remained low in the Hutt Water Collection Area following the 2009 control operation using aerial 1080 and ground control. Given that possum populations recover slowly, the 3-yearly interval for repeat 1080-treatments should effectively keep possum densities close to zero for the full 10-year period and beyond—providing benefits to both vegetation and wildlife.

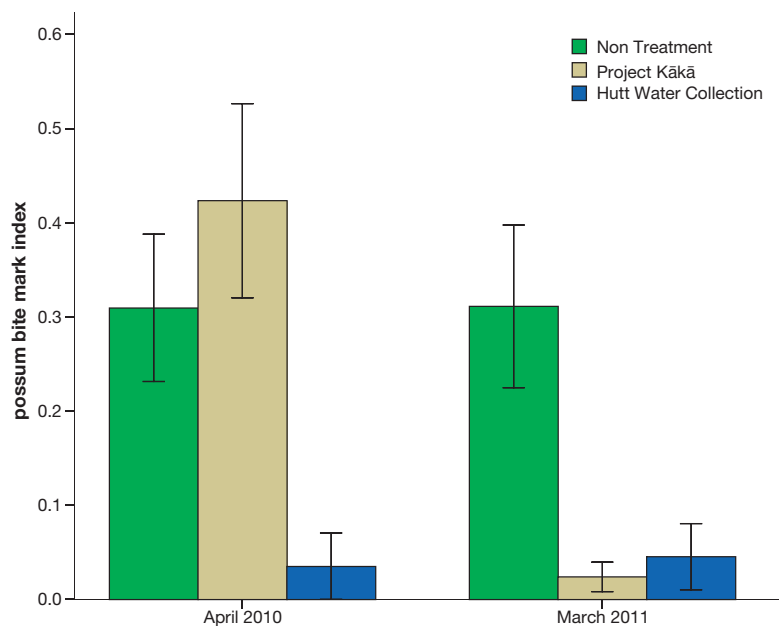


Figure 2. Possum bite mark rates for the Project Kākā treatment area (olive) and non-treatment area (green) before and after the aerial 1080 operation in November 2010 and for the Hutt Water Collection Area (blue) after aerial control in 2009. Error bars are 95% confidence limits around the mean.

The fall in tracking rates for rats and mice was equally dramatic. Normally, rodent numbers fluctuate through the seasons, usually declining into winter and rising in summer. Figure 3 shows the results for rats; tracking rates for rats fluctuated but stayed high in the non-treatment area, while in the Project Kākā treatment area they dropped to less than 1% after the aerial 1080 operation. By mid-2011, they had shown no signs of recovery. The Hutt Water Collection Area tracking results showed only a slow recovery of rat numbers (Fig. 3) almost 2 years after control. At tracking rates of about 10%, the Hutt Water Collection Area rat density in May 2011 was still relatively low and should continue to provide the birds with some ‘breathing space’.

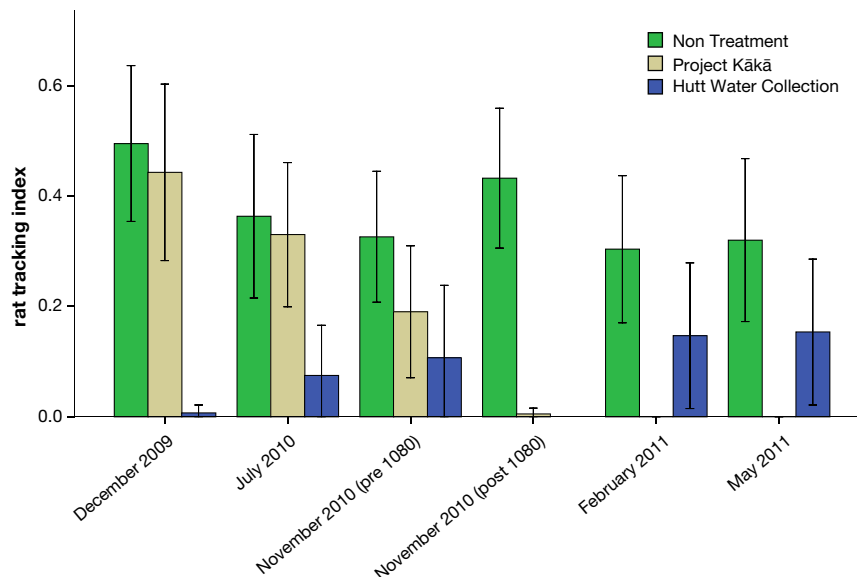


Figure 3. Rat tracking rates for the Project Kākā treatment area (olive) and non-treatment area (green) before and after the aerial 1080 operation in November 2010 and for the Hutt Water Collection Area (blue) after aerial control in 2009. Error bars are 95% confidence limits around the mean.

In the Project Kākā areas mouse tracking rates were low before the 1080 operation and dropped to zero after treatment (Fig. 4). Note how the mice index also dropped in the non-treatment area and in the Hutt Water Collection Area in 2011 without control while rat numbers there had increased (Fig. 3). The relationships between rats and mice in forests are complex and getting a better understanding of the factors driving these changes is part of the Project Kākā research plan. Rodent abundance is closely tied to food abundance, something that is also being monitored throughout the Project. The low mouse tracking rates may indicate poor food supplies and competition by rats, but we need more research to sort out these issues.

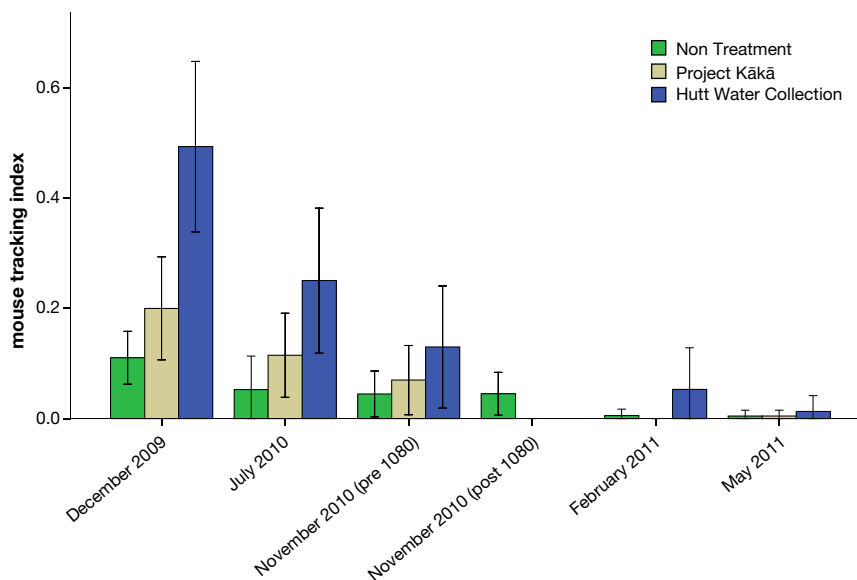


Figure 4. Mouse tracking rates for the Project Kākā treatment area (olive) and non-treatment area (green) before and after the aerial 1080 operation in November 2010 and for the Hutt Water Collection Area (blue) after aerial control in 2009. Error bars are 95% confidence limits around the mean.

Stoats had zero tracking rates 3 months after the 1080 operation in the treatment area (Fig. 5). Although these results are consistent with the expected decrease in stoat numbers, the low tracking rates and high variability prior to the drop make it difficult to draw a robust conclusion. A longer-term dataset will provide more data and, we hope, a better understanding of stoat population dynamics in the Project Kākā treatment and

non-treatment areas. Interestingly, stoat numbers appeared to increase noticeably in the Hutt Water Collection Area 2 years after control, suggesting that reinvasion or natural population increases have led to a population rebound.

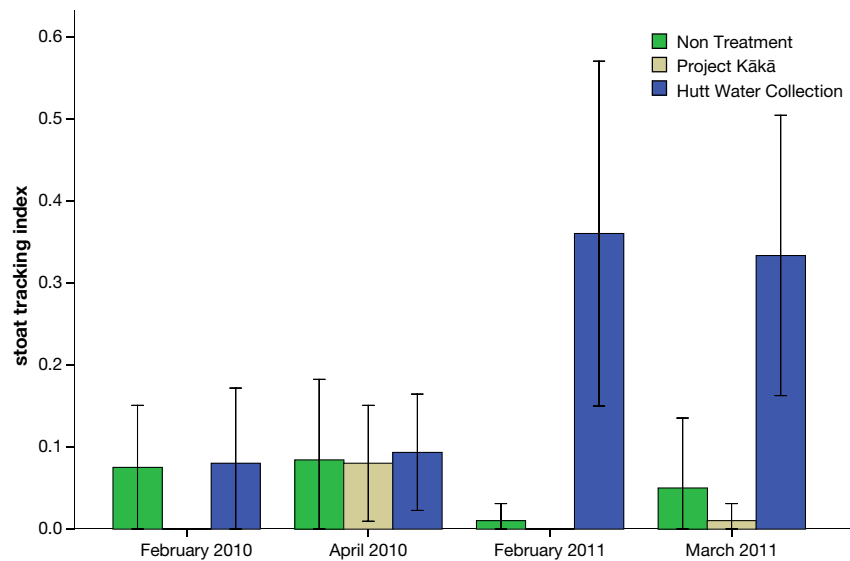


Figure 5. Stoat tracking rates for the Project Kākā treatment area (olive) and non-treatment area (green) before and after the aerial 1080 operation in November 2010 and for the Hutt Water Collection Area (blue) after aerial control in 2009. Error bars are 95% confidence limits around the mean.

The results from monitoring deer and goat pellet groups showed a slight decrease after the 1080 operation in both the treatment and non-treatment areas (Fig. 6), although there was no significant difference between the treatment and non-treatment areas. Pellet numbers were very low in both the treatment and non-treatment areas, and the observed difference is less than 1 pellet group per 40 plots, meaning that even a small change in local deer density (e.g. one deer shifting its territory) could affect the results. Longer-term analysis of deer and goat pellet lines will provide more data which should allow for more confident detection of any changes to deer and goat populations in the Tararua Forest Park.

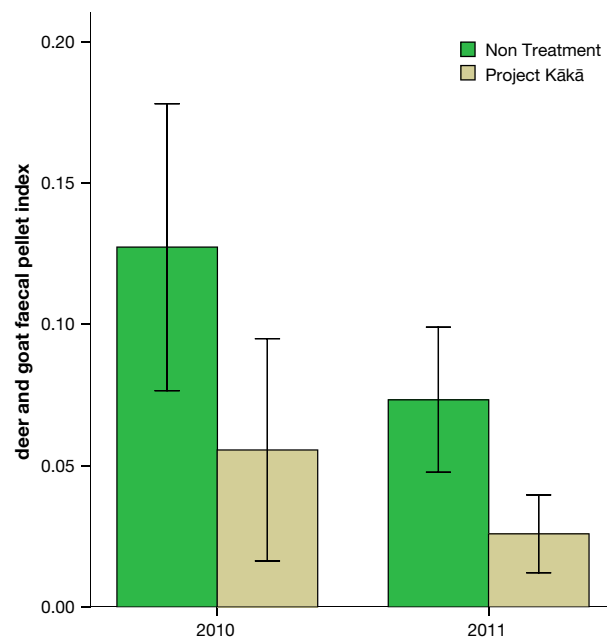


Figure 6. Deer and goat faecal pellet index for the Project Kākā treatment area (olive) and non-treatment area (green) before and after the aerial 1080 operation in November 2010. Error bars are 95% confidence limits around the mean.

11.2. Impacts on birds

Accurately measuring changes in the abundance of forest birds can be difficult; apart from various technical difficulties, the ability to detect birds varies among species and seasons, while weather conditions and even the experience and hearing ability of the observer can affect results. So detecting actual changes in bird abundance is challenging. To overcome these challenges, birds are sampled at the same time of year, in similar weather conditions. Staff are re-trained in monitoring techniques each year to ensure consistency, and digital sound recorders are used as an independently analysable record of bird monitoring.

From a methodological perspective the portable audio recorder for bird counts proved to be very accurate and a useful audit tool of staff accuracy. Some people with the skills for bird monitoring do not have the fitness levels required for the Tararua backcountry and struggle to get around monitoring lines. Audio recorders offer a reliable alternative, as they can be put out by a fit individual and the results analysed later, which reduces the risk of observational error.

As explained above, increased survival of newborn birds will not be picked up until they join the adult population at least a year after breeding. Because bird monitoring occurred immediately after the 2010 aerial 1080 operation, we should not expect an associated response in bird numbers in the Project Kākā treatment area until at least summer 2011, after the first pest-free breeding season. In contrast, increased counts of birds that benefit from reduced rodent, stoat or possum pressure would be expected in the Hutt Water Collection Area, which was aerially treated with 1080 in 2009.

Although increased chick survival due to the 2010 1080 operation is not expected to be reflected in bird counts in the Project Kākā treatment area until 2011, any large negative effects of 1080 on bird abundance should have been evident. However, no treatment effect was detected for any of the 16 bird species for which data was collected in the Project Kākā treatment area, and counts of tomtit, a small territorial bird that has been adversely affected by poorly run 1080 operations in the past, increased in the Project Kākā treatment area and in the Hutt Water Collection Area in 2010 relative to the non-treatment area (figure 10). These results suggest that the 1080 operation had no negative impact on native bird populations, a result that is further supported by the absence of dead native bird sightings after the 1080 operation. The graphed results for four bird species are included as representative of over 16 species for which results have been tabulated. These graphs also show the importance of tracking changes in a non-treatment area to help separate treatment effects from other factors which may influence bird numbers. Figures 7–10 show average values as well as margins of error around the estimated average.⁷

In contrast with the Project Kākā treatment area, positive treatment effects were recorded for kākāriki (yellow-crowned parakeet) and rifleman in the Hutt Water Collection Area where large increases in counts of these birds occurred between 2009 and 2010. Kākāriki and rifleman are particularly susceptible to stoats and rats given their preference to hole-nest in old trees and consequently would be expected to show a positive response to reduced predator pressure. Only one species, bellbird, showed noticeable declines in bird counts in all three areas (Fig. 11). However, although large drops in bellbird counts occurred in both the Project Kākā areas between 2009 and 2010, bellbird counts in the Hutt Water Collection Area (Fig. 11) remained relatively stable. Collectively, these results suggest that the application of 1080 to the Hutt Water

⁷ Margins of error are expressed at 95% confidence limits around the mean.

Collection Area in 2009 has benefited bird species that are vulnerable to rodent, stoat or possum depredation.

Kākā were infrequently recorded during bird counts indicating that they are only present at low numbers within the study area (Fig. 7). Due to the paucity of kākā records, it is not possible to assess changes in the relative abundance of kākā at this stage. However, it is anticipated that additional years of data collection will allow any increases in the relative abundance of Kākā to be detected, should they occur.

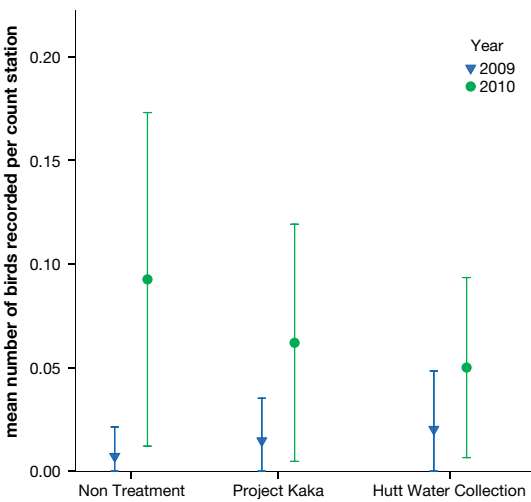


Figure 7. Number of kākā recorded at count stations for the Project Kākā treatment and non-treatment areas before (blue triangle) and after (green circle) the aerial 1080 operation in November 2010 and for the Hutt Water Collection Area after aerial control in 2009. Error bars are 95% confidence limits around the mean.

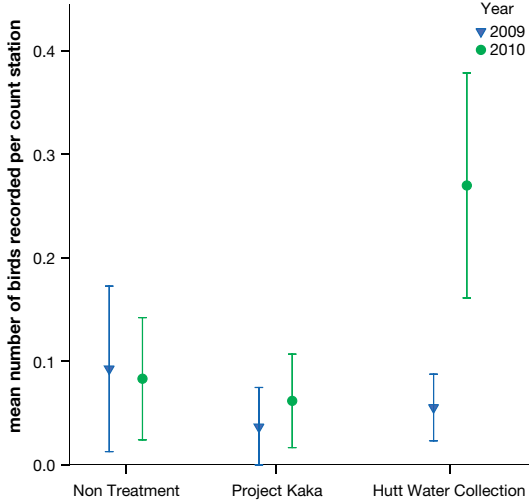


Figure 8. Number of kākāriki (yellow-crowned parakeet) recorded at count stations for the Project Kākā treatment and non-treatment areas before (blue triangle) and after (green circle) the aerial 1080 operation in November 2010 and for the Hutt Water Collection Area after aerial control in 2009. Error bars are 95% confidence limits around the mean.



Photo: Ross Henderson.



Photo: Simon Woolf.

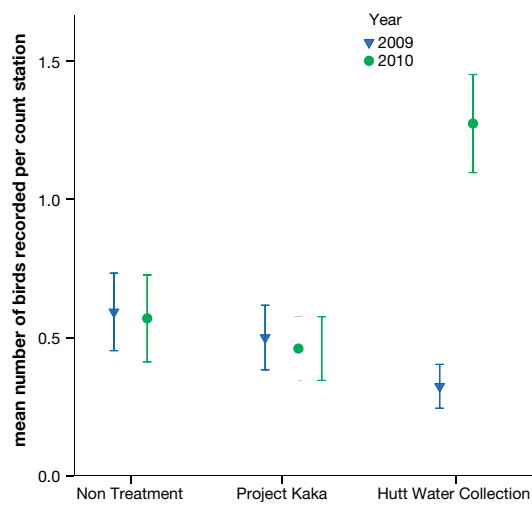


Figure 9. Number of rifleman recorded at count stations for the Project Kākā treatment and non-treatment areas before (blue triangle) and after (green circle) the aerial 1080 operation in November 2010 and for the Hutt Water Collection Area after aerial control in 2009. Error bars are 95% confidence limits around the mean.

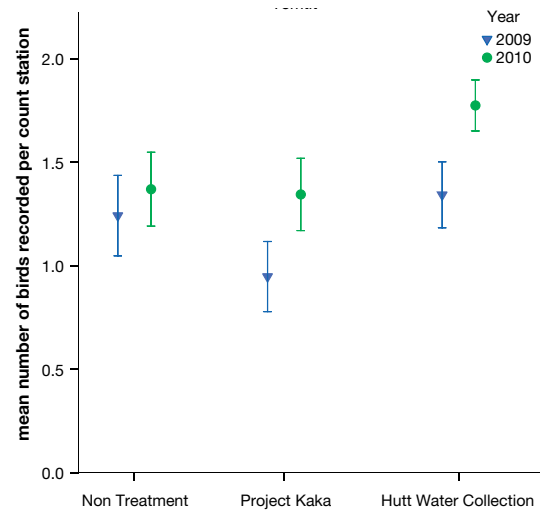


Figure 10. Number of tomtit recorded at count stations for the Project Kākā treatment and non-treatment areas before (blue triangle) and after (green circle) the aerial 1080 operation in November 2010 and for the Hutt Water Collection Area after aerial control in 2009. Error bars are 95% confidence limits around the mean.



Photo: J.L. Kendrick.



Photo: Paul Schilov.

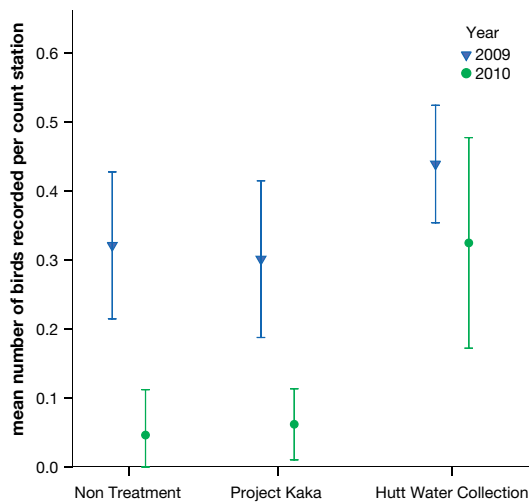


Figure 11. Number of bellbird recorded at count stations for the Project Kākā treatment and non-treatment areas before (blue triangle) and after (green circle) the aerial 1080 operation in November 2010 and for the Hutt Water Collection Area after aerial control in 2009. Error bars are 95% confidence limits around the mean.



Photo: Peter Daniel.

12. Public engagement

Project Kākā marked a significant change in the approach to pest management in the Tararua Forest Park and it was important to explain the rationale for this change to tangata whenua, adjoining landowners and key stakeholders. The area under active management was being reduced (from around 57,000 to 22,000 hectares) and the frequency of treatments switched from 6–7 years to 3-year cycles with extensive monitoring and research projects.

A fact sheet with operational details and precautions to be taken was prepared as well as a brochure about Project Kākā. These were distributed to the six local iwi authorities, none of whom responded with concerns regarding the new approach. Fact sheets were sent to the two regional councils (GWRC, Horizons) and five district councils in the region and were also available at the Otaki Forks and Holdsworth road-ends.

On the western side any aerial application of 1080 baits was at least 1 km inside the Tararua Forest Park boundary and no streams flowing from the treatment area are used for domestic water supplies. Therefore there was minimal impact on adjoining landowners. It was different on the eastern side where the combined DOC-AHB treatment area included the public water supply catchments of the Masterton, Carterton and South Wairarapa Districts and included, or was adjacent to, numerous private landholdings. Between May and June 2010, occupiers and landowners closer than 3 km to the eastern operational boundary were visited and Project Kākā was outlined and discussed. All occupiers were sent a letter and information fact sheet including a map with operational details. There was a very positive response from occupiers and landowners to the conservation objectives of increasing forest health and boosting populations of forest birds to more sustainable levels.

There was considerable interest from hunting groups throughout the greater Wellington area in the Project Kākā concept and approach. DOC staff held six meetings with various branches of the NZ Deerstalkers Association, from the Hutt and Kapiti to the Wairarapa. There was also a meeting with the Horowhenua Hunting Club. While there is a reduced area under management, the Project Kākā area does include places that are often hunted and that will be closed for some months after each treatment. These pros and cons were well aired at the meetings. Hunters also recognised the wider need to improve forest health and status of bird and wildlife populations.

Presentations were made to the Forest and Bird Northern Regional Meeting, to the National Office and to the Wairarapa Branch. Meetings were also held with the Tararua Tramping Club, Masterton Tramping Club, Botanical Society and Wellington Conservation Board. The Conservation Board was supportive of the Project's objectives and appointed a member to serve on the Project's Steering Committee. To increase engagement between DOC and key stakeholders, a reference group was set up with representatives appointed by key groups to meet with DOC prior to the operation and provide feedback.

There will be future opportunities for greater public engagement with pest management and monitoring aspects of Project Kākā. The objective of increasing the public's engagement with, and awareness of, conservation issues was boosted in May 2011 when DOC started a newspaper campaign through the Newspapers in Education pages of The Wairarapa Times Age, the local regional paper. This initiative is encouraging community involvement in conservation through the Wairarapa Wildlife Warriors; Wairarapa residents can become Wildlife Warriors by protecting native birds and animals. The campaign focuses on Project Kākā and how the community can be involved in conservation in the Tararua Forest Park. So far, DOC has released nine issues focused on explaining 1080 effects and working on community education through stories. The newspaper campaign will continue to run as long as there is funding available. DOC is also planning to create an education programme around research and field experience using Project Kākā as a case study.



A group of volunteers have set up a successful stoat, rat and possum control operation at Donnelly's Flat, the eastern entrance to the Project Kākā area. Donnelly's Flat is an area of fertile river flats dominated by podocarps, and provides a high-value food resource for native birds; it is also the area of highest use by visitors to the Tararua Forest Park. It was excluded from the Project Kākā aerial operation because of the high recreational use of the area. This community pest control effort therefore forms a vital part of the Project Kākā restoration effort.

13. Future prospects

Project Kākā has long-term aspirations that cannot be measured in year-to-year results despite the success of the first treatment in achieving a ‘triple hit’ on the possum, rat and stoat populations. The long-term responses of the forests and their wildlife will be the test of the restoration aspects of Project Kākā: Taranui Nature Recovery. The longer goal of the 3-yearly control cycles is summarised below in the stylised Figure 11 for threatened birds, including kākā. The expectation is that a 3-year pulse of 1080 control will provide one year in every three when chick survival is increased and that should be sufficient to allow populations to increase over the long term. All we need is for (bird) productivity to exceed mortality. Forest plants recover more slowly, but the principle is the same.

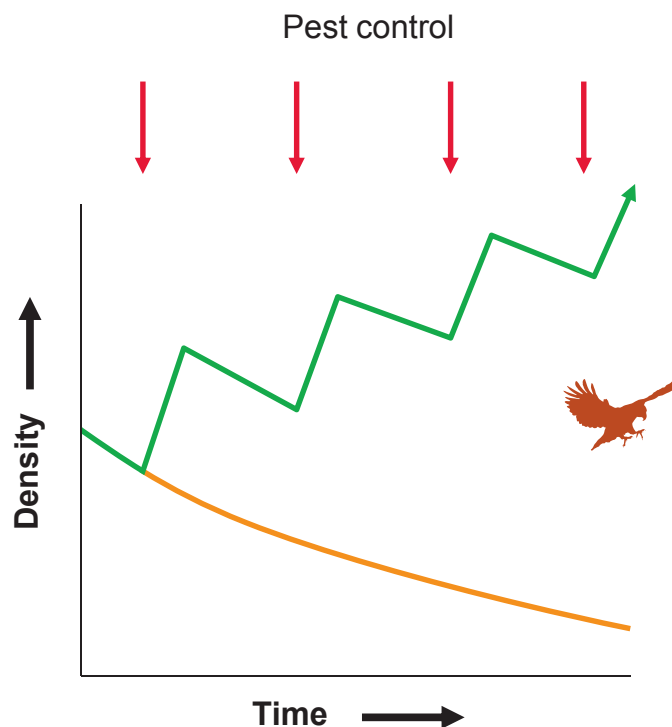


Figure 11. A stylised graph showing the desired increase over time following 3-yearly 108 control cycles (green). Without predator control threatened bird species, such as kākā, will continue to decline (orange).

The monitoring and research aspects of Project Kākā are now underway including additional DOC research studies and those of Landcare Research (Section 8). Collectively, this is a more comprehensive approach to management-related research than has been undertaken before. Given that Project Kākā is located about an hour's drive from two universities (Massey and Victoria) there are additional opportunities for complementary studies by graduate students into other aspects of pest-wildlife responses provided by Project Kākā that could usefully be developed. The 10-year timeframe provides additional certainty around which student research studies could be organised.

The involvement of members of Forest and Bird, hunting clubs and tramping clubs in monitoring part of the Project area is an important way of involving the public and community. Hopefully there will be additional opportunities to involve others in monitoring work, although working safety in physically dangerous places will put some limits around these options.

It is 120 years since Walter Buller wrote about the half-dozen pillows in his house, filled with kākā feathers that were “...so delightfully soft and elastic that it is a positive luxury to sleep on them.” He also wrote of kākā being common enough that “...even in the bright

sunshine a score of them may be seen together, flying and circling about, high above the trees, uttering their loud screams and apparently bent on convivial amusement.” That might be an experience our generation enjoys on Kapiti Island. We can hope and aspire to future generations having the same experience along the bush-clad tracks in the Tararua Forest Park. Project Kākā: Tararua Nature Recovery is the first step along the road of that journey.



View down the Otaki Catchment. Photo: Wayne Boness.

14. Annex. Summary of monitoring programme

The Department of Conservation monitoring programme is based on a BACI (before, after, control and intervention) experimental design framework. This design requires pre- and post-operation monitoring in the treatment and non-treatment areas. The locations of the actual monitoring sites were semi-randomly spread between the different ecosystems, taking into account altitude and aspect differences. Equal numbers of sample units are in the treatment and non-treatment areas and no sampling units are within 1 km either side of treatment boundaries to provide an adequate buffer from treatment and non-treatment effects.

The treatment area for Project Kākā ('intervention' in BACI terms) is the 22,000 hectare area stretching east-west over the Range. The non-treatment area ('control') is an area of about 37,930 hectares in the Park from which possum control (aerial application of 1080 on a six year cycle) has been removed. As well as Project Kākā operating as a 3-year treatment, the possum control at the Hutt Water Collection Area by Greater Wellington Regional Council over 10,000 hectares is effectively operating as a 6-year treatment 'experiment' running in parallel. All monitoring is duplicated there with the exception of seedrain, vegetation (some 20 × 20 plots are monitored), ungulate enclosures and ungulate pellet counts.

Monitoring pest species

Since it is very difficult to measure absolute numbers of small mammals, various techniques that rely on the use of relative density measures have been developed and evaluated. Some of these have been adopted for New Zealand conditions and are being used in Project Kākā.

Possums are monitored using the Bite Mark Index which is based on bites that possums make on wax tags. These are blocks of wax on sheets of plastic that are nailed to trees. Possums are attracted to the tag and their presence is recorded by species-specific bite marks on the wax. This method follows a national protocol outlined by the National Pest Control Agencies (www.npca.org.nz). Two lines each with 20 wax tags spaced at 10m intervals have been set out along each of the 20 rodent tracking tunnel lines in the treatment and non-treatment areas. Possum monitoring will be done during March/April.

The tracking tunnel index is being used to monitor rats and will also be used to track changes in the abundance and distribution of tree weta with no additional sampling effort. Tracking tunnels rely on ink pads and paper to record rat (and weta) tracks and have now largely replaced the use of kill-trapping to estimate rodent densities. Relative rat abundance will be measured in November, February, May and August to estimate seasonal changes in abundance. There are 20 lines of 10 tracking tunnels at 50 m spacing in both treatment and non-treatment areas. For practicality and efficiency these are combined with the possum and stoat lines.

The same tunnels used to monitor rats will be analysed for mouse presence/absence as well since a separate mouse tracking system would be prohibitively expensive. However, variability in mouse numbers is large so the mouse index will be less reliable. Consequently, Project Kākā only aims to detect gross changes (high, medium, low) in relative mouse abundance.

Relative stoat abundance is also estimated using tracking tunnels with 20 lines of 5 tracking tunnels spaced 100 m apart in the treatment and non-treatment areas. Given the wide ranging movements of stoats the lines are at least 1 km apart to ensure independence

of the results. Stoat abundance is measured in early January and late March which is the beginning and end of the period in which stoats commonly reach peak abundance, and when vulnerable bird species, including kākā and kākārīki, are breeding. March monitoring of stoats will occur immediately after rat monitoring.

Trends in deer density will be monitored using the faecal pellet index method. Forty transects are located in the treatment and non-treatment areas using a random stratified approach. Monitoring is being done annually during March/April. This method cannot measure rapid changes in deer density due to the slow decay of faecal material. As a result, repeat measures within a year are unlikely to reveal useful information. Deer monitoring will be reviewed following two monitoring cycles to check whether the frequency of monitoring is adequate. Goat and deer pellets are hard to separate which makes interpretation of results more difficult.

Monitoring bird species

Measuring the abundance of territorial birds over large forested areas is challenging and a great deal of research has been done on the issues relating to the probability of detecting birds and the factors that can confound estimates of abundance and influence the quality (and reliability) of results. A widely used method is the 5-minute bird count and this has been adapted for Project Kākā. Point counts will be undertaken at 120 count stations in both treatment and non-treatment areas. Two point counts will be undertaken at each count station annually over consecutive days during November. (Weather constraints meant that pre-operational bird monitoring was done in November 2009 and after the treatment in December 2010.) Detailed protocols have been set around the timing and recording of bird song to increase the accuracy of results. In November each year, morepork calls will be recorded at 22 sites over a 7hr period from 7pm-2pm using an Olympus LS-10 digital recorder. Audio recordings using a portable audio recorder will also be used for quality control, to check on records made at point counts, and to better understand the relationship between human and digital recorders.

Additional efforts are underway to assess broad changes in the relative abundance and distribution of kākā, kākārīki, kererū and karearea (NZ falcon). These counts will be undertaken during bird counts and opportunistically throughout the year by DOC staff and interested members of the public in the Tararua Forest Park. They will record the number of these birds seen per number of observation hours, the number of kilometres they travelled and the locations of the sightings. Data will be entered into a data entry form on the back of Operation Kākā promotional sheets that will be available from huts, track ends and Department of Conservation Area Offices. These will contain detailed information about why the information is required and will explain the method.

This will be one of a number of opportunities for interested people and groups to get involved in the monitoring programme.

Monitoring invertebrates

There are number of methods to sample invertebrates including pitfall traps, malaise traps, and light traps. However the subsequent analysis required for these methods is costly and time intensive. Recent research in monitoring tree weta abundance using tracking tunnels and assessing relative abundance of tree weta and stick insects from faecal matter collected in seed-rain traps promised two cost effective means of assessing changes in the abundance of tree weta and stick insects over time and between sites. Tree weta and stick insects

are particularly sensitive to rodent predation, are found throughout most mainland forest ecosystems in New Zealand and are easily identified. They are therefore considered to be good indicators of the health of forest invertebrate communities.

Tracking cards collected for rodent monitoring will be analysed to determine changes in adult tree weta abundance as tree weta tracking rates have been shown to be closely correlated to adult tree weta density. In addition, seed-rain samples, which will be collected quarterly, will be analysed to determine the abundance of tree weta and stick insect faecal matter present in samples.

Monitoring plant communities

Project Kākā vegetation monitoring will focus on determining the effects of ungulate and possum browse on growth and mortality rates of plants palatable and unpalatable to possum and deer in kamahi-dominated forest plant communities in the Tararua Forest Park. More general information on plant community structure and composition will also be collected. (Changes in unpalatable plants serve as a 'non-treatment control' to the impacts of deer and possum impacts.)

Kamahi forest communities have been selected as the focus of Project Kākā vegetation monitoring because this forest type is widespread in the Tararua Range, is very well represented within the existing permanent plot network, and is vulnerable to possum and deer browse. Moreover, interest groups and conservation managers are concerned that increased ungulate and possum numbers in non-treatment areas could trigger rapid collapse of kamahi dominated forest in the Tararua Forest Park, similar to that which has occurred in Southern Ruahine and northern Tararua ranges.

New Zealand has a network of 20×20m permanent plots and reconnaissance descriptions that have been used for several decades to monitor forest structure and composition over time. The Project Kākā vegetation monitoring budget is sufficient to sample the forty 20×20 vegetation plots twice over ten years. There are already a number of 20×20 plots that have been set up in the Tararua Forest Park and 40 of these (20 in the treatment and 20 in the non-treatment areas) will be re-measured in 2010 and 2020 to extend the trend data information that already exists.

Two other approaches to monitor vegetation changes will also be used. Sixty paired 10×10 m plots on 24 randomly selected rodent/stoat transects will be established and measured and browse measurements made on tagged palatable and unpalatable seedlings, saplings and trees. Finally, twelve 10×10 m exclusion plots (paired with unfenced 10×10 plots) will be set up and measured, again including browse measurements of tagged palatable and unpalatable seedlings, saplings and trees.

These approaches will complement comprehensive information collected at a few sites using the standard 20×20m plot methods in which uncommon plant species (e.g. *Carpodetus serratus*, *Podocarpus cunninghamii*, *Raukawa simplex* etc) are present only in very low numbers, with a more expansive sampling regime using paired 10×10m plots.

Paired 10×10m plots have primarily been established to measure the impact of possums on forest canopy, but will also greatly increase the number of tagged and measured stems of plants palatable and unpalatable to possums or ungulates in all height classes. This will ensure that smaller changes in mortality and growth rates of these plants will be detected within the monitoring budget. Paired ungulate exclosure and control plots will help separate the impacts of possums and ungulates on forest structure and composition. These will also provide useful reference sites to determine the impact of ungulate browse

on seedling and sapling growth rates and mortality at current levels of abundance vs. zero abundance.

Monitoring seed-rain changes

To test if the abundance and distribution of target pest species (rats, and possums) and breeding of fruit-eating bird species (kākā, kākārīki, etc) are correlated with changes in seed-fall rates four seed-rain traps will be placed in each of the treatment and non-treatment areas under two rimu and two silver beech trees on north facing slopes or terraces. Seed-rain at each site will be collected to coincide with rodent monitoring and will be labelled with the date, tree coordinates, diameter breast height, and health score for the tree.