Conserving Fiordland’s biodiversity 1987–2015

The challenges, the achievements, the knowledge

Te Tiaki i te Taiao ki Tu Rua o te moko

Ngā wero, ngā haumāuiui, ngā mātauranga

Department of Conservation
Te Papa Atawhai

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FRONT COVER:
Looking north from Tamatea/Dusky Sound along the Acheron Passage. *Photo: Rob Suisted.*

BACK COVER:
DOC Biodiversity Ranger Megan Willans checks for translocated rock wrens on the summit of Kā-Tū-Waewae-o Tū/
Secretary Island, at the mouth of Doubtful Sound/Patea, January 2009. *Photo: Rod Morris.*

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A note from the compilers

The Department of Conservation Te Papa Atawhai (DOC) was formed in 1987 following the passing of the Conservation Act, which aimed to integrate some of the functions of the Department of Lands and Survey, Forest Service and Wildlife Service. In September 2013, DOC underwent major strategic and organisational changes, which transformed the way it operated, and the size and geographic boundaries of the areas that were previously known as 'conservancies'. As part of these changes, the boundary of the area administered from Te Anau shifted to take in all of Fiordland National Park, to form an area that is now referred to as 'Te Anau District'. This book covers the period from DOC's establishment in 1987 to September 2015 and includes information about the area that was previously administered by Te Anau Area Office as part of the former Southland Conservancy.

The material presented in this book has been sourced from written correspondence, unpublished reports and scientific papers, and represents the collective effort of a great many individuals. It is the story of conservation efforts in the field of biodiversity in Fiordland and the Te Anau Basin from 1987 to 2015, told by the conservation managers, research scientists and community conservation advocates who worked there. We have included the names of people from outside Te Anau or external to DOC who have contributed to this work. However, in general, we have not included the names of DOC staff based in Te Anau who have led the majority of this work, as they should be considered 'the authors'. That said, we would like to particularly thank the following individuals for their assistance in bringing this work together:

Chloe Corne, Dave Crouchley, Hannah Edmonds, Richard Ewans, Gerard Hill, Richard Kinsey, Sue Lake, Erina Loe, Andrew (Max) Smart and Megan Willans (Te Anau), and Graeme Elliott, Eric Edwards, Brian Rance, Moria Pryde, Colin O'Donnell and Jo Monks (Science and Policy Group, DOC) for providing text summaries for the various chapters; Martin Genet, Glen Greaves, Alistair Hay, Norm MacDonald, Pete McMurtrie, Em Oyston, Sanjay Thakur and Lindsay Wilson (Te Anau), Andrew Digby and Deidre Vercoe Scott (Invercargill), Peter Dilks, James Reardon, Carol West, Eduardo Villouta Stengl and Kerry Weston (Science and Policy Group, DOC), the late Ian Jamieson (University of Otago), Des Smith (Wildlands), Jen Brunton (MPI), Laura Harry (Fiordland Conservation Trust) and Viv Shaw (Pomona Island Charitable Trust) for providing additional input; Martin Sliva, Rod Morris, Rob Suisted, James Reardon, Graham Dainty, Barry Harcourt, Sabine Bernert, Chris Rance, Mark Sutton, Alan Mark, Richard Ewans, Jane Maxwell and DOC Te Anau staff for their photographic contributions and support; Dion Fabbro for creating the maps; and Fiona Moffat and Amanda Todd for valuable editorial advice. The foreword for this production was translated into Te Reo Māori by Melanie Nelson with input from Jane Davis and Tane Davis.

We also acknowledge the unfailing support and commitment of many individuals, groups and businesses who have contributed to the conservation management of Fiordland, the Eyre and Takitimu Mountains, and Mavora Lakes District. We cannot mention everyone by name and corporate/community partnership as this information is not readily available for all projects prior to 2006.

For ease of reading, we have omitted supporting references from this publication but have included references as footnotes where a report is directly referred to or a quote is provided. A full bibliography is available in digital format on the DOC website along with this book (www.doc.govt.nz/conserving-fiordland's-biodiversity). It was not possible to describe all of the scientific research that has been undertaken across the area in this publication as the studies are too numerous and the body of knowledge vast; however, an extensive list of these is included in the bibliography. We have also included a glossary of the scientific names of the plants and animals mentioned in this publication at the end of the report.

Kerri-Anne Edge Hill

Rebecca Reid

Foreword

When the legendary seafarer Tamatea, captain of the Takitimu waka, sailed around the Fiordland coast and discovered the fiords some 700 years ago, the natural environment would have looked very different from how it is today. Native wildlife would have filled the forests, coastal habitats and sea.

At that time, no introduced predatory or browsing pests were present. The arrival of people – both Māori and European – to Te Wai Pounamu/South Island was accompanied by the introduction of a range of foreign pests, which led to the extinction of many species and set the course of many others on a downward spiral. Fiordland's remoteness and sheer mountains proved no barrier – it took less than 20 years for stoats to invade Mauikatau/Resolution Island in 1900, following their liberation in Otago in the mid-1880s.

One by one, species disappeared from Fiordland. Some species, such as moa, native New Zealand thrush (piopio), bush wren (mātuhituhi) and tieke (South Island saddleback), went quite quickly, while others, such as little spotted kiwi, South Island kōkako, kākāpō and South Island brown teal (pāteke), held on until much later.

Today, several of the remaining species continue to decline in this region, and it is clear that without intervention, species such as takahē, kea, rock wren (tuke), kiwi, kākā, mohua (yellowhead), kakaruai (South Island robin), and bats (pekapeka) will disappear from the New Zealand mainland and perhaps into extinction.

This book outlines some of the work that has been carried out over the last three decades to try to halt this decline. Island pest eradication work, species reintroductions, marine protection and ecosystem restoration programmes have made a difference. Not everything tried has been successful, but the principle of taking a calculated risk and pushing boundaries has resulted in marked progress being made.

Much of this work has been a joint effort between Ngāi Tahu iwi through Te Rūnaka o Ōraka Aparima and the Department of Conservation. From the early days, this has been a productive Treaty Partnership, identifying projects that would make a real difference and then gaining support and funding for them. We hope that this summary will be well received and help to progress ecological restoration work throughout Aotearoa/New Zealand. We thank all those who have contributed to this publication both by writing excerpts and in carrying out the conservation work itself. The ancient whakataukī aptly describes our efforts:

I pā te ngaru ki uta, ka rerekē haere te whenua
Each wave breaking on the shore, alters the landscape slightly

Mrs Jane Davis
Kaumātua
Ngāi Tahu

Allan Munn
Conservation Services Director
Department of Conservation

March 2017

Kupu Whakataki

Nō tewā e 700 tau ki mua i haumiri ai te kaumoana rongonui a Tamatea, te kaiurungi o te waka Takitimu, i te ākau o Te Tūtae-o-Tūterakiwhānoa me tana whakatōmene i ngā tai matapiri,he tino rerekē te āhua o te taiao i tōna āhua o nāianei. I kapi ai ngā ngāhere, ngā nōhanga ākau, ngā moana i ngā manu, i ngā ika, i ngā aitanga pēpeke māori.

I taua wā, karekau ngā kararehe kino rāwaho i konei. I te taenga mai o te tangata Māori, o te tangata Pākehā anō hoki ki Te Wai Pounamu i kōkohutiamai ngā tini tūmomo kararehe rāwaho, nā tērā te korehāhātanga o ngā tini tūmomo māori, te tīmatanga hoki o te hekenga ihotanga o ngā tini tūmomo anō. Ehara te tawhiti, ngā maunga hūkere o Te Tūtae-o-Tūterakiwhānoa i te ārai – iti iho i te 20 tau te roa kia whakaeke ngā toriura i Mauikatau i te tau 1900, whai muri mai i te tukunga o ngā toriura ki Ōtākou i waenganui i te tekau tau 1880.

I ngaro takitahi ai ngā tūmomo māori i Te Tūtae-o-Tūterakiwhānoa. I tere ngaro atu ētahi tūmomo, pērā i te moa, i te piopio, i te mātuhituhi, i te tīeke o Te Wai Pounamu, ā, ko ētahi atu pērā i te kiwi pukupuku, i te kōkako o Te Wai Pounamu, i te kakāpō, i te pāteke o Te Wai Pounamu, i ū tonu ai mō te wā roa.

I tēnei wā, ko ētahi o ngā tūmomo e toe ana kei te heke haere tonu ki te takiwā nei, ā, he pūrangiaho te kitea, ki te kore te mahi whakahaere, ko ngā tūmomo pērā i te takahē, i te kea, i te tuke, i te kiwi, i te kākā, i te mohua, i te kakaruwai o Te Wai Pounamu, i te pekapeka, ka ngaro katoa atu i te tuawhenua o Aotearoa, ka ngaro korehāhā atu pea.

Kei te whakatakoto tēnei pukapuka i ētahi o ngā mahi kua mahia i ngā tau 30 ki mua hei ngana ki te whakatū i taua hekenga. Kua whai hua ngā mahi whakakore kararehe kino ki ngā motu, te whakahoki i ngā tūmomo māori, te tiaki i ngā moana, ngā hōtaka whakarauora pūnaha hauropi. Kāore i angitū te katoa o ngā mahi i whakamātauria, heoi anō nā te whai i te mātāpono kote whakaae i te tūraru kua whakaarohia, ko te kōpani i ngā ripa tauārai, kua tino kauneke whakamua.

Ko te nuinga o aua mahi he manawanui ngātahi i waenganui i te iwi o Ngāi Tahu mā Te Rūnaka o Ōraka Aparama me Te Papa Atawhai. Mai rā anō, he Rangapū Tiriti tōnui tēnei, e tohu ana i ngā kaupapa ka mātua whai hua, me te rapu tautoko, rapu pūtea hei whakatinana. Kei te tūmanako mātou ka rāhiritia tēnei whakarāpopototanga, ā, ka tautoko kia ahu whakamua ai ngā mahi whakarauora pūnaha hauropi puta noa i Aotearoa. Kei te mihi atu mātou ki ngā tāngata katoa kua tautoko i tēnei putanga nā te tuhi porohanga, nā te mahi hoki i ngā mahi atawhai taiao ake. E whakaahua tika ana te whakataukī tawhito nei i tō tātou manawanui:

I pā te ngaru ki uta, ka rerekē haere te whenua
Each wave breaking on the shore, alters the landscape slightly

Mrs Jane Davis
Kaumātua
Ngāi Tahu

Allan Munn
Conservation Services Director
Department of Conservation

Pou-tū-te-Rangi 2017

Fiordland, the southwest corner of Te Wāipounamu/South Island, contains some of the most dramatic natural landscapes seen anywhere in the world.

Looking north from Tamatea/Dusky Sound along the Acheron Passage with (L) Mauikatau/Resolution Island and (top R) Wet Jacket arm, with rātā in flower. ***Photo: Rob Suisted.***

Map 1. Fiordland National Park overview.

Fiordland – rugged and diverse

The southwest corner of Te Wāipounamu/South Island contains some of the most dramatic natural landscapes seen anywhere in the world. At 1,260,740 ha, Fiordland National Park is the largest national park in New Zealand and one of the largest in the world (Map 1).

Fiordland National Park forms part of the Te Wāhipounamu (the place of greenstone) - South West New Zealand World Heritage Area (2.6 million ha) listed in 1990. This World Heritage Area encompasses much of the southwest of the South Island, including Aoraki/Mount Cook, Tai Poutini/Westland, Fiordland and Mount Aspiring National Parks.

The Takitimu Mountains (forming the Takitimu Conservation Area) east of Fiordland National Park and southeast of Lake Manapouri are the most prominent mountains in Southland. Regarded by Māori as the upturned hull of the *Takitimu* canoe, these mountains can be seen from most parts of the Southland plains. The Mavora Lakes Conservation Park and Livingston Mountains extend to the north and are both included in Te Wāhipounamu.

Rugged glaciated mountain peaks dominate the Fiordland skyline. Steep-sided valleys, waterfalls, glacier-fed rivers and lakes and sheer rock faces that fall dramatically away into the deep waters of the fiords characterise this wild landscape. Fiordland contains hundreds of coastal and inland islands, ranging in size from small rock stacks to the impressive 20,860-ha Mauikatau/Resolution Island. Combined, the Fiordland islands have a land area of over 40,000 ha.

The region is renowned for its vast extent of natural flora and diverse and abundant wildlife. It is a stronghold for many of the less-common of New Zealand's endemic birds, bats and lizards. Indeed, new animal and plant species are still being discovered and previously unknown populations of threatened species identified. And there is just as much going on beneath the water. Wide recognition was given to the outstanding natural value of Fiordland's marine ecosystems in 2005 with the establishment of the Fiordland (Te Moana o Atawhenua) Marine Area (FMA), which extends from Awarua Point on the West Coast (just north of Big Bay) to Sandhill Point (western point of Te Waewae Bay), and 12 nautical miles out to sea.

When the Department of Conservation (DOC) was established in 1987, the Te Anau Area Office, within Southland Conservancy, became the centre for conservation management for Fiordland National Park, the northern Takitimu Mountains, Mavora Lakes and the Livingston Mountains. DOC's headquarters were (and

Looking over the cluster of islands near the entrance to Tamatea/Dusky Sound. Cook Channel and Long Island in the foreground, and Bowen Channel to Mauikatau/Resolution Island at right. Mamaku/Indian Island sits in front of Long Island and Pukenui/Anchor Island is out to the right with Taumoana/Five Fingers Peninsula beyond. *Photo: Rob Suisted*.

still are) located within the Te Anau township. There is also a field centre at Burwood Bush (near Te Anau), home of the takahē captive rearing programme. A team of seven permanent biodiversity staff was responsible for the protection and management of the district's public conservation land and the terrestrial and freshwater flora and fauna that inhabited the region.

The focus of biodiversity work in 1987 was wild animal control (deer in the Murchison Mountains and chamois in northeastern Fiordland), an early attempt at eradicating deer from Kā-Tū-Waewae-o Tū/Secretary Island in Doubtful Sound/Patea, island inventory monitoring, and species work with takahē and mohua (yellowheads). Searching was still underway for kākāpō in northern Fiordland after 'Richard Henry', the last known Fiordland kākāpō, was relocated from from Gulliver Valley to an island in 1975.

But all of that was about to change! The eradication of Norway rats from Te Au Moana/Breaksea Island (170 ha) in 1987 attracted international attention as a world first in island pest eradication programmes. This project, hugely ambitious at the time, was the beginning of a period of intense biodiversity research and management in Southland Conservancy that has been hugely influential for conservation in the rest of New Zealand and elsewhere.

In 2013, following a major restructuring of DOC, conservancies (including Southland) were disestablished. Boundaries shifted and most of what was Fiordland National Park became Te Anau District, with the inclusion of Waitutu Forest. This book summarises the work done under the auspices of Southland Conservancy. For consistency and simplicity, the geographic scope of the book retains the pre-2013 boundaries but covers the period from 1987 to 2015.

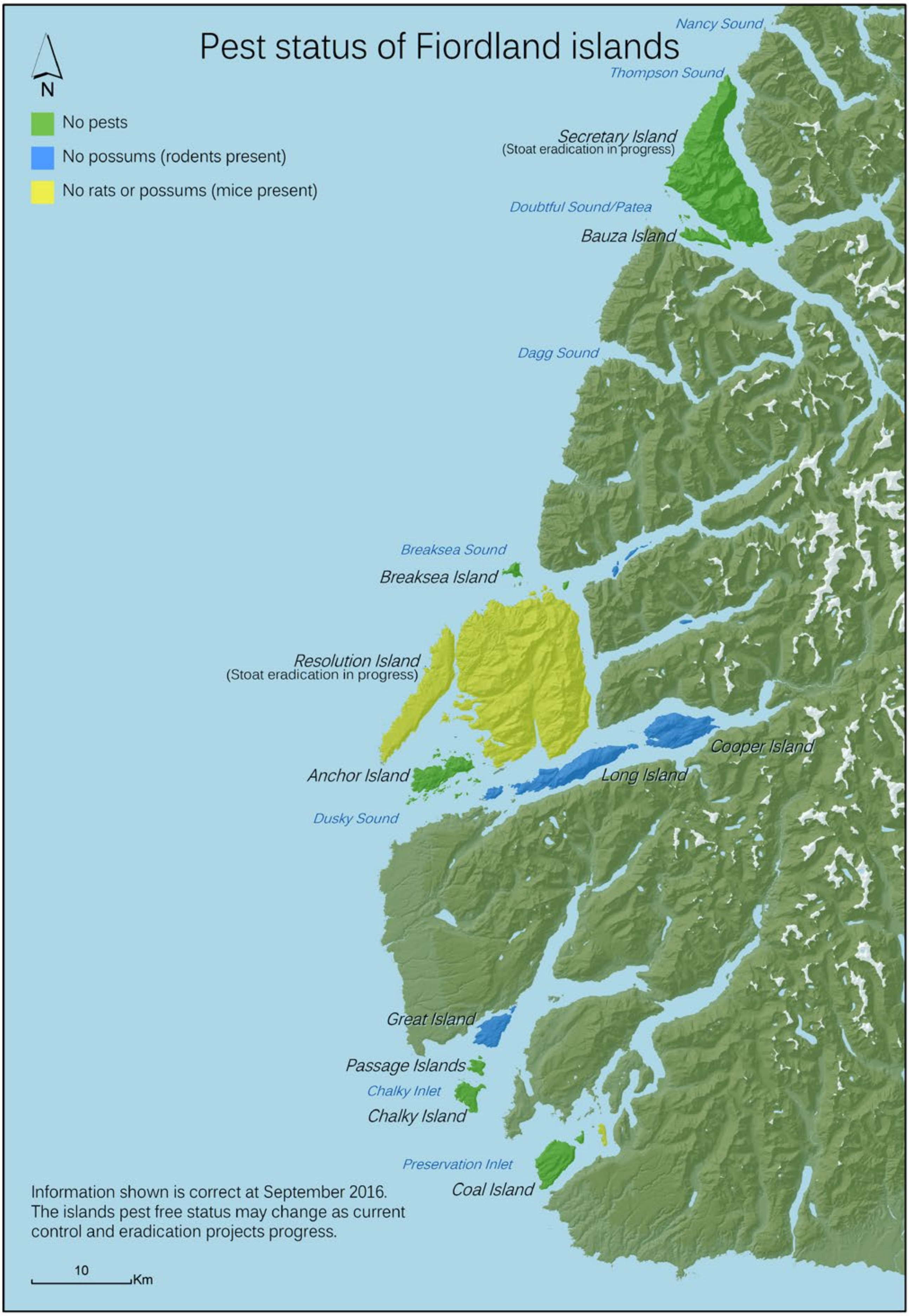
In 2016, DOC's Te Anau District had 51 permanent staff, including 15 biodiversity staff. However, conservation effort extends far beyond what this team manages and delivers, with significant contributions now made by community trusts, national (often corporate) and small business partners, schools and extremely motivated individuals.

Long may these cooperative conservation efforts continue to sustain Fiordland's precious places and species!

Dogs and hunters being dropped off on Kā-Tū-Waewae-o Tū/Secretary Island. *Photo: DOC.*

The general approach for island pest eradications is to develop successful techniques on small islands and then scale them up for progressively larger islands.

DOC Biodiversity Ranger Pete McMurtrie establishing track and trap lines on Kā-Tū-Waewae-o Tū/Secretary Island, 2005. *Photo: Graham Dainty.*



Map 2. Pest status of Fiordland Islands.

Island pest eradications

Integrated biodiversity management is often more cost effective on islands than on the mainland due to the lower numbers and types of pests present, and lower reinvasion rates. Therefore, pest-free islands are considered convenient and safe refuges for many of New Zealand's threatened species – and large pest-free islands are of particular importance as they have the potential to hold large, self-sustaining populations of these species (Map 2).

The value of pest-free islands

Rats, mice and brushtail possums have never been present on some of the islands in Fiordland. Kā-Tū-Waewae-o Tū/Secretary Island (8140 ha), at the entrance to Doubtful Sound/Patea, is one such place and is particularly noteworthy for its diversity of large invertebrates, which include the knobbled weevil – a giant alpine weevil (*Lyperobius* sp.), cave wētā (family Raphidophoridae), a tunnelweb spider (*Hexathele* or *Porrhothele* sp.) and a giant land snail (*Powelliphanta fiordlandica*), with the later being first recorded on Kā-Tū-Waewae-o Tū/Secretary Island in 2007. The Fiordland skink (*Oligosoma acrinasum*) is also present. Kā-Tū-Waewae-o Tū/Secretary Island is the second largest island on the Fiordland coast and the third highest island in New Zealand (1196 m). It is one of only two islands in New Zealand of significant size that has never had rodents present – the other being Adams Island in the subantarctic Auckland Island group. In 2004, the enormous potential for pest eradication and restoration on both Kā-Tū-Waewae-o Tū/Secretary and Mauikatau/Resolution Islands was recognised by the New Zealand Government, which allocated NZ$7.1 million over 10 years to eradicate stoats and deer from them.

Kā-Tū-Waewae-o Tū/Secretary Island. *Photo: Graham Dainty*.

Given the number of islands in Fiordland, it is hardly surprising that this region has a long and particularly noteworthy association with island pest eradication and restoration projects. Shortly after DOC was formed, it successfully carried out the first ever eradication of rats from a large island, removing Norway rats from 170-ha Te Au Moana/Breaksea Island using ground-based baiting methods in 1988. This operation followed the success of a pilot campaign on the adjacent and much smaller Hāwea

Te Au Moana/Breaksea Island at the entrance to Te Puaitaha/Breaksea Sound. On islands such as Te Au Moana/Breaksea, Te Kākāhu-o-Tamatea/Chalky and Pukenui/Anchor, the removal of pest species has resulted in whole-ecosystem benefits, including increased forest health and the re-introduction of threatened bird species such as kākāpō and tīeke. *Photo: Barry Harcourt*.

Island (9 ha) in 1986, and gave DOC an international reputation for pioneering single-species (rodent) eradications on remote islands. Between 1987 and 2015, over 14 additional islands with a total area of more than 31,000 ha were targeted for pest eradication in Fiordland, along with many smaller 'stepping stone' islands that were included for monitoring and control purposes.

True eradication is defined as the complete removal of a pest species with zero chance of reinvasion. For some programmes, the eradication rule of zero reinvasion risk has not been met and so the programme objectives have had to be revised to fit with the currently available pest

A Norway rat taking bait from a station on Te Au Moana/Breaksea Island, during the successful rat eradication programme in 1988. *Photo: Rod Morris*.

Island approach to pest eradication

The general approach for island pest eradications is to develop successful techniques on small islands and then scale them up for progressively larger islands.

Rats and mice DOC has developed best-practice techniques for rat and mouse eradications which have since been used throughout the world. The mouse eradication operation on Te Puka-Hereka/Coal Island (1163 ha) in Fiordland in 2008 was, at the time, the largest ever attempted. It has since been surpassed by Australia's Macquarie Island (12,780 ha), which was declared pest-free in 2014.

Deer and stoats Techniques for deer and stoat eradication are still being developed. The first stoat eradication was conducted on Te Kākāhu-o-Tamatea/Chalky Island (514 ha) in 1999, and this programme was then successfully scaled up for Pukenui/Anchor Island (1130 ha) in 2001 and Te Puka-Hereka/Coal Island (1163 ha) in 2005. Red deer were successfully eliminated from Pukenui/Anchor Island between 2002 and 2007 by ground hunters using hunting dogs to detect the deer. The hunters initially worked independently but switched to team hunting after 2 years. Other techniques have also been trialled on Pukenui/Anchor Island, including remote monitoring of deer capture pens and self-attaching radio collars. These techniques have been further developed on Secretary Island with mixed success, along with additional technological advancements, including the use of high-definition remote trail cameras, superior 'hybrid' hand-held GPS/radio technology, and the identification of individual deer using DNA from fresh deer faecal pellets – a technique that has only been available since 2011. The current deer programme on Kā-Tū-Waewae-o Tū/Secretary Island largely uses a combination of helicopter and ground hunting (including teams) with dogs.

VHF radio tracking collar fitted to a deer in 2009. *Photo: DOC.*

Hunting indicator dogs with a deer on Kā-Tū-Waewae-o Tū/Secretary Island, 2014. *Photo: DOC.*

management methods. For islands where reinvasion is likely or ongoing it is more appropriate to use control to zero-density as the objective for the target pest. Control to zero-density is a state where a pest population has been reduced to such low numbers that it is no longer detectable. This objective recognises the fact that reinvasion is certain and so ongoing management to remove invaders is essential.

Operations in Fiordland have targeted stoats, red deer, Norway rats, mice and Australian brushtail possums. Where achievable, the desired outcome for each of these pest species has been eradication, and long-term control has also been established to reduce the likelihood of reinvasion. With the further development of control techniques over time, it has become increasingly possible to target larger islands with more complex terrain that are in closer proximity to the mainland – and thus have a greater risk of reinvasion.

Deer eradication programmes

Introduced red deer colonised islands in Fiordland in the last 50 years. Due to their good swimming abilities, they have reached all but the outermost islands of Te Au Moana/Breaksea and Te Kākāhu-o-Tamatea/Chalky Island as their numbers have increased.

The large numbers of red deer on Kā-Tū-Waewae-o Tū/Secretary and Mauikatau/Resolution Islands have caused significant changes in the composition and structure of the forest understorey (see *Flora and vegetation monitoring* – chapter 5). Deer preferentially feed on species such as broadleaf, māhoe, kāmahi, five-finger and hen and chickens fern; and in alpine areas, they have selectively grazed on large herbaceous plants, some species of which are now absent. Deer also deplete the forest litter layer, making it low in nitrogen

Richard Ewans with a red deer stag shot near Te Ra/Dagg Sound, Fiordland, 2012. *Photo: Richard Ewans.*

Red deer grazing on Kā-Tū-Waewae-o Tū/Secretary Island. This photo was snapped by one of DOC's trail cameras, set up on the island to aid in the deer eradication project. *Photo: DOC remote camera.*

and high in lignin, which has led to a dramatic decline in invertebrate populations that rely on the forest litter for shelter and food; and they browse on the host plants of some invertebrates (see *Invertebrates* – chapter 5).

The deer eradication programme on Pukenui/Anchor Island ran from 2002 to 2007, with eradication achieved in 2006. Surprisingly, given its proximity to the mainland, this island has remained deer-free since. Two very ambitious deer eradication programmes were also established on Kā-Tū-Waewae-o Tū/Secretary and Mauikatau/Resolution Islands in 2006 and 2009, respectively. The DOC project team worked collaboratively with DOC's Islands Eradication Advisory Group (IEAG), expert hunters and staff from Landcare Research (Graham Nugent and Andrea Byrom) and its commercial DNA-based diagnostic lab EcoGene (Dianne Gleeson and Frank Molinia) to develop an operational plan for both islands. This collaborative approach ensured that the programme was supported by a range of expert knowledge.

The programme on Kā-Tū-Waewae-o Tū/Secretary Island met with initial success, with an estimated 80% of the deer population removed within the planned 2-year timeframe for population knockdown – and initial fears that deer would continually reinvade Kā-Tū-Waewae-o Tū/Secretary Island and compromise eradication efforts were not realised. DNA analysis of deer that were shot on the island and the adjacent mainland indicated that only a very small number of hinds originally arrived on the island and also suggested zero-immigration during the period November 2006 to June 2013. However, despite these achievements, a small population of deer still persisted on Kā-Tū-Waewae-o Tū/Secretary Island in June 2012. Therefore, the project team commissioned Graham Nugent and Cecilia Arienti-Latham of Landcare Research to construct simple eradication and harvest models for the deer population.

Using hunting data and information about the age and sex of each deer shot, Graham and Cecilia were able to assess patterns or trends in deer population size, reproductive rates and kill rates. This not only enabled them to estimate the likely cost of achieving eradication on Kā-Tū-Waewae-o Tū/Secretary Island, but also informed the planning and implementation of other similar deer eradication programmes, most notably on Mauikatau/Resolution Island. They concluded that it would be possible to eradicate deer from Kā-Tū-Waewae-o Tū/Secretary Island using current methods, and so a decision needed to be made on whether to make a final push to achieve eradication within a single year, or to spread the final effort over 2 or 3 years.

In early 2013, a team of ground hunters and their indicating dogs grid searched all accessible parts of Kā-Tū-Waewae-o Tū/Secretary Island to assess the number and distribution of deer. They estimated the population at 14 individuals. It was clear that these remaining deer had become extremely wary and adept at avoiding hunters, dogs and helicopters. Extreme weather, acute topography and the regeneration of the island's understorey gave the remaining deer a significant advantage over hunters. However, no other eradication tools were currently available, and so the only option for eliminating these last deer was to hunt them more effectively.

The revised objective was to reduce the red deer population on the island to 'zero detectable density' within 12 months in acknowledgement of the slight but real risk of reinvasion. Helicopter-assisted team hunting with a combination of indicating and chasing dogs was used to quickly locate and eliminate deer. The DNA profiles of all animals shot and any fresh deer sign (faecal pellets) found was used to determine the familial relationships between deer. In September 2014 there was thought to be only one male deer remaining on the island. In August 2015 an exhaustive search of the island by 12 hunters over 9 days showed no recent sign of deer on the island. The project team are confident that their goal has been achieved and that no deer were present on the island during the time of the last search.

The decision to completely remove the deer population from Kā-Tū-Waewae-o Tū/Secretary Island has been subject to considerable scrutiny and rigour. For this kind of project to be successful, the team of highly skilled hunters, and the technical experts in the field of DNA-

DOC ground-hunting team with a hind on Kā-Tū-Waewae-o Tū/Secretary Island, June 2013. *Photo: DOC.*

A helicopter flies above Secretary Lake on Kā-Tū-Waewae-o Tū/Secretary Island as part of DOC operations, 2005. *Photo: Graham Dainty.*

DOC's Kā-Tū-Waewae-o Tū/Secretary Island hunting team with a stag, 2014. L to R: Puni Tiakiwai, John Clark, Pat Dawson, Robert Tiakiwai, Jordan Munn, Norm MacDonald, Ben Crouchley, Chino Apiata and Dan Harrison. *Photo: DOC.*

based diagnostics and population modelling must be engaged in the process from the outset. The project has now shifted to a monitoring phase using grid searching of the island every 3 years and a network of trail cameras. Any fresh deer sign reported will be immediately followed up using the previously mentioned team-hunting method.

On Mauikatau/Resolution Island, red deer were being removed using a traditional hunting approach that previously worked well for deer suppression in the Murchison Mountains in mainland Fiordland. However, although this programme has succeeded in reducing the deer population, some of the remaining deer are extremely wary of ground and helicopter hunting techniques. Further, the reduction in the number of deer has also led to regeneration of the forest understorey, which will likely hamper future efforts to eradicate the remaining animals using this approach.

In late 2013, two options were considered by DOC for the deer programme on Mauikatau/Resolution Island:

- Continue with the current hunting philosophy and alter the goal of the Mauikatau/Resolution eradication project to 'control to low densities'; or
- If eradication is still the favoured option, take steps to optimise the chances of successfully killing the last deer and remove any risks that are inherent in the current approach.

Critical to this evaluation was consideration of the significant up-front investment that would be required to achieve eradication, together with the cost of ongoing surveillance. However, in the medium term (20–50 years), this investment would be minor compared with the cost in perpetuity of a control programme where deer are suppressed to the desired level. Taking into account the moderately sized population of deer that is currently on Mauikatau/Resolution Island, an ongoing control programme would still require a significant investment in the short term. Furthermore, once deer have been reduced to very low levels, their population would need to be monitored and further control efforts pulsed every few years as required, which would probably equate to greater maintenance effort than the surveillance costs associated with maintaining a state of eradication (or control to zero-density if immigration were to become an issue for the island). Hunter effort may also need to increase over time as the understorey will rapidly increase in density once the pressure of browsing animals has been removed, which will reduce the efficacy of control techniques. Therefore, ongoing control is not necessarily a cheaper option than investing in and then maintaining a state of eradication once a medium-term financial horizon is determined.

The project team are now considering two further options in addition to those outlined in 2013, including high-level control in the alpine zone of the island and/or control to zero density on Taumoana/Five-fingers Peninsula (3500 ha) on the west of the island, with a buffer zone where deer are controlled on main Mauikatau/Resolution Island.

Mauikatau/Resolution Island. *Photo: Richard Kinsey.*

Stoat eradication programmes

Stoats were first introduced to mainland New Zealand in the late 1880s in response to feral rabbit plagues that were destroying pasturelands and posing a serious threat to the New Zealand economy. Stoats are very mobile and are capable swimmers. They were first observed by Richard Henry, curator on Mauikatau/Resolution Island, in 1900 and probably invaded other remote islands in Fiordland (including Kā-Tū-Waewae-o Tū/Secretary Island) at around the same time.

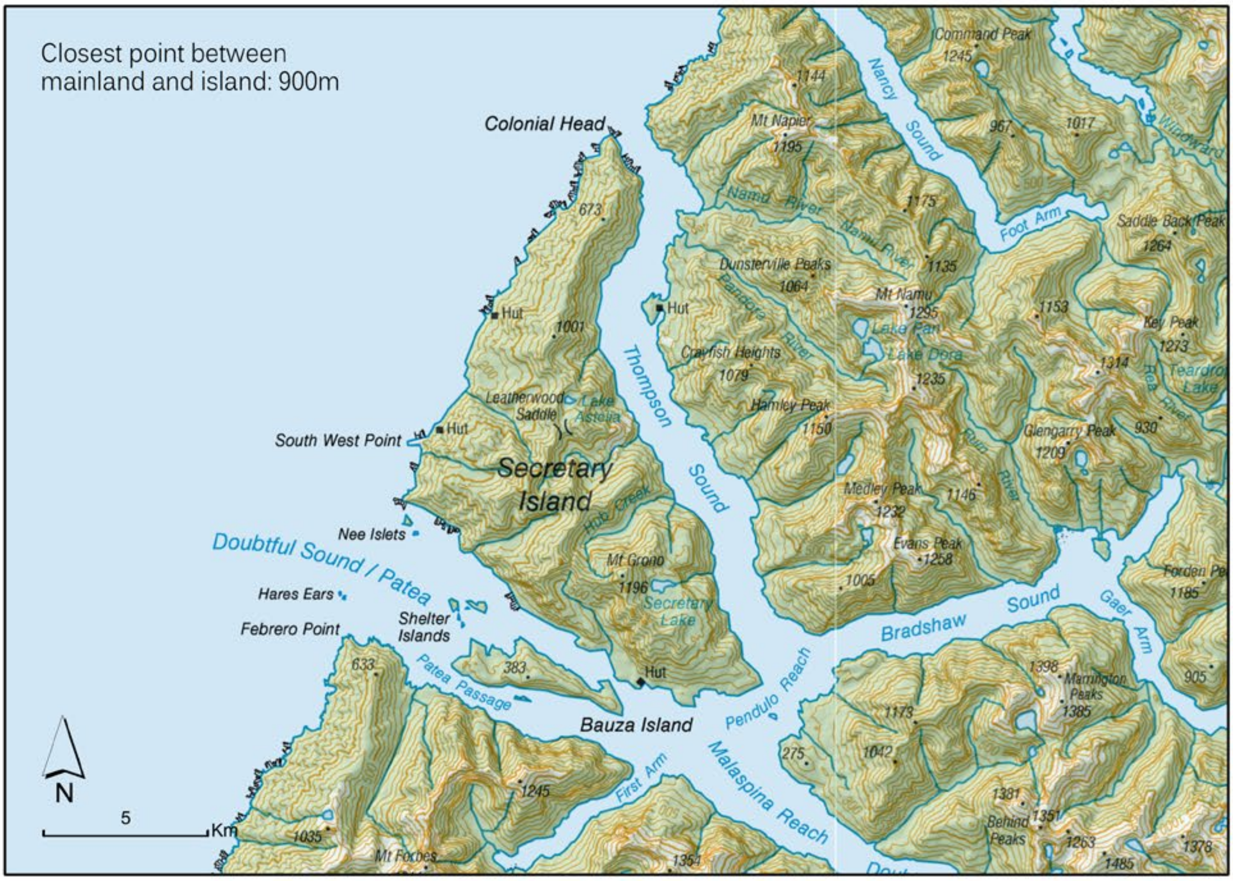
The first ever successful eradication of stoats from an island was conducted on Te Kākāhu-o-Tamatea/ Chalky Island (514 ha) in 1999. In 2000, realising the potential to eradicate stoats from much larger islands in Fiordland, DOC Biodiversity staff in Te Anau and DOC scientist Graeme Elliott initiated a study measuring stoat immigration rates to islands in Fiordland. Stoats were trapped on 19 islands ranging in size from 1 ha to 67 ha and within varying distances from the mainland over a 4-year period in order to produce a predictive model of stoat reinvasion. Of 46 stoats captured, only one was caught on an island further than 304 m offshore. Based on these results, Graeme and the team concluded that large islands such as Kā-Tū-Waewae-o Tū/Secretary and Mauikatau/Resolution would be suitable for stoat eradication attempts.

The project team worked with members of the IEAG, Elaine Murphy (DOC scientist), Darren Peters (DOC technical advisor), and staff from Landcare Research (Andrea Byrom, Dean Anderson and Richard Clayton) and EcoGene (Dianne Gleeson) to develop operational plans for both islands and to ensure that the programme was supported by robust scientific methodology. Work to establish the necessary infrastructure of tracks, traps and bivvies commenced on Kā-Tū-Waewae-o Tū/ Secretary Island in 2004 and on Mauikatau/Resolution Island in 2007, with the initial knockdown of stoats in

The significance of Mauikatau/ Resolution Island

Mauikatau/Resolution Island was gazetted as one of the world's first 'reserves' in 1891. Richard Henry considered islands to be beyond the reach of stoat invasion and so transferred 572 birds (mostly kiwi and kākāpō) to the island sanctuary. However, stoats are competent swimmers and had invaded many of the remote coastal islands of Fiordland only 6 years after their introduction to New Zealand. By 1900, Henry confirmed the worst when he observed a stoat on the island.

Richard Henry (1845-1929) outside his boatshed on Pigeon Island, Tamatea/Dusky Sound, c. 1900. *Photo: DOC Collection.*



Map 3. Distance swam by stoats to Kā-Tū-Waewae-o Tū/Secretary Island and Mauikatau/Resolution Island. The minimum stoat-swimming distance between Kā-Tū-Waewae-o Tū/Secretary Island and the mainland is 900 m across Thompson Sound or 630 m from the mainland to Bauza Island then 550 m across to Shelter Islands and a further 215 m to Kā-Tū-Waewae-o Tū/Secretary Island. For Mauikatau/Resolution Island the minimum distance to the mainland is 550 m across Acheron Passage. Research work lead by Graeme Elliott predicted that stoats would be very unlikely to swim beyond 300 m. This prediction, based on small islands in Fiordland, was not found to hold for these larger islands with long stretches of coastline adjacent to the mainland.

the winters of 2005 and 2008, respectively. Regular reviews were undertaken to assess progress against the programme objectives, to consider the current approach and methodology, and to determine whether the original eradication objective was still appropriate. At that time traps were checked and re-baited three times per year.

Stoats are now controlled to very low levels on both islands, but unfortunately the original goal of full and sustained eradication has not been achieved on either island due to continued immigration, and failure to intercept all resident and immigrant stoats prior to territory establishment and breeding. Fundamentally, stoat reinvasion of both islands is more frequent than either the stoat immigration model or previous experience predicted. DNA analysis of stoats captured on Kā-Tū-Waewae-o Tū/Secretary and Mauikatau/Resolution Islands and in the adjacent areas of mainland since the commencement of the programmes indicates that a small number of stoats swim to these islands during most summers, with increased numbers following rodent plague years (i.e. 8 or more individuals in plague years). Consequently, the current operation is effectively maintaining stoats at very low densities by trapping the offspring of 'hard-to-trap' stoats and most, but not all, invaders.

This moderate-cost management regime appears to be sufficient to sustain species of animals whose populations have some tolerance to low levels of stoat predation. For example, some fauna are responding positively to the low numbers of stoats on Kā-Tū-Waewae-o Tū/Secretary and Mauikatau/Resolution islands, including populations

A stoat trap and tunnel in Kā-Tū-Waewae-o Tū/Secretary Island forest. *Photo: Graham Dainty.*

Can we eradicate stoats?

Despite the intensive control programmes, very small populations of stoats appear to have persisted on Kā-Tū-Waewae-o Tū/Secretary and Mauikatau/Resolution Islands, based on trap capture data, stoat footprints and scats, and trail camera footage. A highly successful collaboration between DOC staff, Landcare Research, EcoGene and the University of Auckland has greatly informed the progress of these eradication campaigns. This partnership, supported by DOC's Islands Eradication Advisory Group (IEAG), has enabled the project management team to re-evaluate the programme's objectives and develop a fit-for-purpose operational plan for stoats on both islands for the next 3–5 years.

Dianne Gleeson (EcoGene) and Andrew Veale (PhD student, University of Auckland) analysed DNA from stoats captured on both Islands and adjacent areas of the mainland, Andrew estimated the age of trapped stoats by counting cementum (tooth enamel) layers on their teeth. It appears that these small, remnant populations are made up of new invaders, descendants of the original population that evaded capture for several years, and the offspring of both.

Genevieve Taylor resets a trap after successfully bagging one more stoat on Kā-Tū-Waewae-o Tū/ Secretary Island. *Photo: Graham Dainty.*

Predictive modelling led by Dean Anderson and Andrea Byrom (Landcare Research) has confirmed that the eradication of stoats from Mauikatau/Resolution Island is not achievable under the current management regime. The objectives of eradication or control to zero-density both require a substantial increase in effort to reduce immigration, and an ability to increase the capture rate of female stoats in particular. However, Mauikatau/Resolution Island stoats are highly productive and the residual population appears to have a strong female bias of 3:1, meaning that a reduction in trapping effort may result in higher stoat numbers and cessation of the stoat project would result in a return to pre-control stoat densities within 2–3 years. The Kā-Tū-Waewae-o Tū/Secretary Island stoat population has not yet been modelled in the same way as the Mauikatau/Resolution population, but the sex ratio of the original population was also female biased (2:1), so it is expected that the consequences of reducing or halting trapping effort would be similar.

DOC Ranger Jane Tansell and Koha on Kā-Tū-Waewae-o Tū/Secretary Island during the first kōkako release in 2008. Koha's role was to sniff out any evidence of stoats in a bid to ensure the island was pest free. *Photo: DOC.*

DOC Biodiversity Ranger Pete McMurtrie weighs a stoat caught during the stoat 'knock down' on Kā-Tū-Waewae-o Tū/Secretary Island, 2005. *Photo: Graham Dainty.*

of Fiordland skinks, weka, bellbirds (korimako) and kākā on Kā-Tū-Waewae-o Tū/Secretary Island and rock wrens (tuke) on Mauikatau/Resolution Island. Several threatened species have also been successfully reintroduced to these islands – most notably rock wrens and mohua on Kā-Tū-Waewae-o Tū/Secretary Island, and mohua on Mauikatau/Resolution Island (see chapter 3). However, this level of control may not be sufficient to enable the successful reintroduction of tīeke or strong recovery and recruitment of kiwi species to these islands, and would not be adequate for translocated kākāpō or New Zealand snipe to persist. North Island kōkako were translocated to Kā-Tū-Waewae-o Tū/Secretary Island over 2 years from 2008 to 2009. Individual kōkako were known to survive and breed on the island, but have subsequently failed to establish (see chapter 3). The reason for this failure is unknown, but it is impossible to ignore the elevated number of stoats caught on the island subsequent to the birds' release.

In 2013 it was concluded that a status-quo approach to the management of stoats on these islands would not achieve eradiction. Nor would it result in control to zero-density, as a small proportion of stoats will continue to remain untrapped. The revised (2015–19) programme objectives for both islands are:

- To achieve and maintain zero-density stoat populations on Kā-Tū-Waewae-o Tū/Secretary and Mauikatau/Resolution Islands by 2019 (i.e. the removal of all known resident stoats on the island and the elimination of invaders before breeding occurs).
- To maintain and improve biosecurity measures to prevent incursions of rodents on Kā-Tū-Waewae-o Tū/Secretary Island and rats on Mauikatau/Resolution Island (which already has mice).

This revised objective for stoats will be achieved by intensifying stoat control in nearby sites on the mainland. This may include the trialling of aerially applied 1080 baits for rats (with the intention of controlling stoats via secondary poisoning from eating the poisoned rats) in winters following observed beech mast events in mainland areas adjacent to Mauikatau/Resolution Island (if rats are predicted to reach a predetermined target of 30% tracking by the month of December). Alternative methods for targeting resident stoats are also to be trialled on Kā-Tū-Waewae-o Tū/Secretary Island. These include a combination of four new trapping and baiting methods (using the current DOC 150™ series traps) that can be integrated into the programme without the need for further developments in technology. The island traps are now serviced four times per year, rather than three, to ensure that fresh bait is available at the most critical times.

The future of island pest eradication programmes in Fiordland

Restoration planning is currently in place for Kā-Tū-Waewae-o Tū/Secretary and Bauza Islands in Doubtful Sound/Patea, all islands within the Tamatea/Dusky Sound Project Area, Te Kākāhu-o-Tamatea/Chalky Island in Chalky Inlet, and the community-led programmes on Pomona and Rona Islands on Lake Manapouri and Te Puka-Hereka/Coal Island in Preservation Inlet. The Tamatea/Dusky Sound project area encompasses all of the terrestrial and marine ecosystems within Tamatea/ Dusky Sound, Te Puaitaha/Breaksea Sound, Wet Jacket Arm and Acheron Passage, including important mainland buffer zones that have intrinsic values, provide additional high-quality habitat, and will enhance the protection of established or proposed pest control areas. The aim of this plan is to provide a strategic assessment of where to direct conservation effort in Tamatea/Dusky Sound and to deliver a coordinated approach to all of the island work in Southern Fiordland. Individuals and corporate businesses (e.g. Te Puka Hereka Trust on Te Puka-Hereka/Coal Island and Fiordland Conservation Trust on Mamaku/Indian Island) have already made a significant commitment to conservation work in this region (supported by local and national funding; see chapter 3), but this plan provides a localised strategic and organised way to respond to opportunities for external funding.

Managing the re-invasion of pests on near-shore and accessible islands in Fiordland (e.g. stoats to Kā-Tū-Waewae-o Tū/Secretary and Mauikatau/Resolution Islands, rats to Pomona and Mamaku/Indian Islands and mice to Rona Island) remains a significant challenge for everyone. There is also an urgent requirement for new and effective 'field-ready' tools for eliminating hard-to-trap stoats in large areas with inaccessible terrain (see *Management of possums, stoats and rats* – chapter 4). To mitigate the risks associated with terrestrial incursions, there needs to be a greater coordinated effort across government agencies – e.g. around the provision of advice on the special conditions attached to Surface Water Resource Consents for coastal operators in Fiordland. An interagency approach is working extremely well in the marine environment and so may provide some tools to address this issue.

Catching trap-averse stoats

Some of the few remaining stoats on Kā-Tū-Waewae-o Tū/Secretary and Mauikatau/Resolution Islands are now actively avoiding trap tunnels – a male stoat on Kā-Tū-Waewae-o Tū/Secretary Island that was a 1-year-old at the time of the original knockdown avoided capture for 4 years and fathered two litters before eventually being caught in 2008. The extremely difficult terrain on these islands also means that female stoats (which have smaller home ranges than males) may never encounter a trap. New tools, including stoat lures and self-resetting traps, are currently being developed to help tackle this problem, but in the meantime DOC staff are working to increase the possibility of stoats encountering traps by creating trap 'stab lines' that access the most inaccessible areas, which cannot be included in trap circuits. Run-through tunnels (open-ended with no bait) and natural scent lures placed inside standard tunnels have also been used. All methods have had some success, but appear still to be capturing only young (less than 1-year-old), inexperienced animals.

The TUN200, Zero Invasive Predator's (ZIP'S) prototype 'best practice' tool for stoats, is an example of new deveopments in technology targeting stoats. It houses two DOC 200™ traps in a 'tunnel' structure and is presently being trialed with a range of lures for both rats and stoats as well as automated reporting and lure dispensing to reduce the labour associated with servicing (see the auto-reporting 'node' on top of the box in the photo). *Photo: Rory Harnden.*

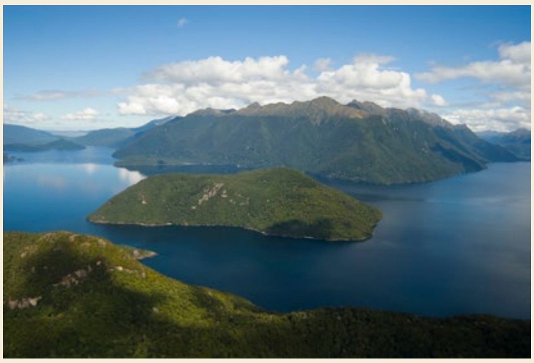
Managing the re-invasion of rodents on Rona and Pomona Islands, Lake Manapouri

Pomona (262 ha) and Rona (62 ha) are islands within Lake Manapouri. The Pomona Island Charitable Trust was successful in eradicating five pest species from Pomona Island – stoats, ship rats, deer, mice and possums – over 2 years from 2006 to 2007. Nearby Rona Island (62 ha) was targeted for mice by the Trust at the same time, and both islands were declared predator free in 2009. However, later in 2009 a single mouse was trapped in a rodent motel on each island and despite extensive trapping a mouse population had re-established on Pomona Island by 2010. Small numbers of mice were detected on Rona Island in 2012 and despite the Trust's best efforts, mouse tracks were recorded in 100% of rodent tracking tunnels deployed across the island in 2014.

Viv Shaw with rat, Pomona Island. *Photo: Chris Shaw.*

Rona Island was being used as a predator-free crèche site for chicks of the critically endangered Haast tokoeka and the presence of mice caused the Kiwi Recovery Group to express concern at the island's ongoing suitability for this purpose. A report on mouse eradication versus control for the island was prepared by Viv Shaw and released by the Trust in 2015. The preference was to eradicate mice using ground-based methods; however, limited resources prevented a one-off eradication and the number of bait stations across the island was scaled back and the programme became one of on-going control. A 25 m × 50 m bait station grid (464 bait stations) was established alongside a network of 42 rodent tracking tunnels. At this time, mice were tracking at 23.8% (using DOC best practice with tracking cards in situ for one night). After two fills of the bait stations with the poison bait brodifacoum, mice were tracking at 0%. In March 2016, after tracking cards had been in the tracking tunnels continuously for 158 nights, mice were still tracking at 0%. It is conceivable that there are presently no mice on Rona Island, making the outcome of the 'control' programme quite remarkable. This was the first time in New Zealand that a ground-based control programme for mice was carried out on an island of Rona's size. Haast tokoeka were due to return in early May 2016.

Rat paw prints were found in a tracking tunnel on Pomona Island in 2010 and a rat was trapped shortly after. By 2011 a small number of rats had been trapped and DNA testing of these rats suggested that a breeding population had established. In late 2012 the Trust established an extensive bait station and trap network aimed at eradicating rats. This was extended in August 2013 and currently comprises 179 stations using Pindone baits and 172 trap sites on a 100 m × 100 m grid. Trapping peaked at 220 rats in spring 2013 and then dropped to no captures in spring 2015 and has subsequently continued at this level.



Pomona Island. *Photo: Graham Dainty.*

Reducing rats to undetectable levels on Pomona Island has been beneficial for the robins and mohua traslocated to the island. Mohua survived the rat re-invasion and appear to be doing well.

This work on Pomona and Rona islands has been possible because of the huge support received from the community, both financially and in terms of the volunteers involved. In July 2015 the Pomona Island Charitable Trust celebrated its tenth birthday. During that 10-year period more than 350 volunteers have put in almost 12,000 hours of work on the two islands.

DOC-led eradication programmes in Fiordland

Completed

- Norway rats (Hāwea Island, 8 ha, 1986; Te Au Moana/Breaksea Island, 170 ha, 1988).
- Stoats (Te Kākāhu-o-Tamatea/Chalky Island, 514 ha, 1999; Passage Islands, 189 ha, 1999; Pukenui/Anchor Island, 1130 ha, 2001; Bauza Island, 480 ha, 2002; Pigeon and Parrot Islands, 126 ha, 2005).
- Red deer (Pukenui/Anchor Island, 2002–07; Kā-Tū-Waewae-o Tū/Secretary Island, 8140 ha, 2006–2015).

Still underway

- Stoats (Kā-Tū-Waewae-o Tū/Secretary Island, 2005–; Mauikatau/Resolution Island, 20,860 ha, 2008).
- Red deer (Tau Moana/Resolution Island, 2009, on hold 2013).

NGO/community-led programmes

- Stoats (Te Puka-Hereka/Coal Island*, 1163 ha, 2005; Pomona Island†, 262 ha, 2006; Rona Island†, 60 ha, 2006).
- Red deer (Pomona Island†, 2006–07; Coal Island, initiated in 2006).
- Mice (Rona Island†, 2006; Pomona Island†, 2007; Te Puka-Hereka/Coal Island, 2008).
- Ship rats (Pomona Island†, 2007).
- Brushtail possums (Pomona Island†, 2007).
- Mice and rats (Mamaku/Indian Island‡, 168 ha, 2010).

Incursion/suspected incursion responses by DOC

- Single male rat trapped on Mauikatau/Resolution Island in 2006.
- Several rats trapped on Blanket Bay Island (50 m offshore from Kā-Tū-Waewae-o Tū/Secretary Island) in 2006.
- Possible mouse sighting at The Gut Hut, Kā-Tū-Waewae-o Tū/Secretary Island, in 2006.
- Possible mouse chew marks detected on a waxtag™ near Blanket Bay in 2009.
- Possible stoat sighting on Pukenui/Anchor Island in 2007.
- Response to vessel sinking off Mauikatau/Resolution Island in 2007.
- Response to vessel sinking off Kā-Tū-Waewae-o Tū/Secretary Island in 2012.
- Single rat trapped on Pukenui/Anchor Island in 2012.
- Response to vessel washing ashore on Te Au Moana/Breaksea Island 2016.

Post-eradication reinvasion

- Rats to Pomona Island in 2010. Bait station and trapping network established 2012–13. Rats maintained at zero-density from spring 2015 to Autumn 2016.
- Mice to Pomona and Rona Islands: A single mouse was trapped in a rodent motel on each of Pomona and Rona Islands in June/July 2009. Extensive trap networks targeting mice were established on both Islands. In March 2010, a further single mouse was trapped on Rona Island. A mouse population re-established on Pomona Island in 2010 and on Rona Island in 2012. Bait station grid established on Rona and mice currently tracking at 0%.
- Rats confirmed as re-established on Mamaku/Indian Island February 2016.

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* South West New Zealand Endangered Species Charitable Trust est. 2004

† Pomona Island Charitable Trust est. 2005

‡ Fiordland Conservation Trust est. 2007

Preventing incursions

The ongoing success of island pest eradication programmes depends on no new plant or animal pests arriving on the islands. DOC's pest control activities have been carried out in accordance with the *Island Biosecurity Plan: Southland Conservancy* and weed management strategies developed for the large programmes on Kā-Tū-Waewae-o Tū/Secretary and Mauikatau/Resolution Islands. In 2008, a new purpose-built island quarantine facility was opened to support the increased level of work on Fiordland islands and to ensure that the rigorous quarantine standards were being met. Rodent motels, bait stations and rodent monitoring devices have also been established at all common mainland anchorages adjacent to rodent-free islands in Fiordland.

Inside DOC's quarantine facility, Te Anau. *Photo: DOC.*

These requirements also extend to operations on board the DOC vessel *MV Southern Winds* and other vessels visiting Fiordland. DOC has worked with local operators to develop their own biosecurity plans for vessels and shore parties. Regular reminders about the importance of island biosecurity are sent out to coastal operators in newsletters timed to coincide with peak boating activity in the region.

Funding and partnerships

The majority of the Fiordland island eradication projects to date have been funded by the Government and led and managed by DOC, including the work on Kā-Tū-Waewae-o Tū/Secretary and Mauikatau/Resolution Islands (which received a $7 million funding package in 2005). However, DOC's work has also been supported by financial sponsorship from many individuals and organisations; in particular, three community trusts have developed their own ambitious restoration projects in partnership with DOC and Te Rūnanga o Ōraka Aparima:

Te Puka-Hereka/Coal Island. *Photo: DOC.*

The South West New Zealand Endangered Species Charitable Trust (est. 2004) initiated a restoration programme for Te Puka-Hereka/Coal Island in Preservation Inlet in 2005. The Trust's focus is site-based on Te Puka-Hereka/Coal Island where they aim to fund and establish a world-class sanctuary for rare and endangered native species of flora and fauna. Their work is being jointly developed with a mix of private philanthropists and corporate and government participants.

The Pomona Island Charitable Trust (est. 2005) has been running a comprehensive community-led restoration programme on Pomona and Rona islands in Lake Manapouri since 2006. Pomona Island is the largest inland island in New Zealand and the Pomona Island Chariable Trust aim to restore it to its presumed natural state prior to the introduction of pests.

The Fiordland Conservation Trust (FCT; established in 2007) was established as an independent locally-based philanthropic Trust to inspire the community to protect the special values in Fiordland and the wider Southland region. In 2010 FCT partnered with individual and group sponsors to enable the eradication of rodents (both mice and rats) from Mamaku/Indian Island. This project built on the stoat control put in place by DOC on Mamaku/Indian Island in 1999 to protect Pukenui/Anchor Island from stoat reinvasion.

Species translocation – defined as the deliberate movement and release of wildlife – is primarily carried out to ensure the persistence of the species.

Juvenile takahē Vancouver emerging from the tussock for her feed at Burwood Bush. Father Tuatahi is in the background. *Photo: Helen Dodson DOC.*

Translocation as a tool for conservation management

What is species translocation and why do we do it?

Species translocation is defined as the deliberate movement and release of wildlife. It is primarily carried out to ensure the persistence of a species. Individuals are often moved into an environment where they can be expected to survive in the absence of (or with a reduced level of) management – for example, onto islands or mainland sanctuaries that are predator-free. In some situations – particularly for critically endangered species such as kākāpō and takahē – the frequent translocation of birds across multiple sites is vital so that small breeding populations can be collectively managed as a meta-population in order to minimise the loss of genetic diversity.

For some species, such as kiwi and whio (blue duck), translocation involves bringing eggs from the wild into captivity for hatching and rearing. As part of Operation Nest Egg (ONE), juvenile kiwi are reared in a safe 'crèche' site until they reach a certain size, at which time they are returned to their source or to a new location. In the case of whio (WhiONE), juveniles are released back into the source location or to another site to establish a new population.

Occasionally, the translocation of a surrogate species is used to assist the restoration of biotic communities that are likely to have been present before the arrival of introduced predators.

All of these approaches have been used for conservation management purposes in Fiordland.

Translocation of whio

Translocation has been used successfully for whio (blue ducks) in Fiordland with the initiation of Whio Operation Nest Egg (WhiONE) and transfers of wild juveniles into protected catchments with very small numbers of whio.

A pair of whio with ducklings in Fiordland. *Photo: Rod Morris*

Species translocations in Fiordland

Between 1987 and 2015 there were 26 translocations of threatened fauna to islands in Fiordland (including those in Lakes Te Anau and Manapouri) that resulted in the establishment and persistence of new breeding populations.

Although bird translocations have far outnumbered those of lizards, frogs and invertebrates in New Zealand, some of the earliest translocations in Fiordland were of the Fiordland skink and two large invertebrate species –

DOC Biodiversity Ranger Hannah Edmonds releases mohua (yellowheads) on Mauikatau/Resolution Island, July 2013. *Photo: Barry Harcourt.*

Bird, insect and lizard translocations to islands in Fiordland, 1987–2015

Population established and persisting

- **Kakaruai**: to Te Au Moana/Breaksea Island 1987; Pukenui/Anchor Island 2002, 2004; Pigeon Island 2007; Pomona/Rona Islands 2009; Te Kākāhu-o-Tamatea/Chalky Island 2010; Mamaku/Indian Island 2013.
- **Fiordland skink**: from Wairaki Island to Hāwea Island 1988.
- **Knobbled weevil**: from Outer Gilbert Island III to Te Au Moana/Breaksea Island 1991.
- **Flax weevil**: from Wairaki Island to Te Au Moana/Breaksea Island 1991.
- **Tīeke**: to Te Au Moana/Breaksea Island 1992; Passage Islands 2001; Pukenui/Anchor Island 2002, 2004; Te Kākāhu-o-Tamatea/Chalky Island 2008.
- **Mohua**: to Te Au Moana/Breaksea Island 1995; Te Kākāhu-o-Tamatea/Chalky Island 2002; Pukenui/Anchor Island 2002; Pigeon Island 2007; Kā-Tū-Waewae-o Tū/Secretary Island 2008; Mauikatau/Resolution Island 2011, 2013; Pomona Island 2011.
- **Rock wren**: to Kā-Tū-Waewae-o Tū/Secretary Island 2008–2011.
- **Orange-fronted parakeet**: to Te Kākāhu-o-Tamatea/Chalky Island 2005, 2006, 2007.
- **Little spotted kiwi**: to Te Kākāhu-o-Tamatea/Chalky Island, 2008, 2009.
- **Haast tokoeka**: from Rona Island crèche site to Te Puka-Hereka/Coal Island (since 2009 – ongoing).
- **Haast tokoeka**: to Pomona Island, 2011.

Kakaruai (South Island robin). *Photo: Eamonn Ganley.*

Present in very low numbers

- **Kakaruai**: to Erin Island 2003; Doubtful Islands 2003; Kā-Tū-Waewae-o Tū/Secretary Island 2008.

Translocation in progress

- **Kakaruai**: Te Puka-Hereka/Coal Island 2015.
- **Mohua**: Te Puka-Hereka/Coal Island 2015.
- **Little spotted kiwi**: to Pukenui/Anchor Island 2015, 2016.

Population established but did not persist

- **Mohua**: to Centre Island 1992.
- **North Island kōkako**: to Kā-Tū-Waewae-o Tū/Secretary Island 2008, 2009.

Little spotted kiwi. *Photo: Tui De Roy.*

Population did not establish

- **Kakaruai**: to Entry Island 1989.
- **Tīeke**: to Bauza Island 2003, 2010; Erin Island 2004.
- **Fiordland tokoeka**: to Doubtful Islands, Lake Te Anau 2002–06 (at least two pairs remain on the islands, while some returned to the Murchison Mountains).
- **Rock wren**: to Pukenui/Anchor Island 2004, 2005.

Translocation as part of meta-population management

- **Takahē**: to Kā-Tū-Waewae-o Tū/Secretary Island 2009 – unsuccessful.
- **Kākāpō**: first translocations to Te Kākāhu-o-Tamatea/Chalky Island 2002, 2005; Pukenui/Anchor Island 2005. Currently, these sites are managed as part of the kākāpō meta-population.

Operation Nest Egg

- **Haast tokoeka**: to crèche sites – Centre Island Lake Te Anau 2004; Te Puka-Hereka/Coal Island and Rona Island (since 2008, ongoing).

Bird translocations to mainland sites in Fiordland, 1987–2015

Reinforcement translocation

- **Mohua**: from Te Kākāhu-o-Tamatea /Chalky Island to Eglinton Valley 2010 (both recipient populations had very few individuals); from Pukenui/Anchor Island to Eglinton Valley 2015.
- **Takahē**: egg transfers within the Murchison Mountains and to Burwood Bush for captive rearing; puppet-reared juveniles from Burwood Bush returned to Murchison Mountains 1988–2010; parent-reared juveniles from Burwood to Murchison Mountains 2015.
- **Whio**: egg tranfers to Punanga Manu o Te Anau/Te Anau Bird Sanctuary for captive rearing; juveniles released into Clinton/Arthur Valleys and Murchison Mountains 2002–11. Three transfers of wild juveniles within northern Fiordland and Mt Aspiring National Park from 2005 to 2014.

Population established and persisting

- **Pāteke** (North Island brown teal): Arthur Valley 2009–13.

Population established but did not persist

- **Kakaruai**: from Eglinton Valley to Cleddau Delta 2011, 2012 (birds dispersed from the delta but persist in Cleddau Valley).
- **Takahē**: juveniles to Stuart Mountains 1987–92.

Bird transfers from sites within Fiordland to other locations (excluding display sites), 1987–2015

- **Mohua**: from Te Au Moana/Breaksea Island to Whenua Hou/Codfish Island Nature Reserve 2003 (successful); Te Au Moana/Breaksea Island to South Branch of the Hurunui, Canterbury 2008; from Te Kākāhu-o-Tamatea/ Chalky Island to Hawdon Valley 2015.
- **Tīeke**: from Breaksea Island to Orokonui Ecosanctuary 2013, 2014.
- **Takahē**: from Fiordland/Te Anau Wildlife Park/Burwood Bush to Tiritiri Matangi Island 1991; Kapiti Island 1989; Mana Island 1987; Maud Island 1984; Maungatautari Ecological Island 2006; Motutapu Island 2011; Cape Sanctuary (Cape Kidnappers) 2012; Tawharanui Open Sanctuary 2014; Rotoroa Island 2015.
- **Haast tokoeka**: from Rona Island to Orokonui Ecosanctuary 2011.

the knobbled weevil and flax weevil – which took place shortly after the establishment of DOC in 1987. Since then, several pioneering translocation programmes have been carried out:

Tīeke management on Fiordland Islands

'Safe' populations of tīeke (South Island saddlebacks) have been established on four predator-free islands, contributing to the future security of this species and allowing birds to be translocated to other sites outside Fiordland. As a result of this work and other translocations throughout the South Island, the threat classification for South Island tīeke has improved from 'Nationally Endangered' to 'At Risk–Recovering'.

In the early 1960s, tīeke were rescued from their last outpost on Taukihepa/Big South Cape Island, off Stewart Island/Rakiura, following invasion of the smaller island by ship rats. They were initially moved to other small islands off Stewart Island/Rakiura. They were then translocated from Big and Kundy Islands to Te Au Moana/Breaksea Island in 1992, and have since been translocated from Te Au Moana/Breaksea Island to Passage, Pukenui/Anchor and Te Kākāhu-o-Tamatea/

A female tīeke (saddleback) from Taukihepa/Big South Cape Island (off the coast of Stewart Island/Rakiura). *Photo: Rod Morris.*

Chalky Islands, where they have established populations. In 2013, Colin Miskelly and Ralph Powlesland wrote a review of conservation bird translocations in New Zealand[1], in which tīeke is described as the most successful taxon in terms of the number of successful translocations (18 (75%), plus five in progress at the time of writing). They noted how remarkable this is given that tīeke would be extinct had they not been rescued through translocation in 1964. The work undertaken to secure tīeke in Fiordland has played a key role in this success.

Although tīeke are no longer present on the mainland in Fiordland, good numbers remain on islands such as Te Au Moana/Breaksea and South Passage, making translocations to other islands and secure mainland sites possible. Increasing pressure to harvest the Te Au Moana/Breaksea Island population for translocations to other sites prompted DOC staff in Te Anau to commission a quantitative survey for tīeke (using the Distance Sampling method) over an estimated 115 ha of Te Au Moana/Breaksea Island in 2013. From this, it was estimated that there were 6.41 birds/ha, which equated to a population of around 1015 birds on the island. An earlier survey estimated 0.42 birds/ha or 400 individuals and calculated the carrying capacity of the island to be less than 500. The recent survey results and subsequent population modelling undertaken by Andrew Grant (DOC) suggest that the current population is now double the earlier figure and still increasing.

Te Au Moana/Breaksea Island, at the entrance to Te Puaitaha/Breaksea Sound, Fiordland. *Photo: Barry Harcourt.*

While it is unknown whether the tīeke population will continue to increase, stabilise or decline, these findings provide a good indication that it can sustain a significant harvest regime. Andrew's model provides for various harvesting scenarios, but he concludes that the removal of 100 birds in one breeding cycle should not be an issue. However, he also stresses the importance of ensuring that future surveys are carried out on Te Au Moana/ Breaksea Island to determine how the population is progressing and when it stabilises.

Orange-fronted parakeet Recovery Programme

This programme established a secure population on predator-free Te Kākāhu-o-Tamatea/Chalky Island.

Orange-fronted parakeet. *Photo: Rod Morris.*

Fewer than 300 orange-fronted parakeets survive on the New Zealand mainland, and the species is classified as 'Nationally Critical' under the New Zealand Threat Classification System. Three remnant populations can be found in alpine beech forest valleys in Canterbury: two in Arthur's Pass National Park and one in Lake Sumner Forest Park.

In 2002, a decision was made to establish a population of orange-fronted parakeets on a secure predator-free island. Te Kākāhu-o-Tamatea/Chalky Island was chosen as the highest priority site for a translocation, as it had recently been declared predator free and did not have a resident population of yellow-crowned parakeets that may have out-competed a small translocated population of orange-fronted parakeets. Therefore, in 2002 a captive breeding facility for orange-fronted parakeets was established at Punanga Manu o Te Anau/Te Anau Bird Sanctuary, to which eggs collected from the wild would be transferred for incubation and then fostered onto red-crowned parakeet parents. The intention was to release 20 orange-fronted parakeet juveniles onto Te Kākāhu-o-Tamatea/ Chalky Island. In February 2003, the first egg transfer was carried out, resulting in four chicks being raised to fledging and subsequently being held at the Bird Sanctuary in an aviary awaiting transfer. The following

[1] Miskelly, C.M.; Powlesland, R.G. 2013. Conservation translocations of New Zealand birds, 1863–2012. *Notornis 60*: 3–28.

year, a further four orange-fronted parakeet eggs were found in the wild; however, these were reared at Peacock Spring/Isaacs Wildlife Trust in Christchurch, as there were no red-crowned parakeets nesting in Te Anau.

Concern that the wild population may not sustain ongoing egg harvesting, combined with the knowledge that parakeets can breed prolifically in captivity, led the Orange Fronted Parakeet Recovery Group to reconsider the captive breeding programme. Therefore, in 2005, a decision was made to establish ten breeding pairs in captivity at both Te Anau Wildlife Park (now Punanga Manu o Te Anau/Te Anau Bird Sanctuary) and Peacock Springs, and to translocate surplus birds (minimum of five) to Te Kākāhu-o-Tamatea/Chalky Island before mid-March 2006. In total, 45 orange-fronted parakeets (20 males and 25 females) were translocated from Peacock Springs to Te Kākāhu-o-Tamatea/Chalky Island in three transfers: December 2005, February 2006 and January 2007. While no juvenile birds were sourced from Te Anau, they were maintained in captivity at the Wildlife Park until 2006.

Te Kākāhu-o-Tamatea/Chalky Island at the entrance to Chalky Inlet. *Photo: Richard Kinsey.*

Since 2007, the key management objective for orange-fronted parakeets on Te Kākāhu-o-Tamatea/Chalky Island has been to carry out an annual census to determine the population status and trend. In 2013, the Recovery Group concluded that the translocation of orange-fronted parakeets to Te Kākāhu-o-Tamatea/Chalky Island had been successful, but that an increase in the number of yellow-crowned parakeets that self-introduced onto the island in 2007 was making it difficult to fully understand progress of the orange-fronted parakeet population. The current focus is still to create safe island populations and to ensure enough captive breeding capacity to allow for further translocations to mainland sites with catchment-wide predator control sufficient to sustain orange-fronted parakeet populations. These sites are currently outside of the Te Anau District.

Rock wren

The first ever successful translocation of rock wrens (tuke) occurred in 2008–11, when birds were transferred from the Murchison Mountains to Kā-Tū-Waewae-o Tū/Secretary Island.

Mohua Recovery Programme

Mohua (yellowheads) were translocated from the Blue Mountains in Otago to Te Au Moana/Breaksea Island in 1995, and have subsequently been successfully transferred to Te Kākāhu-o-Tamatea/Chalky, Pukenui/Anchor, Pigeon and Pomona Islands. Mohua on Kā-Tū-Waewae-o Tū/Secretary Island came from the Dart Valley in Otago, while the population on Mauikatau/Resolution Island was founded by birds from the Landsborough Valley on the West Coast and the Catlins in South Otago.

DOC Biodiversity Ranger Megan Willans releasing rock wrens (tuke) on Kā-Tū-Waewae-o Tū/Secretary Island, 2008. *Photo: Sanjay Thakur.*

A mohua (yellowhead) before release, 2008. *Photo: DOC.*

Kākāpō

Translocations as part of the Kākāpō Recovery Programme saw the return of kākāpō to Fiordland (from Codfish Island/Whenua Hou Nature Reserve off Stewart Island/Rakiura) in 2002 (to Te Kākāhu-o-Tamatea/Chalky Island), with subsequent transfers to Pukenui/Anchor Island in 2005. In February 2011, a rimu-seeding (mast) event led to the first kākāpō nesting attempt in Fiordland in recent history (a single infertile egg). In the 2015/16 summer, 20 female kākāpō nested on Pukenui/Anchor Island. These nests produced 14 healthy chicks and contributed to the most successful breeding season for kākāpō on record, with a grand total of 36 chicks! Kākāpō on Pukenui/Anchor Island and Te Kākāhu-o-Tamatea/Chalky Island are now managed as part of the kākāpō 'meta-population', with ongoing translocations between breeding sites throughout the country to manage further loss of genetic diversity due to inbreeding. The work of the Kākāpō Team has been supported by Kākāpō Recovery national partners: New Zealand Aluminium Smelters LTD (NZAS) for 25 years up until 2015 and Forest & Bird. In 2016, Meridian Energy became the new national partner of the Kākāpō Recovery Programme.

A juvenile kākāpō eating supplejack berries. *Photo: Tui De Roy.*

Little spotted kiwi

Richard Henry moved little-spotted kiwi from Fiordland to Kapiti Island, off the west coast of the lower North Island, between 1890 and 1910, prior to leaving his post on Mauikatau/Resolution Island following invasion of the island by stoats. In 2008, little spotted kiwi were returned to Fiordland (Te Kākāhu-o-Tamatea/Chalky Island) from Kapiti after a more than 100-year absence, which was cause for significant celebration. A second population was established in Fiordland in 2015, with a transfer of 20 birds translocated from Kapiti to Pukenui/Anchor Island in April. A further release of up to 25 birds was planned for 2016.

Stuart Bull of Ōraka Aparima Rūnaka takes part in the translocation of little spotted kiwi to Te Kākāhu-o-Tamatea/Chalky Island in 2009. *Photo: Kara Matheson.*

Takahē

For more than two decades, collection and artificial incubation of eggs from the takahē population in the Murchison Mountains and puppet-rearing of chicks at Burwood Bush Reserve near Te Anau was the mainstay of the Takahē Recovery Programme and key to retaining the only remaining wild takahē population in the Murchison Mountains. It is only because of the dedication of staff tasked with managing the captive-rearing and translocation programme, and the

Map 4. Location of takahē populations in New Zealand.

knowledge gained from this, that takahē are still with us today. However, puppet-rearing of chicks is no longer used as a management tool – instead, semi-captive pairs are now used to raise their own and other chicks. Also, the establishment of breeding adults on predator-free islands and within mainland sanctuaries has allowed for a secure and now expanding meta-population of takahē that is managed across ten locations throughout New Zealand (Map 4).

In 1987, efforts to establish a second wild population of takahē began in the Stuart Mountains, which adjoin the Murchison Mountains to the north and had been identified as the most suitable habitat for takahē outside the Murchison Mountains. Fifty-two takahē were released in the Stuart Mountains over 5 years and were monitored by University of Otago Master's student (and takahē ecologist for DOC) Jane Maxwell. Unfortunately, these birds did not establish at this site, which contained excellent, but fragmented habitat. This lack of success was attributed to the tendency for juvenile takahē to disperse widely, as well as too few birds being released each year over the 5-year programme. Stoat predation in the absence of predator control and lower rates of survival in captive (puppet-reared) birds are also likely to have contributed (see *Takahē* – chapter 5).

From 1988 to 2010, nest manipulation in the Murchison Mountains allowed managers to ensure that most located nests would contain at least one fertile egg. Although takahē generally lay two eggs per clutch, research by Jim Mills in the 1970s showed that single chicks appeared to have higher survival rates than chicks from multiple broods. Therefore, during the same period, single eggs were removed from nests that contained two fertile eggs, both eggs were removed from the nests of early nesters that were likely to re-lay, and young single chicks were taken from twin-chick nests. This resulted in 267 fertile eggs and chicks being removed and transferred from the Murchison Mountains to Burwood Bush. The majority of takahē reared at Burwood Bush were returned to the Murchison Mountains as 1-year-old juveniles to bolster the existing population. In total, 259 birds were released back into the Murchison Mountains – these were predominantly Fiordland stock, but in later years a small number were also from island populations or Burwood Bush.

Research initiated in 2003 and led by University of Otago MSc student Catherine Gruber demonstrated that genetic diversity in island populations of takahē had been lost over a relatively short timeframe as a consequence of not carefully managing the pairing of specific birds following initial releases, leading to disproportionate breeding success for some birds. This is concerning because greater genetic diversity helps populations adapt to changing environments. Catherine subsequently reported a decline in the proportion of breeding takahē across the islands, despite a possible increase in the number of breeders occupying territories, which she attributed to inbreeding depression (when more recessive harmful traits manifest themselves in offspring because of breeding between related individuals).

In 2008, in response to Catherine's research, the Takahē Management Team began to address genetic problems from inbreeding in the island and mainland sanctuary populations by transferring individuals between sites. The birds managed at these locations (which includes Burwood Bush) represent what is now known as the 'meta-population' or 'national flock'. By 2012, a pedigree database had been established to support management of the meta-population. Information from the pedigree database is used to plan transfers of specific individuals between sites, thus ensuring that the

Takahē in Fiordland

The rediscovery of the takahē in New Zealand in 1948 prompted a major effort by government agencies to conserve the species, and this work has continued unabated for the last 65 years. The takahē is the only member of the flightless, ground-dwelling herbivore guild that was formerly present in New Zealand during the Holocene Epoch (which included moa and several rails) to have survived human settlement to the present day. The Murchison Mountains contains the only wild population of takahē. The area is valuable historically as the site of their rediscovery and is considered to be the tūrangawaewae ('place to stand') of takahē. In 2016 the takahē population reached a milestone of 300 birds and its ranking on the New Zealand Threat Classification System improved two places to Nationally Vulnerable.

Geoffrey 'Doc' Orbell (R) and Dr Robert Falla (Dominion Museum director) holding a takahē chick in 1948 during the rediscovery of the species in Takahē Valley, Murchison Mountains, Fiordland. *Photo: DOC Collection.*

Dr Geoffrey Orbell (1908–2007) revisits Takahē Valley in October 1998, 50 years after his famous rediscovery of takahē there in 1948. 'Doc' Orbell was 90 years old when this photo was taken. *Photo: Rod Morris.*

Commercial partnerships

Species translocations have traditionally attracted the greatest interest for project partnerships through leadership, funding and community involvement. The main relationships have been:

Fiordland Conservation Trust in partnership with:

- **Peregrine Wines** (mohua to Mauikatau/Resolution Island; tīeke to Te Kakahu-o-Tamatea/Chalky Island; tīeke to Bauza Island)
- **Chalky Digits** (kakaruai (South Island robins) to Te Kakahu-o-Tamatea/Chalky Island)
- **Fiordland Lobster Company** (little-spotted kiwi to Pukenui/Anchor Island)
- **Southern Discoveries** (Fiordland tokoeka to Sinbad Valley)
- **Lucy Bellerby, Ian & Jenny Willans**, and **the Quatre Vents Foundation** (kakaruai to Mamaku/Indian Island)
- **Ultimate Hikes** and **Otago Community Trust** (pāteke to Arthur Valley; 2010 release)
- **DOC** (kakaruai to Rangitoa/Kā-Tū-Waewae-o Tū/Secretary Island)

Greg Hay (L) and Lindsay McLachlan, owners of Peregrine Wines, help transfer a tīeke to Te Kākāhu/Chalky Island, 2008. *Photo: Barry Harcourt.*

Pomona Island Charitable Trust in partnership with:

- **Meridian Energy** (mohua to Pomona Island)
- **Anonymous** (kakaruai to Pomona Island)
- **DOC** (Haast tokoeka to Rona Island)

South South West New Zealand Endangered Species Charitable Trust in partnership with:

- **Mohua Charitable Trust** (mohua to Te Puka Hereka/Coal Island)
- **DOC** (kakaruai to Te Puka-Hereka/Coal Island)

Additional partnerships supporting DOC:

- **Air New Zealand** (prior to 2012: kakaruai to Te Kākāhu-o-Tamatea/Chalky Island; since 2012 national partner: free flights for species being translocated on Air New Zealand's regular passenger flights, and funding for species translcations to sites on DOC's Great Walks)
- **BDG Synthesis** (rock wrens to Kā-Tū-Waewae-o Tū/Secretary Island)
- **Banrock Wines/Wetland Care NZ/Ducks Unlimited** (2009 & 2011, pāteke to Arthur Valley)
- **Fiordland Lobster Company** (mohua and kakaruai to Pigeon Island; North Island kōkako to Kā-Tū-Waewae-o Tū/Secretary Island;
- **Fiordland Wapiti Foundation** (whio)
- **Genesis Energy** (national partner for whio)
- **Flight Centre** (sponsorship for takahē recovery prior to 2005)
- **Mitre 10 Takahē Rescue** (national partner for takahē 2005–16)
- **Fulton Hogan** (national partner for takahē from 2016)
- **Mitre 10** ('Official Supplier to Takahē Recovery' supporter from 2016)
- **Les Hutchings Foundation** (little spotted kiwi to Te Kākāhu-o-Tamatea/Chalky Island)
- **Mohua Charitable Trust** (mohua to the Eglinton Valley and Mauikatau/Resolution Island)
- **Real Journeys** (little spotted kiwi to Te Kākāhu-o-Tamatea/Chalky Island; whio recovery in Fiordland)
- **South West Helicopters**, **Fiordland Helicopters** and **Southern Lakes Helicopters** (helicopter time and support with translocations)

A takahē ready for transfer in a specially designed Mitre 10 box. *Photo: DOC.*

DOC greatly appreciates the efforts of these businesses, groups and individuals.

Takahē chicks being feed by hand puppet, Burwood, 1999.
Photo: Rod Morris.

genetics of the population are well managed (i.e. there is minimal inbreeding and certain birds' genes are not over-represented in the population). The takahē meta-population currently provides the species with security from the risk of extinction. However, the populations rely on an ongoing management commitment to counter inbreeding and genetic drift through annual bird transfers so that viable fertility rates are maintained. Burwood Bush is central to this aspect of the programme and currently produces around 25 chicks per annum – with this figure forecast to increase to 30 by 2016, with an average of 1.5 chicks produced for every breeding pair.

In 2008, a pilot study investigating the suitability of Kā-Tū-Waewae-o-Tū/Secretary Island for takahē was also initiated and nine takahē were released there over 3 years from 2008 to 2010. A couple of nesting attempts were recorded but chicks were never observed. Suitable habitat for takahē on Kā-Tū-Waewae-o Tū/Secretary Island was limited to regenerating slips and scattered areas on the tops. Therefore, it was determined that the costs and logistics of managing takahē on the island were not merited at this stage in the species' recovery and so the trial was discontinued.

The collection and transfer of eggs within and from the Murchison Mountains ceased in 2011, as did the artificial incubation of eggs and puppet-rearing of chicks at Burwood Bush, and the release of captive-reared juveniles into the Murchison Mountains. An initial assessment of takahē recruitment comparing wild and captive-reared (both puppet- and adult-reared) birds indicated no significant difference in survival rates once juveniles were released back into the Murchison Mountains. However, a subsequent analysis of breeding success indicated that captive-reared birds from Burwood Bush released into the Murchison Mountains had substantially (up to 65%) lower reproductive success than wild-reared takahē. The continued release of captive-reared juveniles into the Murchison Mountains has also been correlated with reduced hatching success in the population over time, meaning that the presence of captive-reared birds in the population was potentially undermining its ability to bounce back from adverse events, such as the significant adult mortality event in 2007 (see chapter 5). Current best-practice for captive management of takahē is for chicks to be raised (individually or in pairs) by adult takahē in large natural pens, and that subadult (1-year-old) takahē helpers are used. Late 2015 saw the largest release of takahē into the Murchison Mountains with the release of 29 young adult birds from Burwood Bush.

Others

Numerous translocations from one mainland site to another have also taken place to establish new populations or to bolster existing ones, with varying degrees of success. In addition, two North Island species have been translocated to sites in Fiordland – the North Island kōkako[2] to Kā-Tū-Waewae-o Tū/Secretary Island and pāteke (North Island brown teal) to the Arthur Valley – to support species recovery and as surrogates for similar South Island species that are considered functionally extinct. Probably the most significant of these is the *Takahe Recovery Programme*, which is perhaps New Zealand's best-known species recovery programme. It is managed from Te Anau utilising translocation and captive rearing and is addressed in more detail later in the report.

DOC Biodiversity Ranger Dave Crouchley holding a kōkako during the first release of the birds on Kā-Tū-Waewae-o Tū/Secretary Island, 2008.
Photo: DOC.

[2] While declared extinct by the Department of Conservation in 2008, the classification of South Island kōkako was revised in 2013 and the species' conservation status was changed to Data Deficient.

Katrina Hale (L) and Sabrina Taylor (R) banding tīeke on the Tītī Islands, off Stewart Island/Rakiura. *Photo: Ian Jamieson.*

DOC Biodiversity Ranger Andrew (Max) Smart releases pāteke in the Arthur Valley, Milford Track, February 2013. *Photo: Graham Dainty.*

Translocations and the role of genetics

Whenever a translocation is being planned, the security of the overall population must come first – particularly when critically endangered species are involved. A small total population size may dictate that only a small number of animals can be transferred from one site to another, which will result in loss of genetic diversity within the new (founder) population and/or the population from which the individuals have been harvested (donor population).

Kākāpō, takahē and tīeke have among the lowest genetic diversity of any threatened bird species worldwide. Until recently, it was a commonly-held view that threatened bird species in New Zealand were less susceptible to the effects of inbreeding depression than species elsewhere. However, some researchers argued that although inbred populations can reach the same population size as outbred populations, they may take longer to reach their optimal population size (carrying capacity), be more susceptible to new impacts (such as introduced diseases or parasites) and be slower to recover from any subsequent population catastrophes. Thanks to the research interests and work of the late Professor Ian Jamieson and the Threatened Bird Research Group at the University of Otago, we now have a much better understanding of the influence of inbreeding on threatened bird species managed both in Fiordland and nationally. This research group uses fieldwork, molecular genetics and population modelling techniques to explore how the loss of genetic diversity affects the survival and long-term adaptability of rare bird species. Over the past 10 years, Ian and his team of research associates and post-graduate students have provided conservation managers with advice and tools to adequately plan translocations with respect to managing inbreeding (e.g. for takahē and kākāpō) and establishing new populations of species (e.g. tīeke and mohua).

Kakaruai (South Island robins) being translocated to Pukenui/Anchor Island in 2004. DOC staff (L to R) Nick Torr, Hannah Edmonds and Gerard Hill. Helicopter pilot Mark Deaker behind. *Photo: DOC.*

Failed translocations – what have we learnt?

Typically, the success of a translocation is measured by whether or not a population establishes. However, numerous transfers are conducted as pilot studies, with the aim of developing techniques for future translocations, or finding out how individual birds settle, pair up and utilise habitat at a new site. The first pilot translocation of mohua involved only six birds released on Centre Island, Lake Te Anau, in October 1992. This release resulted in a small population persisting on Centre Island for several years. More importantly, it enabled staff to develop techniques that were later applied to a number of successful mohua translocations to other sites.

The first ever translocation of rock wrens was attempted between December 2004 and February 2005, when 28 rock wrens were transferred from the Murchison Mountains to Pukenui/Anchor Island. Individual birds were observed on Pukenui/Anchor Island up to 2007, but the population did not persist. However, the information obtained and expertise developed through this initial project provided guidance for a subsequent successful translocation of 41 rock wrens from the Murchison Mountains to Kā-Tū-Waewae-o Tū/Secretary Island in 2008–11. This resulted in a breeding population establishing on Kā-Tū-Waewae-o Tū/Secretary Island, with 66 birds observed in a survey in 2013, 63 of which were unbanded offspring of the founding population.

North Island kōkako translocations

The North Island kōkako is ranked as Nationally Endangered and is subject to intensive conservation management to reverse its decline. The establishment of a large breeding population of North Island kōkako would contribute significantly to the species recovery goal of reaching a population of c. 1000 pairs by 2020. In 2008, it was proposed that a North Island kōkako population be established on Kā-Tū-Waewae-o Tū/Secretary Island, despite it being well beyond the natural range of this species. The island was thought to have the potential to hold a large viable population due to its size, rat- and possum-free status, and very low numbers of stoats. The North Island kōkako is closely related to the 'functionally extinct' South Island species and is thought to occupy a similar ecological niche. Therefore, their introduction to Kā-Tū-Waewae-o Tū/Secretary Island would restore a component of the ecosystem that has disappeared. Moreover, the translocation would afford an opportunity for research into improving kōkako translocation techniques and its success would provide an additional insurance population.

Kōkako from Kaharoa Conservation Area in the North Island arrive on Kā-Tū-Waewae-o Tū/Secretary Island, Fiordland, in their specially designed translocation boxes, September 2009. *Photo: Kirsty Macnichol (The Fiordland Advocate).*

The Fiordland Lobster Company agreed to fund a significant proportion of the cost of the translocation ($80,000), despite the sizable risks associated with translocating kōkako to a remote South Island site for the first time. From 2008 to 2009, 27 kōkako were translocated from three North Island sites to Kā-Tū-Waewae-o Tū/Secretary Island: 10 from Mapara Wildlife Reserve, 7 from Kaharoa Forest and 10 from Rotoehu Forest. Six of the Mapara birds were fitted with radio-transmitters for post-release monitoring. Five survived their first 5 months on the island, while one succumbed to a New Zealand falcon (kārearea) attack. At least four of these birds also survived to 8 months post-release and surveys undertaken in 2011 confirmed that one pair had successfully bred, with an unbanded juvenile being observed.

In 2013, an island-wide survey failed to locate a single kōkako, indicating that the founder population had not established – although it is possible that a few single birds remain on the island, as a contract hunter heard a kōkako call at the time of the survey and another as recently as August 2015. Despite this unfortunate result, there have been some positive outcomes for kōkako conservation and the Secretary Island Restoration Project. In particular, greater synergies have been developed for kōkako conservation within DOC (working across regions), and with iwi and sponsors through their support of the translocations. However, a number of key challenges will need to be addressed if a second attempt is to be made to establish kōkako on Kā-Tū-Waewae-o Tū/Secretary Island or, indeed, anywhere in the South Island. These include:

- Re-evaluating the appropriateness of translocating North Island kōkako to the South Island.
- If translocations are appropriate, identifying suitable sites for future releases in Fiordland.
- Catching sufficient birds to establish a robust founder population.
- Building relationships between partners (iwi and DOC) to enable future translocations to occur.
- Maintaining expectations and relationships with sponsors.

Carmel Richardson, Kaharoa Kōkako Trust ecologist, with kōkako in hand, and DOC Biodiversity Ranger Kerri-Anne Edge, during the second kōkako release onto Kā-Tū-Waewae-o Tū/Secretary Island in September 2009. *Photo: Kirsty Macnichol (The Fiordland Advocate).*

In 2015 a rock wren monitoring programme for Kā-Tū-Waewae-o Tū/Secretary Island was formally established as one of the key outcome monitoring programmes for measuring the benefits of stoat removal on the island.

There have been three unsuccessful attempts to reintroduce tīeke to islands in Fiordland. The first of these was a translocation of 28 tīeke to Bauza Island in 2004, which likely failed as a result of predation by stoats – presumably reinvading from Kā-Tū-Waewae-o Tū/Secretary Island. A second release of 36 birds to Bauza Island in 2010 also did not establish for a range of reasons, possibly including the presence of large numbers of weka, which are known to take tīeke eggs. The third programme involved 38 tīeke being translocated to Erin Island in Lake Te Anau over 2 years (2003–04). This programme was carried out by DOC in partnership with Sabrina Taylor (PhD student) and the late Ian Jamieson (University of Otago). It had two primary research objectives: to assess the value of inshore islands for translocation of threatened species, and to determine the short- and long-term effects of inbreeding in small island populations (see *Translocations and the role of genetics* above). This translocation was also unsuccessful, probably due to the small number of birds released, dispersal of the birds to the adjacent Murchison Mountains and predation by stoats reinvading from the mainland.

Managing the risk of disease

During translocations, animals can become ill due to either stress or diseases which may be spread to new sites by the animals, humans or equipment. Therefore, it is important that measures to mitigate the disease risk are addressed during the translocation planning process.

In 2004, three kākāpō died from the bacterial infection erysipelas, following their transfer from Whenua Hou/Codfish Island Nature Reserve (off Rakiura/Stewart Island) to Te Kākāhu-o-Tamatea/Chalky Island. These highly valuable 2-year-old females were part of a translocation involving 18 kākāpō – and were the first of the hundred or so previously translocated kākāpō to succumb to erysipelas. Initially it wasn't known what had caused the deaths, but subsequent testing showed that most adult kākāpō had been previously exposed to the bacteria. Therefore, it was not a new disease within the population; rather, young and potentially quite stressed birds had simply succumbed to the disease. DOC staff from Te Anau travelled to Te Kākāhu-o-Tamatea/Chalky Island to support the Kākāpō Management Team and constructed temporary holding pens so that each bird could receive either antibiotics or several doses of vaccine, which needed to be administered over several days. This outbreak of erysipelas highlighted the need for constant vigilance with regard to disease management and translocations, as well as day-to-day management.

Taking blood from a kākāpō.
Photo: Tui De Roy.

Takahē juveniles at Burwood Bush in their 'natural pens', 2014. *Photo: Sabine Bernert.*

Compared with other parts of New Zealand, some of the remote areas of Fiordland have been characterised by a quite recent weed and pest invasion history.

A hunter searching at dusk for deer in the Fiordland Wapiti Area, high above Lake Alice in the Edith River, George Sound.
Photo: Rob Suisted.

Map 5. Coastal weed control areas in Fiordland. The Fiordland coastal weed control programme covers the coast from Puysegur Point in the south to Piopiotahi/Milford Sound in the north. Work similar to that done by the former Muruhiku Area Office continues over the section from Puysegur to Bluff.

Mainland weed and pest control

Management of weeds

Fiordland contains some of the most special ecosystems in New Zealand and is also fortunate to be one of the country's most weed-free regions. This status is partly due to the isolation of Fiordland, but is also the result of ongoing vigilance and control of problem weeds implemented by DOC as part of biosecurity measures for work in remote regions (Map 5). Two main types of weed control take place in Fiordland: site-led and species-led. Site-led weed control is about managing and/or removing a range of weed species at particular sites. Weed-led control targets particular species over most sites. A site-led programme is often paired with ecosystem preservation or restoration efforts, whereas weed-led programmes often deliver intensive control, containment and/or eradication of particular species across large areas or regions.

DOC weed team Erina Loe and Sanjay Thakur on Te Au Moana/Breaksea Island about to be picked up by Ali Hay and the DOC vessel *MV Southern Winds*, 2011. *Photo: Graham Dainty.*

Site-led weed control

The Fiordland coast contains some of the most intact examples of pīngao dune ecosystems in New Zealand – at Martins Bay, Transit Beach, Catseye Bay, the north side of Te Hāpua/Sutherland Sound, Coal River and on Spit Island. A report on the vegetation of Fiordland beaches by Peter Johnson in 1979 recommended the eradication of introduced gorse, marram grass and broom from the Fiordland coast, and the regular surveillance of 'troublesome' weeds. In the early 1980s, there were extensive patches of exotic marram grass on a number of Fiordland beaches, including Coal River, Transit Beach and Spit Island in Rakituma/Preservation Inlet, and gorse was also prevalent on some beaches. However, the recommendation of complete eradication is now acknowledged to be impractical, as both gorse seed and clumps of marram grass are washed down the west coast on tidal currents, especially following storm events, and so often re-establish on northwest-facing beaches.

Weed threats

There are many weed threats to the Fiordland region, including a number of problem woody weeds that are present in small numbers and have limited distributions – namely heather, Spanish heath, Darwin's barberry, buddleia, cotoneaster (three species) and an unidentified heath species. These pest plants are actively removed from conservation land whenever possible, but all have the potential to become serious problem weeds in Fiordland.

Darwin's barberry in flower. *Photo: DOC.*

Spanish heath in flower. *Photo: Kate McAlpine.*

Heather in flower. *Photo: Susan Timmins.*

The existing management maintains the dunes and Fiordland coast with as close to no marram and gorse as possible (i.e. management to maintain zero density). Systematic annual surveillance and control trips undertaken between 1988 and 2015 have reduced and

Pīngao on dunes at Coal River, just north of Te Puaitaha/Breaksea Sound on the Fiordland coast, 2007. *Photo: Graham Dainty.*

Native pīngao thrives on a dune at Te Hāpua/Sutherland Sound, Fiordland. *Photo: Graham Dainty.*

Marram grass gaining a foothold in the dunes at Coal River, Fiordland coast, 2007. *Photo: Graham Dainty.*

The exotic sea spurge. *Photo: DOC.*

DOC weed team spraying gorse at West Cape, Fiordland, February 2007. The main weeds controlled on the coast today are marram grass and gorse, as well as montbretia around Puysegur Point lighthouse. *Photo: Graham Dainty.*

confined marram and gorse to occasional localised sites that require minimal spot spraying. Vigilance towards newly arrived environmental weeds[3] is also an important part of these annual visits. For example, if the invasive sea spurge that has recently arrived on North Island beaches – likely via ocean currents from Australia – were to reach Fiordland, it could pose a serious threat to the region's coastal ecosystems.

At Milford Sound/Piopiotahi township, weed control has targeted four key introduced species: five-finger, tutsan, gorse and montbretia. In 2010, DOC staff also worked with hotel staff from what was the THC (Tourist Hotel Corporation) Hotel to remove most exotic plants from gardens in the area, although some Spanish heath remains. DOC continues to work with businesses and their staff to remove these weeds from throughout the Milford Sound/Piopiotahi settlement area. Constant monitoring of weeds along the Milford Road is important, as it forms a pathway into Fiordland for new weeds. Since annual surveillance and control began in 1988, no new incursions have established, although weed plants (including buddleia, heather, gorse, broom, cotoneaster and Himalayan honeysuckle) are found occasionally and removed. Tutsan remains a problem in some areas along the Milford Road and annual maintenance spraying is carried out.

On the Milford Track, the most serious weed is blackberry, which was historically planted by walkers as a food source. Control of blackberry started in 2003 with both aerial and knapsack application of

[3] Environmental weeds are those that can invade native ecosystems and adversely affect the survival of native flora and fauna.

Gorse at Big Bay

A large area of gorse at Big Bay (extending from Awarua Point to Penguin Rock) was thought to be unmanageable and was left until 2004, when control work started with the aerial application of herbicide. Annual visits since then have included using a contractor with an all-terrain vehicle (Argo) helicoptered to the site, as well as knapsack spraying of marram and some broom. Although the area of infestation has been reduced enormously, it is still a significant problem that will require continued funding for a number of years. A large local seed source continues to produce new seedlings each year and will do so for many years to come.

DOC Ranger Ali Hay and Milford Helicopters pilot Snow Mullally walk through dead gorse at Big Bay. *Photo: DOC.*

Colourful curse in the Eglinton Valley

Lupins in full flower in the lower Eglinton Valley. *Photo: Graham Dainty.*

Russell lupin seeds were distributed by early settlers to 'beautify' the Eglinton Valley and lupins are now so widespread that they are not controlled by DOC (although community groups have done some clearing on the braided river beds to assist black-billed gull nesting sites). DOC currently sprays lupins along the Milford Road from the Cascade River north, including the Hollyford Valley. Lupins are prevented from spreading beyond the mouth of the Eglinton River and along the shores of Lake Te Anau. Lupins in the Eglinton Valley could be controlled, but this would require significant long-term funding and would likely be unpopular with tourists who enjoy the colourful flowers. Foxgloves have also been present since the early days of Milford Road construction. Previous attempts to limit their spread have been unsuccessful and they are now so widespread that control is not feasible.

Tutsan. *Photo: John Barkla.*

A blackberry photo monitoring point in the Arthur Valley, Milford Track. The larger and more extensive infestations are in the Arthur Valley, with smaller areas in the Clinton Valley. *Photo: DOC.*

Tordon™ herbicide. Until recently this programme had significantly reduced the amount of blackberry present, and greatly reduced or eliminated many known infestations. However, its ongoing control has been hampered by bad weather, difficult conditions, the availability of skilled staff at the right time and funding, and new areas of infestation are continually being discovered and treated. Therefore, this work requires increased investment to make significant progress. Minor infestations of tutsan, broom, lupin and an unknown species of heather at Glade House in the Clinton Valley are also controlled on the Milford Track.

The Routeburn and Kepler Tracks have largely been kept weed-free. However, the discovery of a mature common heather bush in the Luxmore Basin in 2009 demonstrates the importance of continued vigilance.

Within the Te Anau basin there are a number of reserves and other areas of Public Conservation Land that contain a range of values. These generally have boundaries with privately owned farmland. They include several wetlands, red tussock lands, bog pine shrublands, other shrublands, forest and other vegetation. Weed control is required in these areas to maintain their ecological values and to prevent weeds creating problems for neighbouring landowners. However, the level of resources required to hold these weed infestations even at their current levels is increasing. Rivers in the Te Anau basin generally have well-established weed infestations which require extensive weed control, particularly for broom, gorse and crack willow. The major weed control programmes are on the Upukerora, Whitestone and Mararoa Rivers. These riverbeds have a range of land use and owners (including marginal strips, Conservation Areas, Unallocated Crown Land riverbeds and, sometimes, private land) and land managers (DOC, Environment Southland, Land Information New Zealand and others). Therefore, coordination of the control work across the different agencies and landowners is neccessary. Control of these weeds is required under the Regional Pest Management Strategy (RPMS) and is resourced under 'exacerbater fundings' from Environment Southland. The programme has been funded in the district since the late 1980s and has achieved good results; however, the resources have been reduced significantly in recent years to a current annual budget of only $30,000, which covers work on

Movement of unwanted seeds

Visitors are increasingly tackling the Great Walks as a series of back-to-back tramps over a short period of time and may be unwittingly transporting the seeds of weed species to Fiordland in their clothing and equipment (e.g. the seeds of Spanish heath from the Tongariro Crossing). Biosecurity measures are now well established to help prevent the spread of the freshwater algae didymo in Fiordland (see chapter 6). There is a need for greater public awareness about the importance of removing soil and seeds from equipment and clothing.

Day walkers nearing Glade House at the start of the Milford Track. *Photo: DOC.*

The Whitestone River showing its willow-and broom-infested edge. *Photo: DOC.*

Lupin control as part of the Eglinton River Habitat Project (P.C. Taylor and Martin Sliva), 2009. This project aims to control both pest plants (lupins) and pest animals (stoats) around the shingle areas in the Eglinton Valley where black-fronted terns and banded dotterels breed. *Photo: Martin Sliva.*

just one river – the Mararoa. The Marora River is the least modified in the Te Anau basin and therefore the priority site for weed control undertaken by DOC.

Around the shores of Lake Te Anau there are minor infestations of Russell lupin, crack willow, broom and gorse, as well as an unknown species of heath; and at Lake Manapouri, infestations include gorse, Darwin's barberry, lupin, Montpellier broom and crack willow. All of these infestations are controlled regularly and no other problem weeds have become established.

Species-led weed control

No serious weed incursions have occurred in Fiordland since monitoring work began in 1988. This situation will only continue if the current programme of surveillance, control and biosecurity is maintained. Of key concern is DOC's inability to control listed weeds on land that it does not administer. To this end, DOC will continue to work closely with Environment Southland to strengthen the pest plant classification of target weeds in the RPMS for the Te Anau/Manapouri region. For example, some of these plants – in particular heather, Spanish heath, Darwin's barberry and buddleia – need to be classified as 'eradication pest plants' which, under the strategy, are defined as pests 'of limited distribution and density …' which [have] the potential to have serious negative impacts on the community or environment. The goal is to eradicate these pests'[4].

Stonecrop

Stonecrop is an introduced creeping evergreen succulent that spreads aggressively to form a dense mat, often to the exclusion of native plant species. It favours inhospitable sites with undisturbed, bare ground, such as roadsides, beaches, riverbeds, rocky screes and even concrete structures or tile roofs. It can grow from sea level to an altitude of 1500 m and is common in Central Otago, where it forms a bright yellow cover over entire hillsides in the summer. It produces large amounts of long-lived seeds that are easily dispersed, and also grows readily from detached leaves and shoots. The plant is very hardy, tolerating wind, salt, drought, frosts and poor soil. It is hardly surprising, therefore, that once stonecrop is established it is virtually impossible to get rid of.

Although stonecrop is widespread on roadsides throughout Southland (probably since the mid 1990s), it was only noticed on the approach to the Te Anau Basin in 2004. Since then, surveillance and control of stonecrop has been undertaken in January each year on all sealed roads in the vicinity of the Basin. The primary objectives of this ongoing programme are to prevent the plant's spread into vulnerable habitats within the Te Anau area and Fiordland National Park, to halt its spread into the Te Anau Basin, and to control all plants to zero-density. In addition, all sites within the area that are

Stonecrop growing aggressively at the Te Anau boat harbour. *Photo: DOC.*

known to have hosted stonecrop have been documented for surveillance and control with herbicide, and photographic monitoring has been used at some sites to track the effectiveness of herbicide treatment. As a result, stonecrop has been eliminated from some sites, and is now confined to very small, isolated patches on some road verges within the Te Anau Basin, and at known sites within the Te Anau and Manapouri townships.

Stonecrop is most likely to spread to the Te Anau Basin via the Mossburn–Te Anau highway, as herbicides that are currently sprayed by road maintenance contractors around road marker pegs do not kill stonecrop but, rather, favour it, as they remove competing weeds. Consequently, mowing equipment must be cleaned prior to entering the district, as it is thought that the machinery could be a potential source for chopping and spreading the weed.

Pine trees

Fortunately, the area previously administered by DOC's Te Anau Area Office has only ever had isolated pockets of wilding pines – mainly *Pinus contorta* and *Pinus mugo*. However, both of these species can spread aggressively and have the potential to invade large areas of conservation land if not eliminated or contained.

Following submissions from DOC staff, Environment Southland included *P. contorta* and *P. mugo* in the 2007 Southland RPMS as containment plants, requiring all *P. contorta* and *P. mugo* to be destroyed by those occupying the land it is growing on. This change resulted in the eradication of some problem roadside infestations of *P. contorta* by Transit New Zealand. Further small pockets of pines in the district have been removed by DOC staff along several rural roads, the Whitestone River, Kepler Mire and at Ashton Hut in the Eyre Mountains.

The largest area of wilding pines by far in the region is found in the Takitimu Mountains. Exotic pine trees (mainly *P. mugo*) were planted on the Cheviot faces of the

[4] Regional Pest Management Strategy for Southland 2013. Environment Southland, Publication No. 2013-1, Invercargill, New Zealand.

Exotic pine plantations on the Cheviot faces of the Takitimu Mountains, 2009. *Photo: DOC.*

Loading a helicopter with herbicide to spray wilding pines in the Takitimu Mountains, January 2012. *Photo: DOC.*

Takitimu Mountains by the New Zealand Forest Service in the 1970s as a trial to prevent erosion on steep slopes. Seedling trees have since spread well outside the original planted plots and there is the potential that pines will spread much more widely through wind dispersal of seed. Pine trees are seriously modifying the native vegetation cover in this region, and could cause significant ecological changes as a result of increased shading and the dense litter of needles covering the ground.

The Cheviot faces have important botanical values and also provide suitable habitat for lizards. Around 2008, the rare Barrier skink was found in scree on these faces – well outside its usual known range. Cryptic skinks are also common, and other unusual lizard species could be present (as they have been found in nearby catchments), including common skinks, green skinks, Eyre Mountains skinks and Takitimu geckos.

Between 2006 and 2012, the area of wilding trees on the Cheviot faces was divided into separate blocks and contractors were employed to cut one block per year, resulting in approximately 15 ha of trees being cut. Cutting was monitored annually to ensure that no green foliage remained and, with the exception of 2012, the requirement of a 95% success rate for killing trees was met each year. In 2012, the contract was put out to tender, which saved a considerable amount of money, but resulted in a disappointing 63% success rate. The remaining 65 ha area was boom sprayed by helicopter in December 2012 and January 2013 using the herbicide 'Lucifer'. This method is far quicker and considerably cheaper than using contractors to cut the trees. However, it can take up to 3 years to see the full effect of the herbicide and initial monitoring reported the persistence of a number of green shoots.

Ground crew cutting wilding pines in the Takitimu Mountains. *Photo: DOC.*

A view of wilding pine control during a monitoring trip in the Takitimu Mountains, 2012. *Photo: DOC.*

The only remaining untreated wilding trees on the Cheviot faces are isolated outliers that have spread from the main plantations. Follow-up control is now required to complete this work and prevent further spread of the trees. In particular, the cut trees require some aerial spot spraying, the sprayed area will need follow-up aerial spot spraying once sufficient time has elapsed for the initial spray to have taken full effect, and outlying pines need to be spot sprayed by helicopter using the basal spray 'X-tree'.

Douglas firs

Over the past few years, huge Douglas fir plantations have been established on private land within the Te Anau District. The most significant of these are at Redcliff, adjacent to the Takitimu Mountains, and at Te Anau Downs Station, adjacent to Snowdon Forest. Douglas firs are notorious for releasing seed downwind and a significant number of seedlings have already established on conservation land, especially at Redcliff. This spread is likely to be a serious and ongoing problem, and control work will require substantial resources of time and money. Ideally, the control of wilding trees from plantations should be the responsibility of the land occupier/owner as part of the consent process, but it appears that this requirement has not been met. The planting of trees such as Douglas firs that pose serious threats to nearby high-value environments should be discouraged.

Douglas firs have also spread into conservation land from farmers' shelter belts (at Ewe Burn on the Milford Road, for example). The new basal spray (X-tree) that is currently being trialled in Fiordland should be an effective control tool, but these wilding firs will be a continuing problem as long as the source trees remain.

Biological control

The Environmental Protection Authority (EPA) has approved the use of a number of bio-control agents in New Zealand for the control of pest plants, including local releases of insects for the control of ragwort and broom:

- **Ragwort** Ragwort is now very common in Fiordland, even around inland lakes and remote coastal areas. Currently, biological control is the only feasible way of controlling plants in these situations. Larvae of the ragwort flea beetle live on the roots and crown of the rosette of ragwort, reducing the plant's vigour and ability to flower. They prefer drier conditions and tolerate cold, making them well suited to the Fiordland climate. This beetle has been released on the Milford Road, and at Kaipo, Big Bay, Martin's Bay Lodge/Airstrip, Hidden Falls (Hollyford) and Mavora Lakes.
- **Broom** A number of agents are available for the control of broom. The most successful is the broom psyllid, whose adult and juvenile forms both feed on new growth and cause wilting, and are able to inflict severe damage or even death of the plant when densities are high. The broom psyllid has been released in catchments of the Waiau, Whitestone and Mararoa Rivers.
- **Thistles** Several bio-control agents are available for the control of Californian and other species of thistle. These could be appropriate for use in remote areas where thistles are still in low numbers, such as along the Fiordland coast and in Takahē Valley in the Murchison Mountains.

DOC is a member of, and supports, the Te Anau Biocontrol Group, which is administered by Environment Southland's Biological Control of Weeds Programme. This group promotes and assists with the release of bio-control agents in the Te Anau district. In the future, bio-control could become a useful tool for some weed species, alongside more traditional methods of weed management.

Ragwort. *Photo: Jeremy Rolfe.*

Milford Helicopters pilot Snow Mullally releasing ragwort flea beetles at Big Bay, 2008. *Photo: DOC.*

Management of deer, chamois and goats

Compared with many other parts of New Zealand, colonisation and the subsequent control and/or eradication of feral ungulates (such as deer and goats) within the Te Anau District has been characterised by a quite recent invasion history into some remote areas, fewer taxa to manage and less risk of new incursions or re-introductions. This history is in part due to the extreme mountainous terrain of northern Fiordland and the harsher climate and lower productivity of the district's ecosystems. The shear vastness of the public conservation estate also means that the establishment of new wild animal populations (as a consequence of farmed animals escaping) continues to be less of a risk[5] than elsewhere. By the 1940s, red deer, first introduced into New Zealand in 1851, were widespread in the district. Exceptions included northern parts of Fiordland (Cleddau River catchment, Sinbad Gully and Harrison River catchment) and some of the islands in the fiords – (see *Deer eradication programmes* – chapter 1). The Cleddau River catchment is the only place considered to be deer free on Fiordland's mainland today. Goats were successfully eradicated from Fiordland by 2000. Small isolated populations of feral pigs persist throughout the district; however, their numbers have not warranted any control effort. With the exception of deer control, the only other mainland wild animal control programme in the district is for chamois, which were first recorded in northern Fiordland in 1972.

Red deer control

Red deer control in the Murchison Mountains

Red deer colonised the Murchison Mountains in Fiordland National Park during the 1930s and 40s. In 1948, takahē were rediscovered in the area. They have similar food preferences to deer, particularly when

Red deer in tussock country, 2005. *Photo: DOC*.

Typical deer browse on tussock, Fiordland, 1990s. *Photo: Daryl Eason*.

feeding on alpine tussock grasses, so efforts began to control the number and dispersal of deer to protect the takahe and their habitat.

The former Wildlife Service of the Department of Internal Affairs was initially responsible for deer control and killed at least 5000 animals by 1962. However, these early control efforts were insufficient to halt the rapid proliferation of red deer, which had spread throughout the Murchison Mountains area by around 1960 and continued to increase in number, causing considerable damage to vegetation.

In 1962, responsibility for the control of deer in the area passed to the New Zealand Forest Service, at which time hunting on foot intensified. This was followed in 1976 by commercial hunting from helicopters (supervised by the Forest Service). The introduction of commercial live trapping in 1983 was stimulated by the high commercial value of live-caught wild deer (used to establish deer farms). Some private hunting was also permitted around the fringes of the area.

In 1987, the deer control programme became the responsibility of DOC, by which time the commercial value of wild deer had fallen. Consequently, the live capture of wild deer was all but finished and the viability of helicopter venison recovery was marginal. Control operations continued to be based on a combination of helicopter hunting and seasonal ground-based hunting (carried out by DOC staff and contract hunters). However, over the following decade, the annual levels of hunting effort varied greatly depending on fluctuations in the price of venison and staff availability.

A review of the Takahē Recovery Programme in 1997 (see *Takahē* – chapter 5) identified that the variable and reduced annual hunting effort over the previous 10 years had allowed a recovery in deer numbers in the Murchison Mountains. Hunting effort and kill data collected since 1962 were used to construct an estimate

[5] Under Section 12A of The Wild Animal Control Act 1977 and in accordance with Department of Conservation Deer Farming Notice No. 5, 2008 the farming of wild animals outside of their known feral range is disallowed.

of the population size between 1964 and 1996, which indicated a substantial (>90%) decline in deer density between 1964 and 1988, followed by a small increase between 1988 and 1996.

Consequently, the Takahē Recovery Group was keen to clarify the goals of the deer control programme and to ensure that sufficient effort was maintained to achieve these. They set a control target of maintaining the deer population at <350 individuals, as significant recovery of the tussock grasslands had been recorded when this had previously been achieved in 1988. Resources were allocated to implement a more systematically structured contract hunter-based ground control and helicopter hunting programme to achieve this control target.

In 2003, Wayne Fraser and Graham Nugent from Landcare Research completed a detailed analysis of all hunting effort, deer kill and faecal pellet survey data, which confirmed earlier population size and trend estimates. They estimated that the deer population had been reduced to just over 400 animals between 1998 and 2003, and that an annual harvest of between 100 and 140 individuals would be required to maintain the control target of a population of <350 deer.

Therefore, since 2003 the deer control programme has worked to an annual control target of 120 deer, with an average annual harvest of 126 deer between 2004 and 2012. This has successfully suppressed deer numbers across the Murchison Mountains and, in places, resulted in dramatic changes in vegetation, including increased quality of takahē habitat. In the 2012/13 season, a 2-year trial was instigated for two local helicopter operators to recover deer out of the Murchison Mountains on a cost recovery basis rather than DOC paying for helicopter time. This trial was successful and deer control in this area is now achieved via a performance-based contract with a single operator engaged through a tendering process.

The commercial value of wild red deer has made a significant contribution to meeting some of their control costs over the last 40 years. However, the 'boom and bust' nature of the wild venison recovery industry means that reliance on this support will always be a risk, as any cessation of commercial deer recovery will lead to the degradation of alpine habitats. New hunting strategies and tools have been trialled, and work to increase efficiencies should be ongoing. However, skilled ground-based and helicopter hunters who are familiar with the area will continue to be a critical element of the deer control programme.

The control programme has benefited from a long history of basic data collection and associated research which has helped to develop clear conservation goals and control targets. Periodic review of the results supported by scientific analysis and a commitment to ongoing vegetation monitoring will be required to see this work continue successfully.

Looking down the Ettrick Burn to Centre Island on Lake Te Anau, Murchison Mountains, Fiordland. *Photo: Martin Sliva.*

The effect of fluctuating venison prices on deer control efforts

Although the level of Wild Animal Recovery Operations (WARO) in the Fiordland region fluctuated between 1970 and 2000 in response to changes in the price of venison, a high level of deer control was still achieved. Bill Lee, a Landcare Research scientist who monitored alpine habitats in the Stuart Mountains over this period, observed a continuing improvement in the vegetation, with a greater abundance of browse-sensitive herbaceous species.

In April 2002, all feral venison processing ceased in New Zealand due to possible poison contamination issues. Stricter conditions for supplying feral venison for export were established to provide for the sale of game, but low venison prices brought a halt to any WARO operations in the region until the 2005/06 season. As a result, deer numbers increased in Fiordland and the less-disturbed populations of deer made greater use of alpine habitats. An alpine grassland monitoring programme that was established in Fiordland at this time identified significant levels of browse at all sites measured, apart from the Murchison Mountains, where a longterm deer control programme had been running to protect takahē habitat.

Increased venison prices since 2007 have resulted in a greater level of WARO activity in Fiordland, with a concurrent decrease in deer browse in Fiordland alpine habitats.

Fiordland Wapiti Area

Wapiti (elks) are a Canadian species of deer, larger than red deer. The only herd of wapiti in the southern hemisphere is in Fiordland. In early 2000, the Fiordland Wapiti Foundation (FWF) along with other interest groups became concerned about the impact of increased deer numbers on the Wapiti Area ecosystem (Map 6), and about the hybridisation of red deer with wapiti. The lack of culling of red and crossbred deer over the summers of 2001/02 to 2003/04 (previously undertaken by commercial helicopter hunting) was of particular concern. FWF successfully raised funds through financial contributions and donations to manage animal control within the Wapiti Area. They consulted with DOC to establish Animal Control Plans for the period 2005–12 under provisions of the Wild Animal Control Act 1977 (Part 1, Section 5), as well as the Fiordland National Park Management Plan 1991 (which was later superseded by the Fiordland National Park Management Plan 2007).

The Fiordland National Park Management Plan 2007 included an implementation point to 'Encourage community group initiatives for and participate in agreed animal control programmes' (Section 4.5)[6]. Inclusion of this point resulted from a significant number of submissions during the drafting of the Plan seeking a more sustainable long-term managed approach that engaged interest groups in the control of deer within the Wapiti Area of the National Park.

After lengthy consultation between DOC and FWF, a ground-breaking Management Agreement was signed in December 2011 requiring the development of annual Animal Control Plans (hereafter referred to as the Animal Control Plan) to achieve the relevant biodiversity objectives of the Fiordland National Park Management Plan 2007 – particularly to maintain browse-sensitive indigenous flora species.

In 2015/16, the objectives were (in order of priority):

- To remove at least 850 deer from the Wapiti Area of Fiordland National Park through helicopter-assisted hunting.
- To focus control efforts on deer possessing predominantly red deer-type characteristics and wapiti crossbred animals with poor wapiti-type characteristics or poor trophy potential.
- To use, wherever possible, supervised commercial aerial recovery of red deer and crossbred animals.

Results achieved against each of these objectives are reviewed against result and outcome (including vegetation) monitoring targets, and reported on each year by FWF.

Managing the frequency of helicopter hunting and ensuring that there is a targeted effort can increase the

A wapiti/red deer cross bull with cows and hinds in Fiordland high country. Pure-bred wapiti (elks) were established in Fiordland near George Sound on 3 March 1905, when 18 animals were released. This was the only herd of wapiti in the Southern Hemisphere. *Photo: Rod Suisted.*

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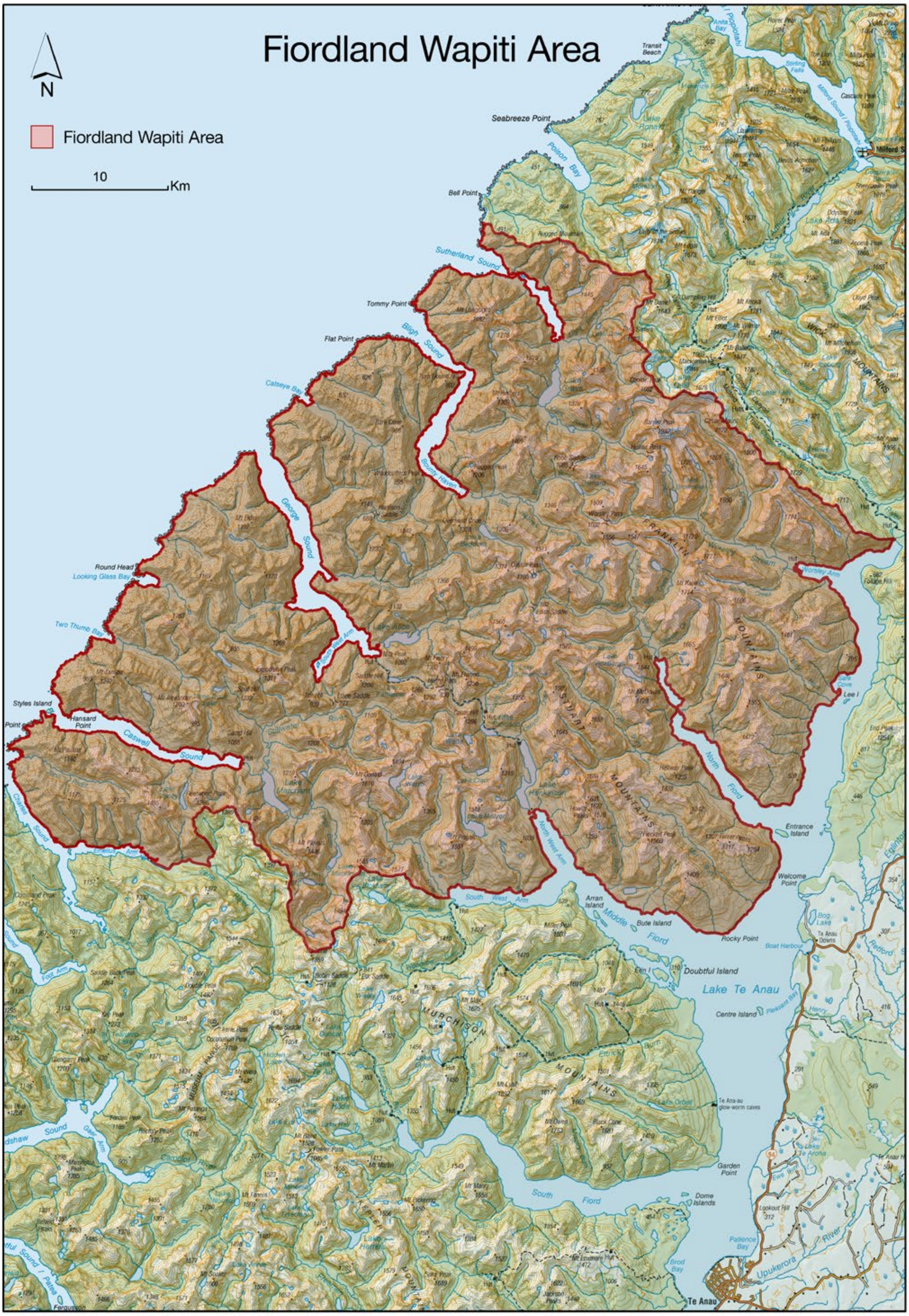
6 Fiordland National Park Management Plan 2007, New Zealand Department of Conservation.



Map 6. Fiordland Wapiti Area.

effectiveness and efficiency of this tool in achieving deer control over the long term – as illustrated by the long-running deer control programme in the neighbouring Murchison Mountains, where positive results can be seen in recent vegetation monitoring. FWF's commitment to maintaining a long-term deer control programme and protection of the takahē through establishing and maintaining stoat trapping in the Wapiti Area were considered when DOC decided to approve this alternative approach to managing deer for the area. Although (as previously mentioned) WARO activity can achieve high levels of deer control, its effectiveness can fluctuate greatly in response to the price of venison.

The Animal Control Plan for the area has been aimed at removing a significant number of deer annually over the long term. Where possible, carcasses of animals shot through the control programme have been recovered for sale to support the hunting operations. This recovery has not been carried out as a WARO concession operation but, rather, under the authority of the control plan, with the helicopter operators more recently working to a set hourly rate. Cull-and-leave operations will also be undertaken at times to ensure that a significant annual harvest is achieved. These operations generally target higher deer densities in forested areas that are less suited to recovery operations. Recreational balloted hunting remains an important part of the FWF programme.

The Animal Control Plan has also provided for the monitoring of deer activity. Trail cameras are being used to gain a better understanding of the demographics of the wapiti-type deer population, and habitat use and home ranges are being studied using radio telemetry and visual marking.

DOC is responsible for managing the vegetation monitoring programme in the Wapiti Area, which includes alpine browse transects and forest Seedling Ratio Index (SRI) plots. However, the planning of this work in the Wapiti Area is carried out in consultation with FWF and opportunities for FWF member involvement in fieldwork are made available.

Goat eradication – Clinton and Arthur Valleys

Feral goats became established in the Clinton and Arthur Valley areas of Fiordland National Park in the early 1900s, apparently from liberated domestic stock kept at Glade House and Milford Sound/Piopiotahi for milk supply.

By 1989, feral goats had been eradicated from the Arthur Valley through a combination of recreational hunting and government department-initiated control efforts – with the last two animals removed by a local helicopter pilot, Kim Hollows.

The Clinton Valley population proved harder to remove. From 1946 to 1997, sporadic hunting efforts (combined with lengthy periods of zero control) allowed for huge fluctuations in the density of feral goats in the area, with approximately 983 goats removed during this period. In 1998, a new plan to eradicate feral goats from the Clinton Valley was developed and implemented. This plan outlined a systematic and sustained approach to hunting, with the aim of total eradication of feral goats from Fiordland National Park. Eradication would be deemed successful when no goats had been sighted or removed from the operational area, and no sign had been seen for 2 years after the removal of the last feral animal. In the eradication phase of this programme (1998–2008), 38 feral goats were removed from the Park, with the last one shot in the Clinton Valley operational area on 1 May 2000.

Feral goat. *Photo: DOC.*

Chamois control

Chamois were first recorded in northern Fiordland in 1972. At this time, an aerial hunting programme to limit their dispersal south was initiated by the New Zealand Forest Service and then carried on by DOC. A limited number of animals were also recovered through the WARO harvest.

The behaviour of chamois and their broad usage of habitats make them particularly difficult to monitor. Anecdotal evidence suggests that chamois dispersal is independent of density, so immigration will continue even when numbers are low. A 1988 review of chamois control in Fiordland by Ken Tustin highlighted areas of concern, including the animals' continued southwards dispersal despite the control efforts since 1972.

After the 1988 review, a monitoring programme was established to gain an understanding of the density and distribution of chamois in Fiordland National Park. 'Islands' of alpine habitat on which chamois were known to occur and areas of suitable habitat were identified and assessed by helicopter, with all chamois or sign recorded. These 'islands' were to be flown systematically in similar conditions, but control was only to be initiated if chamois numbers were deemed to be above a predetermined intervention point – primarily because the monitoring work would be achieved more efficiently without time being spent hunting the animals. As new areas of 'choice

Clinton Valley, showing the Milford Track which runs through it.
Photo: Nir Ketaru.

habitat' were found, the number of 'islands' monitored increased so that, by the end of 2002/03, 43 had been mapped. The fact that chamois occurred on such 'islands' meant that the control could be focused; however, only a few of these areas could be aerially hunted each year due to the limited budget.

In 2003/04, chamois numbers were trending significantly upwards and control commenced with the objective of reducing chamois density to below a determined 'intervention point' to protect ecosystems. This intervention point was set at no more than three animals seen per 10 minutes' flying time during the monitoring. At the end of the 2003/04 season, results showed that at least 40% of the animals shot were outside the mapped 'islands'. A further review of the control programme in 2005/06 concluded that it was desirable to control chamois to densities that were as low as practicable across the entire area of Fiordland National Park south of the Milford Road. Therefore, this area was divided into three main control blocks (Northern, Central and Southern), within each of which 'core' areas were identified for focused hunting effort and monitoring.

Since 1998, the control programme has concentrated on chamois distribution and density south of the Milford Road, while populations north of the Milford Road have been left to commercial operations and recreational hunting groups. However, the population in the Darran Mountains is likely to be contributing to the ongoing problem of increasing chamois density in the area south of the Milford Road and some level of monitoring to form a baseline of chamois numbers is needed in this area.

In 2013, the chamois programme was again reviewed (under contract, by Richard Ewans). His review report stated that 'It is widely acknowledged that eradication of chamois from Fiordland National Park is currently both financially and technically unfeasible … reducing and maintaining chamois densities to/at low levels is highly likely to be the most effective and efficient way of ensuring protection of alpine ecosystems from damaging chamois densities in the long-term'[7]. He also reported that chamois control operations between 2003 and 2013 appeared to have been successful at reducing chamois densities in the main known populations over most of Fiordland National Park south and west of the Milford Road. He continued, 'Consistent high densities

Chamois in alpine herbfield, Fiordland. *Photo: James Reardon.*

[7] Ewans, R.; Oyston, E. 2014: A review of chamois (*Rupicapra rupicapra*) management in Fiordland National Park 1998 to 2013: evaluating success and future options. Report prepared for the Department of Conservation, Te Anau District Office, Te Anau. 28 p.

A chamois about to be shot from a helicopter during culling operations in Fiordland. *Photo: Richard Ewans.*

of chamois shot in the northern block between Franklin Mountains and Milford Road are most likely to be due to shortage of hunting intensity. Other explanations such as animals being missed on flights, animals living in subalpine shrubland or forest and immigration from outside the operational area may require investigation if increased effort in this area does not result in reduced densities'. Richard also concluded that the 1998–2003 monitoring of chamois densities on 'islands' was partially successful in identifying the distribution of chamois across Fiordland National Park, and for identifying the need for 'search and destroy'-type control operations. He pointed out, however, that assumptions about the efficacy of commercial and recreational harvests in controlling chamois densities were flawed, and that the lack of control efforts during the 1998–2003 period represented a lost opportunity to reduce densities at the time. Chamois control operations complement commercial helicopter hunting of deer (WARO) and together these operations provide a high level of protection for flora in alpine ecosystems across the 1.2 million hectares of Fiordland National Park.

Richard's review made four recommendations:

- Increase resourcing to increase effort in the northern block and comprehensively hunt the ridges west of the Main Divide in Fiordland when snow conditions allow. (Operational success should be assessed after 3 years and a decision made as to whether research is needed to address any knowledge gaps.)
- Continue to collect full track and waypoint data for flights, along with kill sheets, and ensure consistency in data collection management.
- Develop an operational plan for controlling chamois in Fiordland National Park using more systematic hunting. This plan should include target kills per unit effort for each block and for the National Park as a whole, as well as budgeting for comprehensive research using Judas animals to address the following knowledge gaps:
  - Location of groups of animals in western areas often not hunted due to snow conditions.
  - The extent to which chamois are living in forested areas in the northern block.
  - The extent to which animals are being missed on control flights.
  - Immigration into the northern bock.
- Evaluate operational success using prescribed Geographic Information System (GIS) analysis and repeat this analysis of kills per km flown in observable habitat every 3 years to evaluate success.

Management of possums, stoats and rats

The impact of introduced possums, stoats and rats on New Zealand's fauna is well documented. Professor Carolyn (Kim) King's iconic book *Immigrant killers*[8] provides an excellent account of the invasion and introduction history of possums, stoats and rats and the conservation of New Zealand's wildlife to 1984. At that time possums were seen as serious conservation pests mainly as a result of their selective browsing on native plants. Although possums had been observed on occasion eating birds and insects, few people appreciated the role they played as a direct predator of native birds. This understanding changed in the 1990s with confirmation that possums are a significant nest predator of North Island kōkako. Today, possums, stoats and (ship) rats are considered the most significant predators in the mainland forests of New Zealand.

Possums

Fiordland was one of the last regions in New Zealand to be colonised by brushtail possums. While large inshore islands such as Kā-Tū-Waewae-o Tū/Secretary and Mauikatau/Resolution have remained possum-free, it appears that possums have now colonised almost all of mainland Fiordland – and, disappointingly, they have reached the Mount Forbes Peninsula between Te Ra/ Dagg Sound and Doubtful Sound/Patea as recently as the last 3–5 years.

[8] King, C. 1984: Immigrant killers. Introduced predators and the conservation of birds in New Zealand. Oxford University Press, 224 p.

Possum control in the Eglinton Valley

Targeted control of brushtail possums commenced in the Eglinton Valley in 1994, with the key management objective of protecting and enhancing biological diversity of the valley ecosystem by reducing the impacts of possums. Taskforce Green workers ran leg-hold trap lines and hand-laid cyanide paste along the forest edge and up accessible ridges/spurs in a 2450 ha core area on both sides of the valley between the Eglinton River East Branch and Smithy Creek, and in 1995 this programme was expanded to include bait station lines. Two additional blocks (north and south) expanded the core area, taking in a total area of approximately 6400 ha in 1996 and 7355 ha in 1997. Monitoring results showed that control of possums was achieved each year, with Residual Trap Catch Index (RTCI) levels below the 3% target.

From 2000 onwards, contractors were used to carry out possum control in the valley. A mosaic of treatment methods was applied at different times across the valley, with good results (RTCI consistently below 3%, see 'Possum control in the Eglinton Valley' table). At this time, the management objective also shifted to consider the more specific goal of reducing possum impacts on beech mistletoes, which were in serious decline. In 2006, permanent bait station grids were also deployed for rat control, in response to a beech mast event.

By 2011, ground control for possums covered 4800 ha of the Eglinton Valley and also acted as the control tool for rats. Monitoring following combined rat and possum control operations using the bait station grids has shown that possums have been reduced to low levels within this block (less than 0.5% RTCI); and beech mistletoe monitoring in 2004, 2009 and 2014 showed that healthy populations remained at sites where possum control had been undertaken. During 2014, the bait station network was activated in response to a beech mast event and a predicted rise in rat levels. Rats and possums were supressed within the bait station area, but rats increased past the trigger level for control outside of the grid in the higher-altitude forest. Baits containing the toxin 1080 were applied aerially in early December 2014 (following pre-feeding with non-toxic baits) across 10,300 ha as part of DOC's 'Battle for our Birds' beech mast response programme (See 'Battle for our Birds' box). This successfully controlled rats and possums to very low levels.

Brushtail possum. *Photo: Alan Cressler.*

Possum control in the Pembroke Wilderness Area

Possums were first recorded in the Pembroke Wilderness Area in 1981. By 1997, Allan Munn, then Biodiversity Programme Manager for DOC, had observed that possum damage was visually obvious in the area south of the John O'Groats River, with widespread dead and dying rata trees in the canopy and the subcanopy of tree fuchsia, pate, māhoe and tōtara heavily browsed. Possum damage was also being reported by hunters, fishermen and DOC staff, and pre-control possum densities were as high 30–55% RTCI in the coastal forest.

A programme to reduce possum numbers in the Pembroke Wilderness Area commenced in 1999. The specific management objective was to reduce browse on palatable species such as southern rātā, māhoe, mistletoe, tree fuchsia, wineberry and haumakoroa. The programme was well funded for the first 3 years, with widespread aerial and ground control. The control target of 5% was not always met, particularly for aerial control, but at that time (prior to current best practice with pre-feeding) this was not uncommon. However, it became apparent that the relatively warm coastal environment in the Pembroke Wilderness Area favoured high possum densities and so, without ongoing management, the possum population had the potential to recover to pre-control levels within 3 years. Therefore, from 2002 to

Eglinton Valley forest. *Photo: James Mortimer.*

Why is the Eglinton Valley so important?

Located in the northwestern corner of Fiordland National Park, the Eglinton Valley is a stunning glaciated valley with steep sides, a wide, uniform valley floor and a braided shingle riverbed that is constantly changing with the flow of the Eglinton River. It is one of the few extensive lowland areas of mixed southern beech forest in New Zealand, and supports populations of more than 30 threatened plants and animals, as well as some rare plant communities. The Eglinton is also one of only a few valleys in Fiordland to have road access, making it easily reached and highly visible.


The Eglinton River and valley. *Photo: Martin Sliva.*

The ecosystem approach to conservation of threatened biodiversity has been developed and refined in the Eglinton Valley, with more than 30 years of research and the implementation of multi-species pest control. Since the ground-breaking ecological studies of stoats, mice, forest birds and beech cycles carried out there by Carolyn (Kim) King (and others) in the 1970s, further research has been undertaken on bats, forest birds, lizards, invertebrates, vegetation, monitoring methods, predators and predator control. Of primary interest have been the agents of population decline for hole-nesting forest wildlife (kākā, long-tailed and lesser short-tailed bats (pekapeka), mohua (yellowhead) and yellow-crowned parakeet (kākāriki)) and threatened plants (mistletoes and grassland communities). This work has involved numerous dedicated and long-serving DOC science and technical staff, contractors, local DOC staff undertaking pest control and species work, research students, and scientists from Landcare Research, and has resulted in no fewer than 140 published papers and theses – a true testament to the dedication of these individuals and the valuable knowledge gained. Learning from the research has also been fed back into management prescriptions. Research on mohua provides a good example of the outcome monitoring research and adaptive management that is used in the Eglinton Valley.


Colin O'Donnell radio tracking bats at Knobs Flat, Eglinton Valley, 2012.
Photo: Sabine Bernert.

In 1990, heavy beech seedfall (a mast) provided an opportunity for DOC scientists Graeme Elliott, Peter Dilks and Colin O'Donnell to experimentally reduce stoat numbers during a rapid increase in their population (an irruption or plague) to determine whether stoat trapping was a viable management option to assist mohua recovery. The experiment was then repeated in the summers of 1991/92 and 1992/93, when stoat numbers were much lower. A comparison of mohua productivity between one trapped and one untrapped site in the first season showed a substantial difference in their nesting success: 80% of the nests in the trapped area fledged young, compared with only 36% in the untrapped area. This resulted from mohua breeding pairs producing nearly twice as many young in the trapped area, despite there being fewer nests, and a


Stoat being ear-tagged, Eglinton Valley 1996.
Photo: Rod Hay.

higher proportion of breeding females disappearing from the untrapped area. In subsequent summers, breeding success was higher than previously recorded in both the trapped (87–90%) and untrapped (75–100%) areas, and numbers of mohua continued to recover. Further, trapping during the plague year only influenced stoat numbers immediately on the trapping grid, whereas trapping in the non-plague years may have affected a larger area of habitat. Therefore, the team concluded that the local reduction in stoat numbers caused by trapping was sufficient to increase mohua breeding success in both plague and non-plague years. In summary, the study has shown that a local reduction in stoat numbers caused by trapping is sufficient to increase mohua breeding success in years with both high and low stoat numbers. It has also demonstrated that many other forest birds face similar threats, and forest bird communities as a whole require integrated predator control programmes to reverse population declines.


Mohua in red beech, Eglinton Valley. *Photo: DOC.*

Mohua have continued to be monitored in the Eglinton Valley for nearly 20 years. Through that time, three other factors have been revealed as being critical to the viability of this species. Firstly, cold winters have been shown to reduce the survival of mohua below normal population levels, making the population more vulnerable to elevated levels of predation. A double heavy seedfall (mast) event in 1999–2000 also had a big impact on the population, as it led to a prolonged plague of ship rats, which caused unprecedented levels of predation on the bird population, with mohua numbers declining by 90% and these birds disappearing entirely from parts of the valley. Finally, during the summer of 2003, an epidemic of leaf roller caterpillars (thought to be *Epichorista emphanes*) resulted in over 60% of red beech trees becoming defoliated in some areas. The impact this defoliation might have had on the survival of forest wildlife populations, including mohua, was not determined. Mohua are gleaners so the increase in numbers of caterpillars may have benefited the small mohua population present in the Eglinton Valley at that time.

Battle for our Birds (and Bats)

A heavy beech seedfall (a mast event – see later box) occured across most South Island beech forests in 2014. DOC's 'Battle for our Birds' campaign aimed to save native birds and bats that were at risk from the massive predator plague that commonly follows heavy seedfall events. The intention was to aerially apply cereal pellets containing 1080 if rat indices (such as tracking rates) reached certain thresholds at key sites, which included the Iris Burn Valley (11,000 ha), the Clinton, Arthur and Sinbad Valley catchments (23,500 ha), and the upper and lower Hollyford Valley (total 35,000 ha). In the Eglinton Valley, ground-based rat and possum control began in early winter using the existing bait station network (4800 ha). The intention was to supplement this programme with aerially applied 1080 only if rat numbers also increased uphill of the ground control area. Mainland peninsulas between Te Au Moana/Breaksea and Tamatea/Dusky Sounds (35,000 ha) were identified to receive rat and possum aerial 1080 control if modelling suggested that rats would reach a predetermined trigger of 30% tracking by December 2014. The aim of the Dusky operation was to reduce the spread of possums and prevent a stoat plague, thereby reducing the risk of stoats swimming to Mauikatau/Resolution Island. Rodent levels were monitored through autumn and winter using tracking tunnel lines in all the sites to determine if the threshold levels would be reached. Based on these monitoring results the Iris Burn, Clinton, Lower Hollyford and Eglinton aerial operations went ahead; while the Arthur/Sinbad, Upper Hollyford and Breaksea/Dusky operations were deferred, as these areas did not reach the rodent thresholds. The 'Battle for our Birds' programme is ongoing.


Mountain beech forest near Lake Manapouri. *Photo: DOC.*

2010, possum control was abandoned in the high-country areas and focused instead on 1000 to 3000 ha blocks on a rotational basis in lower-altitude areas, predominantly using ground control which, in most cases, achieved the 5% RTCI target. Unfortunately, the prioritisation of biodiversity funding resulted in the cessation of possum control in the Pembroke Wilderness Area in 2011.

In 2014, under the 'Battle for our Birds' campaign, 18,900 ha of the Hollyford Valley received aerial rat and possum control. This block encompassed part of the Pembroke Wilderness Area between the Kaipo River and Martins Bay. The establishement of the Hollyford Conservation Trust (Te Roopu Manaaki o Whakatipu Waitai) in 2015 marked the beginning of an ongoing commitment by the Trust to use ground-based control methods for possums, stoats and rats within a 2500 ha portion of the lower Hollyford Valley that encompasses both private and public conservation land (including the northern portion of the Pembroke Wilderness Area). The first stage (900 ha) was completed in 2015 and the intention is to complete the remaining areas in 2016.

Possum control in the Clinton, Arthur and Cleddau Valleys

Possum control was initiated in the Clinton and Arthur Valleys (collectively taking in the Milford Track Great Walk and surrounding valleys), and the Cleddau Valley in 2005. The management objectives for this region were to reduce possum browse on palatable species such as mistletoe, tree fuchsia, wineberry and haumakoroa, and to address the high levels of disturbance by possums on kiwi (northern Fiordland tokoeka) nests in the Clinton Valley. This disturbance was observed on video surveillance from 2001 to 2005, and while nest failures and/or chick mortality (for young chicks) could not be directly attributed to possums, there was concern from DOC staff that possums could be a contributing factor.

Possum control has been predominantly by aerial broadcast of 1080 cereal pellets; however, some ground control using hand-laid 1080 pellets and trapping has also been undertaken in smaller areas. Rodent tracking following a heavy beech seeding (mast) event triggered an aerial 1080 operation in the Clinton Valley during 2014 that successfully controlled possums, rats and stoats. A similar operation was planned for the Arthur and Sinbad catchments in the same year but rodent trigger levels were not reached, and the operation did not go ahead.

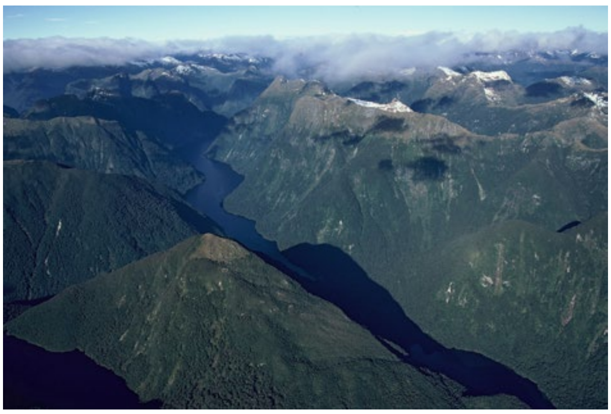
Possum control on the Mount Forbes Peninsula

Mount Forbes Peninsula (20,000 ha) is connected to the mainland by a 60 ha isthmus known as 'Narrow Neck', which prevents the joining of Te Ra/Dagg Sound and Crooked Arm of Doubtful Sound/Patea. Until very recently, it was thought that this peninsula was the largest possum-free mainland site in New Zealand. This belief was based on informal observations and limited *ad hoc* monitoring spanning several decades. However, in 2013 it was thought that possums had colonised the area as far as Death Peak and that they were present throughout Hall Arm.

In February 2013, contractors (using 170 leg-hold traps) carried out 3 nights of possum monitoring on the isthmus. The results confirmed the presence of at least one possum, with a single sprung trap containing fur. Chew marks were observed on three trees close to the sprung trap and it was concluded that the collected sign was likely to have been from a single male possum. Chew marks were also found on the wax tags, indicating the presence of adults aged 2½ years and older. In August the same year, the isthmus was revisited with the aim of clearing any possums present and establishing a 50 m × 50 m kill-trap grid that would prevent further possums from migrating onto the peninsula, so that colonisation by possums could be stopped while a decision was being made about the long-term management of the site. Ninety leg-hold traps were set out over 3 nights and a further 150 Sentinel™ kill traps were established in a 50 m × 50 m grid. No possum sign was detected by the tracking dogs at that time. At the first trap check in late October, two possums were found in Sentinels and chew marks were recorded on five wax tags across the full width of the isthmus. Possums are now likely to have established on the isthmus and moved onto the peninsula, so the relative merits of eliminating possums from the Mount Forbes Peninsula in the near future are currently being assessed.

Possum control in the Murchison and Kepler Mountains

To date, there has been no systematic possum control in the Murchison Mountains. Any possum removal that has occurred has been for commercial fur recovery only and on a limited basis, due to restricted access to the area. In preparation for the possible use of aerial 1080 for possum (and rat) control, work has already begun to develop a bird repellent for cereal 1080 to deter kea and takahē, both of which may take the standard bait. Preliminary pen trials for takahē look very promising, but a number



Te Ra/Dagg Sound. *Photo: DOC.*

Possum control in the Eglinton Valley

Year	Location	Method	Result (% RTCI)
1994/95	6400 ha core area	Leg-hold traps, hand-laid cyanide paste and bait stations	1%
1995/96	6400 ha core area	Leg-hold traps, hand-laid cyanide paste and bait stations	1%
1996/97	7355 ha core area	Leg-hold traps, hand-laid cyanide paste and bait stations	1%
1997/98	1825 ha north and south of core area	Leg-hold traps, hand-laid cyanide paste and bait stations	1.7%
1998/99	2425 ha core area	Leg-hold traps, hand-laid cyanide paste and bait stations	0.8%
1999/2000	2080 ha core area	Bait station lines with potassium cyanide (Feratox™)	Not available
2000/01	870 ha core area	Bait bags containing 1080 pellets stapled to trees	1.2%
2001/02	2080 ha core area	Bait station lines with potassium cyanide (Feratox™) in core area	1.1%
2001/02	1916 ha between Eglinton River East Branch and Fiordland National Park boundary	Leg-hold traps, hand-laid cyanide paste and 1080 pellets between Eglinton River East Branch and Fiordland National Park boundary	Not available
2002/03	3194 ha between Smithy Creek and Lake Fergus	Leg-hold traps, hand-laid cyanide paste and 1080 pellets	1%
2003/04	3600 ha of higher altitude forest in the southern part of the valley between Walker Creek and the upper Eglinton River East Branch	Aerially applied 1080 pellets @ 3 kg/ha	0.6%
2004/05	1500 ha core area	Bait station lines with potassium cyanide (Feratox™) in core area	2.7%
2004/05	750 ha block between Walker Creek and the Eglinton River East Branch	Leg-hold traps, hand-laid cyanide paste and 1080 pellets between Walker Creek and Eglinton River East Branch	Not available
2006/07	Total of 3680 ha, including 950 ha treated for rats and possums in three blocks at Walker Creek, Knobs Flat and Plato Creek; remaining 2730 ha in northern valley	Rat grid blocks used pre-fed 1080 cereal pellets in bait station grid (100 m x 100 m); remaining area used hand-laid 1080 pellets	0.5%
2007/08	3290 ha north of the original core area	Hand-laid 1080 pellets and leg-hold traps	0.3%
2008/09	Core area and Walker Creek	Trend monitoring only	0.3% & 2.7%
2009/10	3300 ha in expanded bait station grid area	Bait station grid (100 m x 100 m) with potassium cyanide (Feratox™)	0.4%
2011/12	4800 ha in expanded bait station grid area	Bait station grid (100 m x 100 m) with potassium cyanide (Feratox™)	Not available
2013/14	Valley-wide monitoring	Pre-control trend	4.8%
2014/15	4800 ha in expanded bait station grid area	Bait station grid (100 m x 100 m) with potassium cyanide (Feratox™)	Not available
2014/15	10,300 ha	Aerial broadcast operation – 1 kg/ha pre-feed + 1 kg/ha 1080 cereal pellets	0%

A love affair with mistletoe

In the mid-1990s, beech mistletoes were found to be declining across New Zealand as a result of browsing by brushtail possums. Therefore, a mistletoe species recovery plan was established and a recovery group formed. DOC's former Southland Conservancy was identified as a national stronghold for two species: the yellow-flowered mistletoe and the scarlet mistletoe – and the red mistletoe was also present. To determine whether mistletoes were being damaged and/or killed by possum browsing, monitoring was undertaken at six sites in Southland, which included the Eglinton Valley and Mavora. By 2004, all monitored sites had suffered losses – although in some cases the decline could be attributed to causes other than possums (e.g. loss of host trees, disease and lack of bird pollinators) – and both the Eglinton and Mavora areas showed a serious decline in mistletoe numbers. The high mortality of mistletoe meant that individual plants were constantly being lost from the monitoring programme, leaving insufficient sample sizes for robust statistical comparison. Therefore, a new monitoring regime was established at three sites using best practice guidelines for loranthaceous mistletoes, allowing the population as a whole to be monitored rather than a few selected plants.

Red mistletoe in tree, Fiordland. *Photo: DOC.*

In 2009, the Eglinton and Mavora plots were re-measured. Recruitment plots are generally established as a long-term monitoring tool, with little change expected for at least 5 years. However, early indications showed that the Eglinton sites (which are under possum control) contained healthy mistletoe populations. Contrary to expectations, the two sites at Mavora (where there is only intermittent possum control for the purpose of fur recovery) also indicated a reasonably healthy population, with an increase in the number and size of plants, as well as improved foliage cover. In 2014, the Eglinton plots were again re-measured and results confirmed that the plants have increased in size and that recruitment of young plants into the population has occurred.

There are limitations with the monitoring as it is currently set up in the Eglinton Valley and at Mavora. There are currently only six plots at each location, the plots were non-randomly located in areas where mistletoe were already present and easily accessible, and there is no standard way of analysing mistletoe recruitment plot data or distinguishing the sample unit which could be the individual mistletoe, the host tree, or the recruitment plot. It is also sometimes difficult to ascertain possum browse on some mistletoe species. In 2014 a decision was made to not continue with the Mavora plots but rather focus on the Eglinton Valley where there is large-scale possum control in place.

Red mistletoe showing possum browse. *Photo: DOC.*

In 2012, 11 new recruitment plots were established in the Kepler Mountains as part of the Kids Restore the Kepler Project, all of which were within the possum-control area for yellow-flowered mistletoe. A key objective of future possum control in this area is to protect mistletoe.

of complexities need to be addressed for this species, including assessing the likelihood that a bird would take baits in a wild situation. Therefore, larger field trials are now being considered. The most stable and effective bird repellent for cereal 1080 that would still achieve comparable levels of pest control to standard bait is also yet to be identified.

In the Kepler Mountains, possum (and rat) control was undertaken as part of the Kids Restore the Kepler[9] Project in 2012 and 2013, using bait stations set up in a 450 ha block. The monitoring results showed relatively high densities of possums in the area, considering the vegetation type. The 450 ha area that had also undergone rat control contained approximately a third

[9] Kids Restore the Kepler is a major conservation project with a difference. As well as having conservation goals seeking to restore birdsong in the area, the project also has a strong education focus. It aims to help Fiordland's young people, from pre-school through to college, develop knowledge, values and skills so they can be confident, connected and actively involved in caring for their environment.

Possum control in the Pembroke Wilderness Area

Year	Location	Method	Result (% RTCI)
1998/99	4351 ha from Milford Sound to John O'Groats River	Ground-based control over 1518 ha; aerial bait application over 2833 ha (3 kg/ha)	Pre-control: 16–22% Post-control: ground 2%; aerial 0.7%
1999/2000	5175 ha from John O'Groats River to Kaipo River	Ground-based control over 1825 ha; aerial bait application over 3350 ha (3 kg/ha)	Pre-control: 48% Post-control: ground 2%; aerial 9.5%
2000/01	6909 ha from John O'Groats River north to Kaipo Valley	Ground-based possum control	Pre-control: 18–36% Post-control: ground 2.7–3.3%
2001/02	10,167 ha		Pre-control: 20–36%
2001/02	Coastal blocks between Kaipo River and Martins Bay	Ground-based control over 3104 ha of coastal blocks	Post-control: most ground blocks met target of <5%; two blocks were 8.5%, but 3.2% after being reworked
2001/02	Inland between Kaipo River and Lake McKerrow/Whakatipu Waitai	Aerially applied baits over 7063 ha total – included a small coastal block of 328 ha (3 kg/ha for most of the area; 5 kg/ha on coastal block)	Post-control: coastal aerial block 8–16%; inland aerial block 2.7%
2001/02 rework	1096 ha coastal blocks between Kaipo River and Martins Bay that failed to meet possum control targets from the previous year	Ground-based control	Post-control: 4.8%
2002/03	1282 ha between Professor Creek and Kaipo River	Ground-based control	Pre-control: 13% Post-control: 3%
2003/04	1327 ha south of John O'Groats River	Ground-based control	Pre-control: 12% Post-control: <1% except for one block (413 ha) which was 7.8%
2004/05	2177 ha north of Piopiotahi/Milford Sound	Aerially applied baits (3 kg/ha for the majority; 5 kg/ha on coastal block)	Pre-control: 11% Post-control: 1%
2005/06	1065 ha north of John O'Groats River	Ground-based control	Pre-control: 21% Post-control: 0–2.4%
2006/07	2186 ha between Professor Creek and Kaipo River	Ground-based control	Pre-control: 21% Post-control: 3.4–5.0%
2007/08	1159 ha from Sydney Creek to May Hills	Ground-based control	Pre-control: 24% Post-control: most passed at 4–5%; one block of 338 ha failed at 10.6%, but was reworked to achieve 4%
2008/09	4540 ha within the Kaipo River catchment and south side of Whakatipu Waitai/Lake McKerrow	Ground-based control	Pre-control: 18–56% Post-control: 0.5–6%
2009/10	1935 ha within the Kaipo River catchment (not treated in previous year)	Ground-based control	Pre-control: 19–35% Post-control: 1.7–17%
2014	18,900 ha in lower Hollyford Valley from Alabaster Junction to Martins Bay (including the PWA from the Kaipo River to Martins Bay)	Aerially applied 1080 baits Baits hand-laid around private sections	Post-control: 1.7%

Possum control in the Clinton, Arthur and Cleddau Valleys

Year	Location	Method	Result (% RTCI)
2004/05	6910 ha Clinton North Branch and Neale Burn Valley	Aerially applied 1080 baits (3 kg/ha)	Pre-control: 13%
2004/05	577 ha in the lower Clinton Valley	Ground-based control	Post-control: aerial 0.8%; ground 4%
2005/06	2720 ha aerial control Clinton West Branch	Aerially applied 1080 baits (3 kg/ha)	Pre-control: 13%
2005/06	Ground control across 473 ha in the lower Clinton Valley	Ground-based control	Post-control: aerial 1.4%; ground 0%
2006/07	3370 ha in the upper Arthur Valley	Aerially applied 1080 baits (3 kg/ha)	Pre-control: 16.4% Post-control: 2.2%
2007/08	7300 ha in the lower Arthur and Joes Valleys	Aerial broadcast of 1080 pellets (3 kg/ha);	Pre-control: 22.4%
2007/08	735 ha ground around Lake Brown/Ada wetland	Ground-based control – hand-laid 1080 pellets	Post-control: aerial 0.7%; ground 0.7%
2010/11	400 ha in the Gulliver and Tutoko Valleys along stoat trap lines	Ground-based control with kill traps along stoat trap lines as part of comparative trap trial	Pre-control: 4–9% Trend monitor 2014: 6%
2011/12	800 ha in the lower Clinton Valley	Ground-based control with kill traps on 200 m x 100 m grid	Pre-control 2010: 4.5% Trend monitor 2014: 6%
2012/13	2135 ha in the Clinton and upper Arthur Valleys	Ground-based control with kill traps along stoat trap lines	Not available
2014/15	9000 ha in the Clinton West and North Branch, and Neale Burn Valleys	Aerially applied baits – 1 kg/ha pre-feed + 2 kg/ha 1080 cereal pellets	Pre-control 2014: 10.6% Post control: 0%

of the possum density compared with the rest of the management area (3020 ha total). Options for possum control in the Harts Hill area are currently being drafted by DOC and will be provided to the Fiordland Conservation Trust (who administers the project) for consideration. Rat tracking following a heavy beech seeding triggered an aerial 1080 operation across 11,000 ha of the Iris Burn Valley during 2014. While rats were the primary target, the operations also successfully controlled possums and stoats to very low levels.

Stoats

Stoat control in Northern Fiordland

Until 1997, control of stoats on the Fiordland mainland had been limited to trial work in the Murchison Mountains for the protection of takahē. This involved trapping in the Snag, Ettrick, Chester and Mystery Burns from 1982 to 1989, and a 50 ha trial at Deer Flat in the Eglinton Valley that aimed to assess the impact of stoat control on nesting success of mohua. Valuable research on the ecology of stoats in Fiordland, including their home range and diet, was also conducted by Kim King, Elaine Murphy and others; and a range of small-scale management and research trials had been carried out that investigated the influence of trap covers and tunnels, baits, and trap layout on trapping success. By this time, the benefits of stoat trapping for kākā in the Eglinton Valley were also beginning to be understood.

By the late 1990s, stoats were increasingly being identified as the most significant conservation pest species in New Zealand, with some of the most influential research on this having been undertaken on mohua and kākā in the Eglinton Valley. In 1997, a single trapping line comprising 193 wooden trap tunnels was installed along 40 km of the Eglinton Valley to determine whether low-intensity, continuous trapping could maintain stoats at a low enough density to protect these two forest bird species. These traps, which were a combination of Mark IV and Mark VI Fenn™ traps (to target ferrets), were checked and re-baited monthly. In 1999, ten monitoring lines for stoats and rodents (using tracking tunnels with ink pads) were established. Since 2007, the trapping programme has undergone a number of refinements, including the replacement of all Fenn™ traps with the new design stainless DOC 150™ and 200™ series traps, which was completed in 2011. The scale of trapping also increased between 2007 and 2013, bringing the total number of trap tunnels currently to 360. Stoats

P.C. Taylor removes another dead stoat as part of the Eglinton River Habitat Project. *Photo: Martin Sliva.*

are now controlled to low numbers in the Eglinton Valley and the the outcomes of this programme for mohua, kākā and other vulnerable species are evident (see *Fauna* – chapter 4).

In 2000, serious concern about the decline of whio in unmodified catchments in Fiordland prompted the establishment of 160 trap tunnels for stoats covering 30 km of river in the Clinton Valley, along the Milford Track. In the same year, tracking tunnel lines to monitor relative stoat abundance were also installed in the Clinton Valley and in the adjacent non-trapped Arthur Valley. In 2005, these tracking tunnel lines were expanded and modified to comply with new best practice guidelines; however, monitoring for stoats using these tracking tunnels ceased in 2009 in favour of using trap-catch data for result monitoring purposes[10]. In 2005, additional trap lines were established in the Cleddau River catchment, side branches of the main Arthur River, the entire Clinton Valley catchment and the Worsley Stream / Castle River catchment. In 2009, the Sinbad Valley was also included and by late 2013 more than 200 km of river habitat in the northern part of Fiordland National Park became part of the network, comprising 1200 double-set DOC 150™ trap tunnels. The resulting Northern Fiordland Whio Security Site (Map 7) now covers approximately 65,000 ha. Some of this work was – and still is – undertaken by external groups, including tourist operators and the Fiordland Wapiti Foundation who run the stoat control in the Wapiti Area, or has been funded through partnerships – for example, Southern Discoveries have formed a commercial partnership with DOC to carry out the the Sinbad Sanctuary Project.

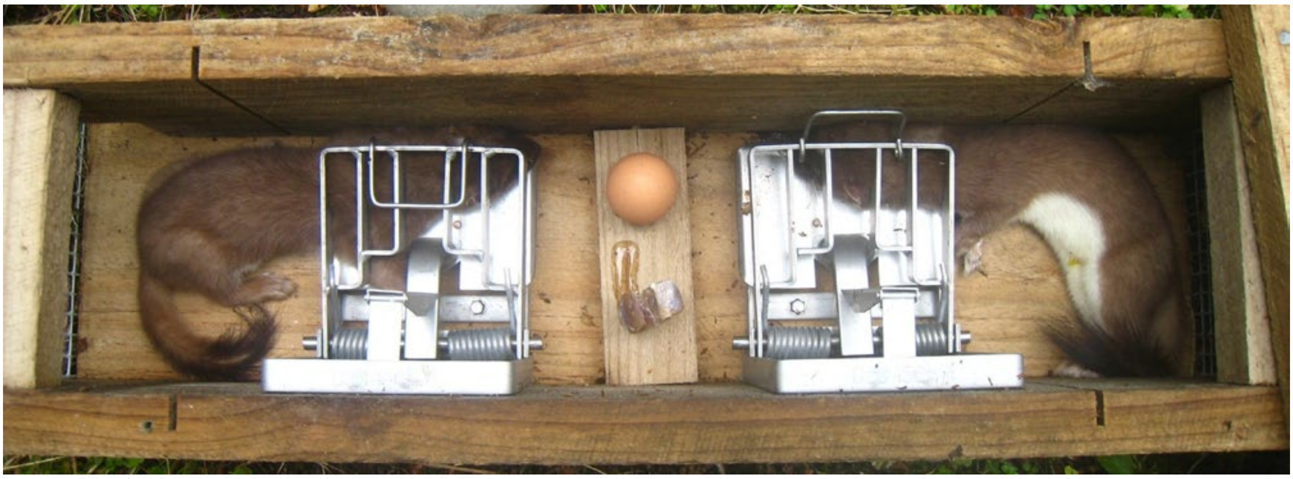
In 2006, stoat control was initiated along the Hollyford Road. This work was initially carried out by Downer, but the lower Hollyford Road traps are now serviced by members of the Gunns Camp Trust. In 2013, stoat trapping was established by the New Zealand Alpine Club in the alpine area of the the upper Hollyford / Gertrude Valley, principally for the protection of rock wrens. At the same time, small-scale trapping around McKenzie Hut (Routeburn Great Walk) was extended along the entire western side of the Routeburn Track – the initiative of hut warden Evan Smith, who instigated the collection of donations from trampers to fund this work. This programme has now been integrated with a similar trapping programme on the eastern side of the Routeburn Track in Mt Aspiring National Park.

In 2015, the Hollyford Conservation Trust – Te Roopu Manaaki o Whakatipu Waitai – initiated pest control work on a 2600 ha area at Martins Bay, Lower Hollyford Valley. Stoat control was established over a 900 ha grid in 2015 with a view to expanding this nework over the entire 2600 ha by the end of 2016.

The northern region of Fiordland is characterised by steep, U-shaped glacial valleys, which often limits

An adult kākā killed on its nest by a stoat. *Photo: Rod Morris.*

[10] Stoat tracking was repeated in the Clinton Valley before and after the 1080 operation in 2014, but no stoats were detected in either monitoring period.



Double stoat capture in DOC 150™ traps, Murchison Mountains, 2009. *Photo Shinji Kameyama / DOC.*

trapping to the valley floors. Flooding after intense rain storms also affects significant numbers of traps, putting them out of action until they are reset, and some traps are destroyed by avalanches during winter and spring, and so need to be replaced. All of the traps within the northern part of the district are checked approximately monthly, apart from those in avalanche-prone areas, which are unchecked over a 2–3-month period during winter.

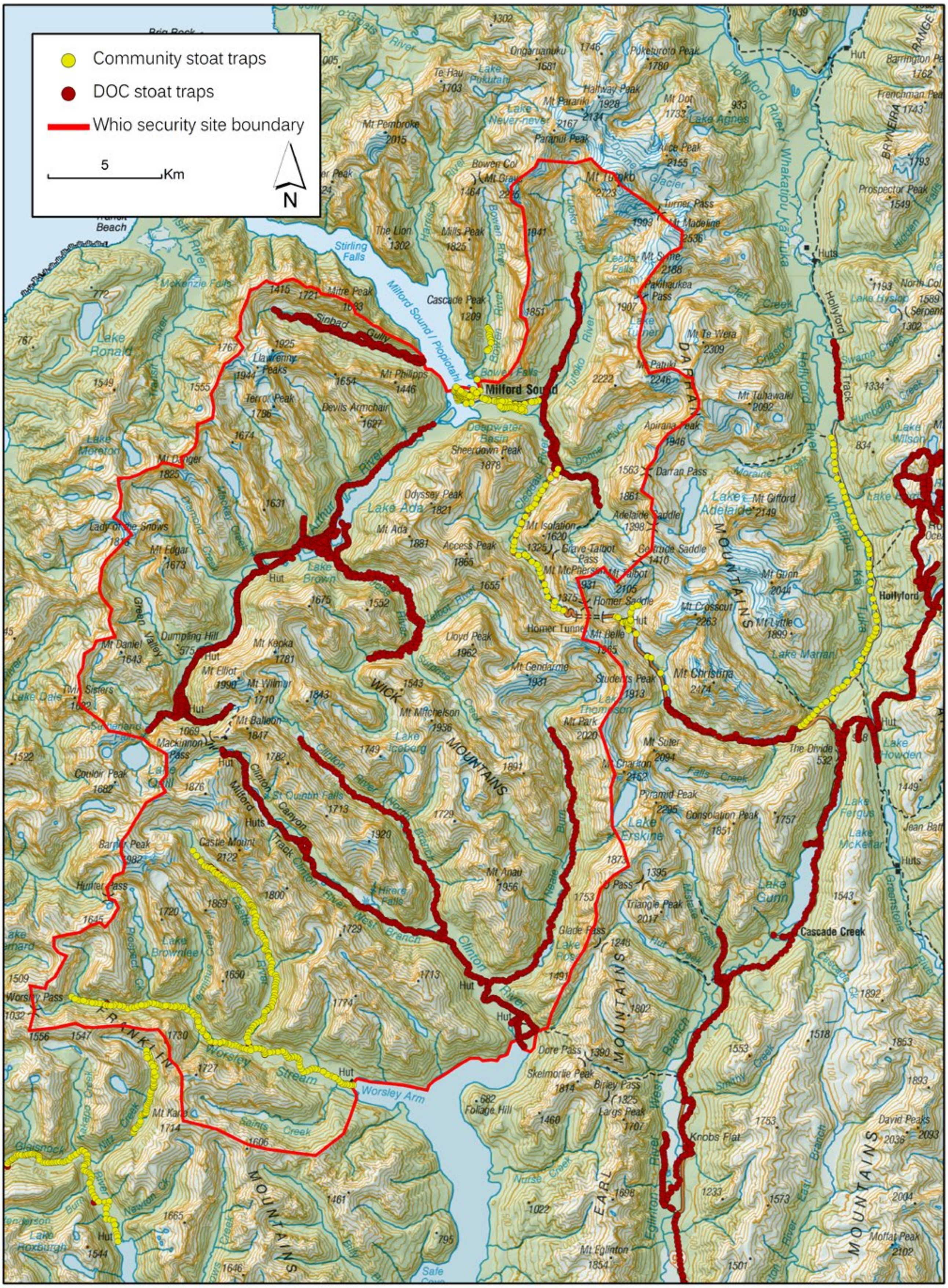
Stoat control in the Murchison and Kepler Mountains

In 1998, stoat control was proposed across the eastern 15,000 ha of the Murchison Mountains (Map 8), in order to quantify the true impact of predation on the takahē population. However, there was little direct evidence for predation of takahē by stoats, and so a low-intensity trial was designed whereby takahē productivity and survival at a trapped site was compared with an untrapped site. Funding was available for 2 years to establish the trial with trapping in the Mystery and Point Burns, and Takahē Valley in the Murchison Mountains. In 2002, the remainder of the proposed eastern 15,000-ha block was trapped using a landscape-style network (following valley floors, ridgelines and spurs) of 700 trap tunnels containing Mark IV Fenn™ traps at 200 m spacings. These traps were checked four times per year.

In 2005, 20 tracking tunnel lines were established across both the trapped and untrapped areas in the Murchison Mountains to determine whether they would provide a useful index of rodent and stoat abundances. DOC guidelines for this technique require tracking tunnels to be set along randomly orientated lines in locations that have been selected to sample a representative range of habitats in the area of interest. Initially, these lines were run in March and December 2005, and January 2006, with ten tunnels per line. Each tunnel was baited for 3 nights with peanut butter to lure rodents and meat bait for stoats. Initial results led the Takahē Management Team to eliminate the rodent monitoring component in favour of attempting to get a measure of stoat abundance. Therefore, the number of tunnels was reduced to five per line (with the removal of every second tunnel), the number of monitoring nights was increased to seven, only meat bait was used, and the tunnels were set on day one and cleared after the seventh night. This system was run in February 2007, November 2007, February 2008 and February 2009. Unfortunately, however, this method was not deemed sufficiently sensitive – for example, despite 2007 being a catastrophic year for takahē (attributed to stoat predation) and high numbers of stoats being trapped, there was only one occasion where stoat footprints were recorded (in the untrapped area). Therefore, stoat abundance monitoring in the Murchison Mountains was discontinued.

In 2009, stoat control was expanded to cover the entire 50,000 ha of the Special Takahē Area in the Murchison Mountains. Between 2009 and 2012, 1600 additional trap tunnels with DOC 150™ series traps were put in place. In 2013, the distance between trap tunnels along lines was reduced from 200 m to 100 m and 550 extra tunnels were deployed at sites where rat numbers had peaked during plague years and where reasonable numbers of takahē occurred – giving a total of 2150 trap tunnels in the Murchison Mountains by the end of 2013. By this time, all of the Fenn™ traps had also been replaced and the majority of tunnels above the bushline had been upgraded or replaced with a new design to mitigate interference by overly curious kea; the number of trap checks was also increased from four to six. This work was supported by DOC's national partnerships with Takahē Mitre 10 Rescue and Genesis Energy (for whio recovery).

A further change that occurred in the management of stoat control in the Murchison Mountains – as with many other mainland stoat control areas in Fiordland – was the contracting-out of trap servicing in November 2010. This shift has made managing such a large and challenging trapping programme more achievable. The biggest ongoing challenge for this site is maintaining a functioning trap network in alpine areas that are prone to significant snow falls, avalanches and persistent



Map 7. Northern whio security site and stoat trapping network. The map shows the current stoat trapping network in northern Fiordland National Park, including the Eglinton 1997, Clinton 2000, Cleddau 2002, Arthur 2003, Joes 2005, Worsley/Castle and Hollyford 2006, upper North Branch and upper Neale Burn 2008, Lake Brown trapping 2009, Sinbad Gully 2009, and doubled trap density along Milford Track 2012. Prior to 1997, stoat control in the northern part of the National Park was limited to a 50 ha trial block at Deer Flat in the Eglinton Valley. By 2013, stoat control extended along more than 200 km of riverine habitat in the large glacial 'U-shaped' valleys that are characteristic of this part of Fiordland.

Map 8. Murchison Mountains stoat trapping area. At the time of DOC's formation, stoat control over the entire Murchison Mountains was considered 'completely impractical'. Today, the entire 50,000 ha Special Takahē Area undergoes stoat control.

Stoats in high places

Male stoat fitted with radio transmitter, Eglinton Valley, Fiordland. *Photo: DOC.*

Historically, stoat research and management in the South Island focused on beech forest systems, with very little known about the ecology of stoats in the alpine grasslands that occur above the natural altitudinal limit of beech forest. Indeed, stoat control operations that were underway in Fiordland were based on the assumption that adjacent montane areas acted as a barrier to stoat immigration. Des Smith, a PhD student from the University of Otago, live-trapped and radio-tracked stoats in alpine grasslands above the Borland Burn, Fiordland, during the summer and autumn of 2003 and 2004. He observed that stoats spent significantly more time in alpine grassland than in adjacent beech forest and concluded that montane areas that contain alpine grasslands are unlikely to be barriers to stoat immigration – rather, they may be a source of dispersing stoats that reinvade control areas. His work also highlighted the threat that stoats pose to endemic animal species inhabiting alpine grasslands.

interference by kea. In 2013, the largest storm and flood event to have been observed in recent history in the Murchison Mountains was responsible for destroying 105 trap tunnels, predominantly in the southeastern third of the peninsula, devastating areas of track, and causing considerable damage to six DOC bivvies. In late 2013, work commenced on filling existing gaps in the trapping network on the Murchison Mountains by doubling the trapping infrastructure, with an additional 100 km of trap lines established to mitigate the rat and stoat plague that was expected in winter–spring 2014. By 2016, more than 3500 double-set trapping tunnels were in place across the Murchison Mountains. The objective is to permanently supress the stoat population across the entire 50,000 ha Special Takahē Area, allowing for the protection of stoat-vulnerable species (see chapter 4). Notably, there was no takahē mortality attributed to stoat predation in the Murchison Mountains during the 2014 rodent and stoat plague event.

In the adjacent Kepler Mountains, a line of 70 stoat traps was established along the Iris Burn in 2002. In 2007, The Kepler Challenge Committee took over maintenance of this line and extended the network around most of the Kepler 'Great Walk' track, with the addition of a further 260 tunnels. In 2012, Kids Restore the Kepler established 3000 ha of stoat control across the eastern Kepler Mountains, deploying 800 tunnels over a landscape-style network.

One less stoat in the Kids Restore the Kepler area! Jasper Carter from Mararoa School (age 6) and Ruud Kleinpaste from Kids Restore New Zealand show visiting teachers from Taupo the contents of a stoat trap. *Photo: Kerryn Penny.*

We are only just beginning to understand the impact of stoats and rodents in the alpine zone; traditionally, New Zealand's alpine fauna has been thought of as relatively secure from the impacts of introduced mammalian predators, because cold temperatures are thought to limit activity of mammals above the treeline. Increasingly however, data is being collected that indicates that introduced predators are contributing to significant declines in threatened fauna including the rock wren (see *Fauna – rock wren* – chapter 4). In order to undertake effective pest control at high altitude, best practice management tools need to be developed. This work is now underway, along with an attempt to quantify seasonal, annual and geographical variations in predation risk. Three of fourteen alpine ecosystem sites within this DOC science programme are within Fiordland National Park: Lake Roe, Merrie Range, Southern Fordland; Plateau Creek, Murchison Mountains; Homer/Gertrude Cirque.

Rats

Rat control in the Eglinton Valley

The beech mast event in 1995 and double-mast event in 1999 and 2000 prompted a significant increase in efforts to control stoats in Fiordland. However, during the double-mast event, a large and prolonged rat plague also occurred in the Eglinton Valley, where no rat control was in place. As a result, the mohua population was drastically reduced and long-tailed bat numbers

Art work and message on takahē translocation boxes sponsored by Mitre 10. *Photo: DOC.*

The ongoing challenge of controlling stoats

Significant advancements have been made in stoat control in Fiordland, particularly within the last 15 years. However, as with the island stoat eradication programmes, the critical issue of minimising immigration back into control blocks and targeting un-trappable stoats with novel methods are ongoing. Substantial progress is still needed in the areas of long-life lures and baits, self-resetting traps, and alternative methods of control (e.g. para-aminopropiophenone (PAPP)). Aside from the challenges of maintaining trap networks in an environment like Fiordland's, the biggest problem compromising our ability to deliver effective stoat control through trapping are rats and mice. In beech mast years, the abundance of food sees rat numbers rapidly increase, subsequently driving the stoat population upward, with disastrous effect on our native fauna. When traps are infrequently checked, this results in traps becoming clogged with dead rats, thus compromising stoat control.


'Another stoat down' in Fiordland. *Photo: Graham Dainty.*

declined by an estimated 30%. Consequently, in 2006, experimental ground control of rats was undertaken across 950 ha in the Eglinton Valley using Philproof™ bait stations spread across three blocks at Walker Creek, Knobs Flat and Plato Creek to respond to heavy beech seeding in autumn. Bait stations were filled with non-toxic pre-feed pellets, followed by cereal 1080 baits, to target both rats and possums. The four subsequent fills were of Racumin™ (active ingredient coumatetralyl – a first-generation anticoagulant) sachets. The management target for controlling rats was to achieve a tracking rate of 5% or less, with species recovery targets of >60% nesting success for mohua and >70% adult annual survival for long-tailed and lesser short-tailed

The important role of DOC's partners in pest control

Mainland pest control in Fiordland, particularly for stoats, has wide support from corporate sponsorship, local businesses and community groups, including:

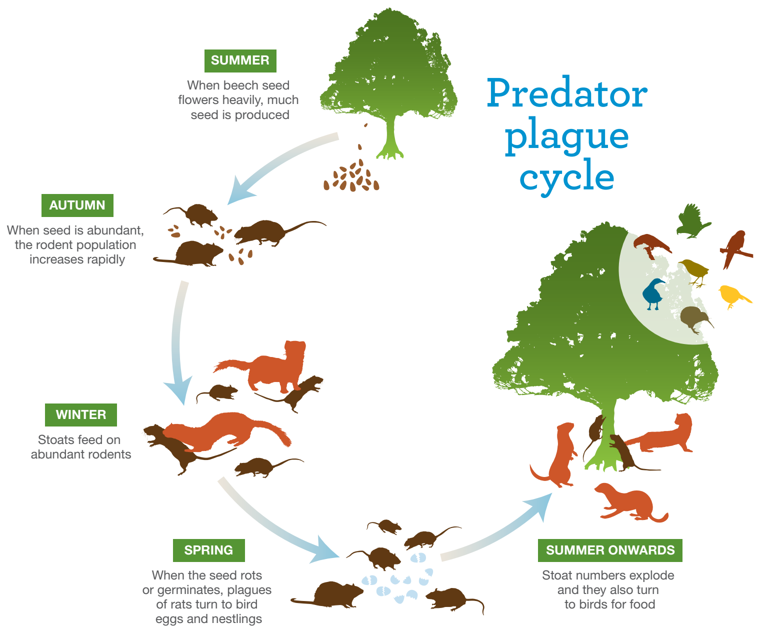
- **Air New Zealand** (trapping expansion and intensification along the Milford Track Great Walk).
- **Cruize Milford** and **Eco Tours** (trapping on the Cleddau Delta in Milford Sound/Piopiotahi).
- **Deep Cove Outdoor Education Trust** (trapping at Deep Cove).
- **Downer** (established trapping along the Hollyford Road).
- **Fiordland Conservation Trust**. Flagship projects on the mainland include:
  - Sinbad Sanctuary sponsored by **Southern Discoveries.**
  - Kids Restore the Kepler sponsored by **Kids Restore NZ**, **Community Trust of Southland** and **Distinction Hotels**. Includes a significant conservation education component with all of the education providers within the Te Anau-Manapouri basin.
  - Milford Trapping Network undertaken by **Trips & Tramps**.
  - West Arm Lake Manapouri – Deep Cove Pest Control – sponsored by **Meridian Energy** and the **Wilmot Road Users Group**.
- **Fiordland Marine Limited**, formerly **Fiordland Explorer Charters** (trapping for possums and stoats in the Wilmot Pass Area).
- **Fiordland Wapiti Foundation**, with support from **Southern Lakes Helicopters** and **Placemakers Te Anau** (trapping in the Fiordland Wapiti Area).
- **Go Orange Kayaking**, formerly **Fiordland Wilderness Experience** and **Real Journeys** (trapping around camp sites in Doubtful Sound/Patea).
- **Gunns Camp Charitable Trust** (trapping along the lower Hollyford Road).
- **Hollyford Conservation Trust** (trapping and possum/rat control, lower Hollyford Valley).
- **Hollyford Guided Walks** (trapping around Long Reef, Martins Bay, to protect tawaki (Fiordland crested penguins)).
- **Kepler Challenge Committee** (trapping along the Kepler Track Great Walk).
- **Knobs Flat Accommodation** and **True Travel Limited** (trapping and weed control around shingle river beds within the Eglinton Valley to protect nesting black-fronted terns and banded dotterels (pohowera)).
- **Milford Sound Lodge** (trapping in lower Cleddau).
- **NZ Alpine Club**, Southern Section (trapping in the Bowen, Gertrude and upper Hollyford Valleys).
- **Real Journeys** (trapping at Harrison Cove, Milford Sound/Piopiotahi).
- **Southland Trailer Yacht Squadron** (trapping at Stockyard Cove and Hurricane Passage, Lake Manapouri, to support restoration work on Pomona Island).
- **Takahē Mitre 10 Rescue** and (since 2016) **Fulton Hogan** as the new national partner for takahē (trapping in the Murchison Mountains Special Takahē Area).
- **Alpine Tours**, **Te Anau Lake View Holiday Park**, **Fiordland Wapiti Foundation**, **Fiordland Helicopters**, **Navi Outdoors Ltd** (trapping adjacent to the Murchison Mountains Special Takahē Area – Doon Valley).
- **Wild Animal Control Ltd** (Mt Forbes possum monitoring).
- Many **volunteers** and **small groups** within the Te Anau and Manapouri communities.

bats. Prior to the control operation, Des Smith (supported by local DOC biodiversity staff) also fitted radio collars to ten rats and monitored these throughout the operation to determine their fate.

Significantly fewer rat tracks were recorded in the treatment area than the non-treatment area following the bait applications in winter and spring 2006, but rat tracking still exceeded the management target for summer 2006/07. However, all of the radio-tagged rats died (eight within the first two nights), suggesting that 1080 had a high impact on the rat population – the two rats that made the smallest daily movements survived longer than the others. Live capture rates for rats were consistent with the rodent tracking data, showing a

What is a mast event?

Mast seeding is the production of unusually large quantities of seed that occurs in some plants in some years. In Fiordland, mast events are predominantly driven by beech trees and tussock grasses. Most years, total beech seed set is usually less than a few hundred seeds per m^2. In mast years, seed set can reach thousands of seeds per m^2. These occasional large flower and seed crops usually lead to correspondingly large increases in populations of seed consumers (e.g. mice and rats) and, consequently, predator populations (e.g. stoats and feral cats) – a predator plague – which generally results in increased predation on native birds and insects. In 1999 and 2000, there were two consecutive beech mast events that led to increased predation of threatened endemic birds and bats through most South Island beech forests. In the Eglinton Valley, this double-mast event resulted in a large and prolonged rat plague, during which the mohua population was severely reduced and long-tailed bat numbers declined by an estimated 30%.



reduced abundance of rats within the poison area after 1 month. However, rat numbers began to increase again 4 months after the control operation.

Of some concern was the potential for non-target species – particularly the kakaruai (South Island robin) – to be exposed to the Racumin paste. Although the sachets were contained within bait stations, rats and possums were able to pull them out of the stations, leaving the toxin available for birds. Monitoring of robins by DOC science and technical staff showed that 50% of pairs were exposed to Racumin during the operation, and evidence was also found of direct consumption of baits or traces of Racumin in several dead nestlings. Racumin is a first-generation anticoagulant that achieves maximum potency following multiple feeds rather than a single dose, making it less likely to cause secondary poisoning of non-target species and to have a lower environmental persistence than second-generation anticoagulants such as brodifacoum. However, the results from this robin study showed that the use of Racumin in sachets in areas where robins are present needed to be reconsidered. However, while the loss of robins in the rat control block at Walker Creek was greater than expected given the programme of pest control, the loss of robins at Knobs Flat (outside the rat control area) was marginally higher, suggesting that their survival in the rat control block would likely have been lower in the absence of pest control.

When the next mast event was predicted for 2009, considerable debate ensued about the relative merits of ground-based versus aerial poisoning of rats in the Eglinton Valley. Beech seed fall data revealed that masting appeared to be patchy and mainly restricted to areas of red beech in the lower valley, rather than the upper valley. It was eventually agreed that ground-based control would be carried out – again at Walker and Plato Creeks – rather than treating the entire 18,000 ha valley. However, if rat tracking exceeded a predetermined threshold (which varied by month), an aerial 1080 operation would be undertaken across the valley. The bait station block was extended up to the Eglinton East Branch, expanding the total area protected to 1500 ha. The bait was also changed to pindone cereal pellets for rats and potassium cyanide (Feratox™) for possums, replicating methods used successfully elsewhere, particular in North Island sites.

A main road runs the length of the Eglinton Valley and the terrain is relatively accessible for ground control. Therefore, this offered an ideal opportunity to test a combination of approaches for rat control. Ground control has the advantage of flexibility in timing – it can be started when needed and continued for as long as needed. This adaptability can also allow for the protection of different species at particular times of the year when they are assumed to be most vulnerable – for example, during the mohua breeding season or during the winter for bats, when they are in a state of torpor. Year-round sustained rat population management in the Eglinton Valley drew on experience gained during the 15-year control efforts at Te Urewera National Park (2000 ha) and Waipoa Forest (4000 ha) in the North Island. The result in the Eglinton valley was that rats were successfully controlled and maintained at less than 1% tracking during what was a moderate beech mast year – their numbers never increased in the middle of the valley.

Fears that both ruru (koukou, morepork) and lesser short-tailed bats would be exposed to secondary poisoning were unfounded. The survival of short-tailed bats was probably enhanced by rat control, with 319 (99%) of the 322 bats recorded in the pre-monitoring period (August) known to be alive in October 2009 and 312 of 322 bats (97%) known to still be alive in January 2010. A number of ruru that had been hit by cars within the control area were tested for pesticide residue during and after the operation, but there was no evidence of secondary poisoning.

In 2010, an area (1800 ha) from Plato Creek south to Deer Flat was included in the programme, bringing the total bait station network to 3300 ha. In 2011, a further 1450 ha were added, thereby linking all existing blocks to form one continuous 4800 ha area that covered both sides of the valley from Walker Creek through to Lake Fergus. During 2011, moderate to heavy beech seeding was experienced, and rats were controlled to below 5% with just two bait station fills in the upper valley and one fill in the lower valley.

This site in the Eglinton Valley is now one of the largest areas of ground-based rat control in the world. However, the question still remains: when would it be appropriate to implement an aerial 1080 operation in the Eglinton Valley? The relative cost of each method has been central to this debate. In 2011, sustained possum and rat control was achieved over 4800 ha of the Eglinton Valley for the same price per hectare as aerial control; and in the lower valley, where only one toxic bait fill was required, the cost was less. Possum control using this method has also met post-treatment targets.

Fundamentally, we are still identifying the scale of pest control needed to allow for the protection of some species. For example, bats have extensive home ranges of up to 10,000 ha that extend beyond the control block. Therefore, in particularly severe mast years, managers may need to control rats and stoats over a much larger area by carrying out an aerial 1080 operation in order to adequately protect these vulnerable species. The current approach is to predict the magnitude of the mast event and to have both ground and aerial methods available. During 2014, rats did irrupt across the whole valley, including the higher-altitude forest. Aerial 1080 baits were applied across 10,300 ha to control both possums and rats.

A rat enters a baited tunnel, Te Au Moana/Breaksea Island. *Photo: DOC.*

Rat control in the Murchison and Kepler Mountains

The control of rats is equally challenging in the Murchison and Kepler Mountains. Rat control is planned for the Murchison Mountains but has not yet begun. A prolonged period of high rat captures in 2011–12 in the Murchison Mountains had the potential to seriously compromise stoat control and, in turn, impact on the critically small population of takahē there. Therefore, trap checks increased from six times per year to fortnightly over the entire 50,000 ha block below the bush line in autumn and winter 2012. However, although this mammoth effort may have prevented a catastrophic loss of adult takahē to stoats, it was not a sustainable response to the rat problem in beech mast years. Therefore, the intention is to establish ground-based rat control at two or three sites, taking in an area of between 2500 ha and 5000 ha, in order to protect populations of mohua and long-tailed bats. As previously mentioned, the use of large-scale aerial 1080 within the Murchison Mountains is reliant on developing an effective bird repellent for takahē and kea, which is currently not available.

In the eastern Kepler Mountains, bait stations were established on a 450 ha block between the Control Gates and Brod Bay as part of the Kids Restore the Kepler project, with the same management target of < 5% tracking. Rat control was undertaken in 2012, 2013 and 2014 in response to moderate mast events in the Kepler Mountains, with rats successfully controlled in each of the three years (pre-control tracking: 2012 – 52%; 2013 – 21%; 2014 – 38%). The intention is to extend this 450 ha block by a further 1300 ha in 2016. An additional

Moira Pryde and Brice Erbert put a transmitter on a ruru (koukou, morepork) to monitor its health during intensive rat bait operations. *Photo: Colin O'Donnell.*

550 ha bait station grid was established in 2014 to protect a recently discovered population of long-tailed bats in the Iris Burn Valley, which is also within the Kepler Mountains (but not formally part of Kids Restore the Kepler). At the time this grid encompassed all known maternal roost sites and became operational in autumn 2014 as part of DOC's 'Battle for our Birds' pest control programme. Additionally, rat tracking indices increased beyond a set threshold over the wider Iris Burn Valley, and aerial 1080 baits were applied over 11,000 ha in August 2014, targeting rats and possums in the whole catchment.

In November 2014, a network of Goodnature A24™ self-re-setting traps were established over 200 ha at Harts Hill within the Kids Restore the Kepler Project area. The intention was to determine whether these self-re-setting traps, used at the same density as conventional kill traps, could effectively knock down rat numbers and then control them during a rat plague event in Fiordland. Therefore, the Harts Hill project was initially set up using DOC's current best practice guidelines for ground-based rat control on a 50 m × 100 m grid. Rat tracking went from 68% in the trial block in November 2014 (versus 74% in the non-treatment area) to 0% in February 2015 (versus 68%); 0% rat tracking was observed in April 2015 (versus 68% in the non-treatment area). Following the success of this trial, the grid was extended over 600 ha, but the density of A24™ traps was effectively halved (100 m × 100 m grid). The network achieved the desired level of rat control (0% and 1% rat tracking at 2 and 3 months post-treatment respectively), reducing the cost of traps for the project by half.

In the Murchison Mountains, where there is no targeted rat control in place, rat captures peaked in 2012 but not in 2013, highlighting the patchiness of masting events. Therefore, managers need to have the flexibility to manage key sites (e.g. for critical species) more intensively rather than simply applying intermittent control over large areas. For example, in the Kepler Track area, the lakeshore beech forest appears to provide very good habitat for rats, as trees may seed more frequently than at other sites, so rat control possibly needs to be carried out more frequently here than at other Fiordland sites.

Rat control in the Cleddau Valley

In 2007, a much smaller (40 ha) rat control block was established in coastal forest on the old Cleddau River delta at Milford Sound/Piopiotahi. The intention was to control rats (and stoats) to a level that would allow the native bird species present to breed successfully, leading to a general increase in birdlife around the Milford Sound/Piopiotahi township. Bait stations and stoat traps were set up in a grid across the block. In 2008, the bait stations were replaced with rat kill-traps in a trial investigating the effectiveness of two different types of rat trap: single-set DOC 150™ traps versus single-set Ka Mate™ traps. The DOC 150™ series traps (for rats and stoats) were found to outperform the Ka Mate™ traps, which were subsequently replaced. All of the single-set trap tunnels were replaced with double sets in 2013. Unfortunately, the kakaruai (South Island robin) transfer to the Cleddau Delta was unsuccessful, as the birds dispersed outside the area, although they have settled further up the Cleddau Valley. However, bird call counts after 3 years of trapping indicated a substantial increase in common native forest birds such as bellbirds (korimako), tomtits (miromiro) and tūī.

The Fiordland region is not only floristically significant nationally, but is also an important stronghold for several threatened species.

Celmisia species in seed above Secretary Lake, with Thompson and Bradshaw Sounds in the distance.
Photo: Graham Dainty.

Ecosystem response to pest control

Flora and plant communities

Since 1987, considerable effort – both planned and opportunistic – has gone into surveying threatened flora (plant species) and vegetation in general (plant communities) in Fiordland. This region is not only floristically significant nationally, but is also an important stronghold for several threatened species.

Around 1000 vascular plant taxa[11] are thought to occur in Fiordland, which makes the region much richer, ecologically, than previously understood. The Fiord Ecological Region contains 11 species classified (under the New Zealand Threat Classification System) as Threatened, 96 as At Risk, 2 as Vagrant and 5 as Data Deficient – and several of these have their national stronghold within Fiordland. Nationally important populations of some species classified as Naturally Uncommon also occur. Fiordland is also known to be an important region for endemism, with 24 taxa endemic to Fiordland, 11 near-endemic and a further 13 restricted to southern New Zealand. The single most important habitat for threatened plant conservation in Fiordland is the lakeshore turf communities. Other important habitats include sand dunes, valley floor grasslands, wetlands, cliffs and forests.

However, despite the importance of this region, few threatened plant monitoring programmes and practically no plant-species-specific conservation management programmes are currently in place – although the region's broader-based ecosystem management programmes do provide benefits for at least some of the threatened plant species and communities (e.g. the Murchison Mountains, Eglinton Valley and Kā-Tū-Waewae-o Tū/Secretary Island programmes). In the next 25 years, it is anticipated that there will be more impressive conservation outcomes for flora and vegetation in Fiordland, including active conservation management and monitoring for additional species through DOC's Natural Heritage Management System (NHMS) and active Ecological Management Units.

Key achievements in the region for plant conservation to the end of 2015 included:

- A substantial improvement in our knowledge of the distribution and status of threatened plants in Fiordland.
- Recognition and documentation of the flora, vegetation and wider ecological values of the Fiordland / Te Anau Basin area.
- Identification of national strongholds for heart-leaved kōhūhū, the shrub *Melicytus flexuosus*, the tree daisy *Olearia lineata* and small-leaved coprosma in Back Valley.
- Recognition that the lakeshore turfs found around Lakes Manapouri and Te Anau are among the most significant plant habitats in Fiordland (these communities are a national stronghold for several plant species).
- Protection of the Dale bog pine area as Dale Conservation Area.
- Retirement of the Mavora Lakes and Eglinton Valley from grazing.
- Working with community groups to restore and manage important ecological values (notably Pomona Island Charitable Trust, Te Puka-Hereka/ Coal Island Trust, Waiau Fisheries & Wildlife Habitat Enhancement Trust and QEII National Trust).

The Dale bog pine area. *Photo: Brian Rance.*

Flora and vegetation surveys

Written flora and vegetation reports for Fiordland have been produced from at least 54 surveys and/or sites. These surveys originated as threatened plant or 'interesting place' surveys (e.g. limestone geology, ultramafic geology, granitic stonefields, wetlands), either to support management (especially on some islands) or opportunistically. A number of surveys were also undertaken to determine the impact of land-use

[11] Taxon (singular) and taxa (plural) represent any taxonomic unit(s) from the lowest rank (species and subspecies) and higher (e.g. family, genus).

DOC botanist Brain Rance at work surveying a wetland on Mt Titiroa, 2012. Brian has done a considerable amount of the vegetation survey work carried out in Fiordland. *Photo: Sue Lake*.

activities, including DOC structures and activities, Resource Management Act (RMA) consents, and Tenure Review and Crown Pastoral Land Act consents.

Vegetation assessments

Vegetation assessments are often made when land use change activities are proposed for a certain area – particularly where these are likely to impact on indigenous vegetation. DOC has been involved in undertaking vegetation assessments for the following areas:

- Milford redevelopment
- Mt Prospect Station (RMA and Crown Pastoral Land Act (CPLA))
- Glen Echo Station (RMA – subdivision)
- Ram Hill Block, Landcorp Hikuraki Station (RMA)
- Claytons Block, Landcorp Centre Hill Station (RMA)
- Jericho, Landcorp Farm (RMA)
- Landcorp Mararoa Station (RMA)
- Landcorp Duncraigen Farm (RMA)
- Wilson Lime, Elmwood Creek (RMA)
- Routeburn to Hollyford Tunnel proposal concession
- Riverstone Holdings Ltd monorail concession

Red tussock dominates the valley floor of the Thomas Burn catchment on Mararoa Station. A combination of a QEII Open Space Covenant and a Habitat Enhancement Agreement (which protects more-modified areas) has seen complete protection of 12 km of stream on the property. *Photo: Mark Sutton.*

Documenting the ecological values of these areas has allowed their protection to be advocated and better environmental outcomes have been achieved including, in some cases, QEII Open Space covenants.

Vegetation monitoring

Several plant and ecosystem monitoring projects have been instigated in Fiordland, including:

- Alpine grassland condition.
- Forest health (many permanent forest plots were established by the New Zealand Forest Service, prior to the formation of DOC – see chapter 3 and *Management of deer, chamois and goats* – chapter 4).
- Grassland composition/condition at Mavora Lakes and the Eglinton Valley.
- Mistletoe at Eglinton Valley and Mavora (see *Management of possums, stoats and rats* – chapter 4.
- Lakeshore turfs (undertaken by Meridian Energy).

'Under the mistletoe'. DOC staff searching for mistletoe in the beech canopy above during mistletoe monitoring at Mavora Lakes, 2006. *Photo: DOC.*

Alpine grassland condition monitoring was established in the Murchison Mountains in 1989, and targets indicator species that are known to be preferred foods of both deer and takahē. Permanent transects and plots were established in mid-ribbed snow tussock grassland sites in two representative regions, and these are measured every 5 years to monitor vegetation changes and use by deer. Another monitoring programme was established in the Murchison Mountains in 2002, which targets key takahē winter food plants. Five forest margin sites were selected based on the knowledge that they were used by both takahē and deer, and three plots were established at each site – one fenced to exclude deer, one fenced to exclude both deer and takahē, and one unfenced control – which are also measured every 5 years.

In 2005, a method of monitoring deer browse on selected palatable alpine herbs was trialled at four sites in the Murchison Mountains and in the adjacent Doon region, after the commercial venison industry stalled and deer numbers increased to high levels in Fiordland (see

Threatened and uncommon plant species with strongholds in the Fiordland region

***Alepis flavida* (yellow-flowered mistletoe)** – Important populations are found at the Lake Te Anau control structure to Broad Bay, Boyd Creek 'tops' track, Murchison Mountains eastern lake faces and Mavora; also scattered across many other sites.

***Brachyscombe linearis* (lakeshore dwarf daisy)** – This endemic species is restricted to Lakes Manapouri, Te Anau and South Mavora.

***Carex tenuiculmis* (red sedge)** – Good populations occur in parts of the Upper Mararoa Valley and Dawson City wetland complex; also scattered across many other sites.

Coprosma pedicellata – An important population occurs in Back Valley; it is uncommon elsewhere in eastern Fiordland.

***Deschampsia caespitosa* (tufted hair grass)** – Important populations occur locally around the shores of Lake Manapouri (and quite possibly Lake Te Anau), Lake Ada/lower Arthur River and Glen Echo Station (RMA – subdivision).

Hebe arganthera – An endemic species that is restricted to limestone and marble geology outcropping in upland Fiordland. The largest population occurs in Takahe Valley.

***Melicytus flexuosus* (a shrub)** – Important population occurs in Back Valley; uncommon elsewhere in eastern Fiordland.

***Olearia lineata* (a tree daisy)** – Important population occurs in Back Valley; uncommon elsewhere in Fiordland.

***Peraxilla colensoi* (scarlet mistletoe)** – Important populations occur in the Murchison Mountains and on the eastern lake faces of both the Glaisnock and the Eglinton valleys. Also scattered at many other sites, including Fiordland islands.

***Pittosporum obcordatum* (heart-leaved kōhūhū)** – Important population occurs in Back Valley; unknown elsewhere in Fiordland.

***Ranunculus ranceorum* (a buttercup)** – Important populations are found in the lakeshore turf communities of Lake Manapouri (and quite possibly Lake Te Anau).

***Ranunculus ternatifolius* (a buttercup)** – Important populations occur in damp red tussocklands (e.g. Mavora) and damp hollows in forests.

***Sticherus tener* (umbrella fern)** – Important population occurs on Taumoana/Five Fingers Peninsula, Mauikatau/Resolution Island.

***Tetrachondra hamiltonii* (a creeping herb)** – Important populations are found in the lakeshore turf communities of Lake Manapouri (and quite possibly Lake Te Anau).

***Trithuria inconspicua* (an aquatic rush)** – Important populations occur in Lakes Manapouri, Te Anau, Hauroko and Mavora.

Yellow-flowered mistletoe. *Photo: John Barkla*

Tufted hair grass. *Photo: Chris Rance.*

Heart-leaved kohuhu. *Photo: Chris Rance*

Scarlet mistletoe. *Photo: Chris Rance.*

Ranunculus ranceorum turf. *Photo: Brian Rance.*

Notable vegetation surveys undertaken in the Fiordland Region, 1987–2015

Wetlands

- Sinclair Road (Landcorp Eweburn Farm, either 1991/92 or 1992/93), Riverslea Farm (Landcorp, 1991), Te Anau Downs Station (1994), Te Anau Basin (1995; included 42 wetlands), Boyd Creek 'tops' (1999), Rakatu Wetlands (2000), Mararoa Valley (2001), Centre Burn Wetland (2002), Mt Prospect Station (2003), Back Valley (2007), Home Creek Wildlife Management Reserve (2010), Rainbow Reach wetlands (2010), Balloon Loop (2013), Te Anau Downs kahikatea forest (2013), Kākāpō Swamp (2013).

Back Valley near Manapouri is a key site for a number of threatened plant species. *Photo: Brian Rance.*

Limestone geology

- Monk Lake (1993), Lake Wapiti (1994), Xanadu Cave (1995).

Ultramafic geology

- Mt Cerberus – southern Livingstone Mountains (1995), Mt Richmond Central – central Livingstone Mountains (2000), Mt Moffat – northern Livingstone Mountains (2008), Bald Hill (2009).
- Granitic stonefields and upland ribbonbog wetland.
- Mt Titiroa (2012).

Xanadu Cave. *Photo: Chris Rance.*

Islands

- Te Au Moana/Breaksea Island (1989), Entry Island (1989), Hautere/Solander Island (1997), islands of Tamatea/Dusky Sound and Doubtful Sound/Patea (2002), Pukenui/Anchor Island (2002), Kā-Tū-Waewae-o Tū/Secretary Island (2003), Te Puka-Hereka/Coal Island (2005), Pomona Island (2005), Mauikatau/Resolution Island (2009), Cooper Island (2015).

Mt Cook buttercup (*Ranunculus lyalli*) in full flower above Lake Eyles, Murchison Mountains, Fiordland, 2012. *Photo: James Reardon.*

Management of deer, chamois and goats – chapter 4). The monitoring programme was developed to test the impact of deer browse on selected alpine herbs along 220 transects across 44 sites located throughout the Fiordland alpine zone. The baseline belt transects (50 m × 2 m) were set up in 2006 and repeat measurements were completed across all sites in 2008/09, and 2011–13. Results showed that the condition of the herbs significantly improved following the recovery of the venison market and the resumption of aerial deer hunting. This series of three measurements also provides valuable baseline information for any future investigation into the impacts of deer at these sites, and the method could be easily and affordably expanded to additional alpine sites of particular concern or interest.

Alpine grassland monitoring at other sites includes 30 modified alpine Wraights plots on Kā-Tū-Waewae-o Tū/Secretary Island.

John Whitehead monitoring the impact of deer browse on alpine grasslands, Transit shelf, Fiordland, March 2006. *Photo: DOC.*

Grassland composition and condition monitoring was established in 1995 at Mavora to determine the impact of stock grazing in the Conservation Area. Three paired 50m Scott height-frequency monitoring lines (inside and adjacent to fenced exclosure plots) were established in dry short grassland, tall red tussock grassland and wetland. The lines were re-measured in 1996, but the area was subsequently retired from grazing and the monitoring discontinued.

In the Eglinton Valley, grassland composition and condition monitoring was established in 1998, following the removal of grazing. Three 50-m Scott height-frequency monitoring lines were established at grassland flats south of Eglinton River East Branch, south of Black Creek (Mirror Lake) and in a wetland at Knobs Flat, and photo points were also set up. Exotic grass species still dominate these areas, slowing any potential recovery of the native grasses.

Lakeshore vegetation monitoring is undertaken by Landcare Research on behalf of Meridian Energy, as part of their RMA consent requirements. It involves re-measuring permanent transects around the shores of Lakes Te Anau (21 transects) and Manapouri (16 transects) to determine whether changes in wetland turf species, other ground cover, shrub counts, small tree numbers and tree diameters relate to lake-level management. This monitoring is undertaken 5 yearly (unless very high or very low lake levels occur) and, to date, monitoring has been undertaken and reported on in 1997, 2000, 2005 and 2010. While natural changes and fluctuations in the abundance of common species have been observed, there has been no evidence of an impact from the hydroelectric scheme. Unfortunately, it has not been possible to include some of the threatened plant species that occur around these lakes in a statically robust manner in the monitoring due to their limited abundance. However, targeted monitoring for some of these species should be picked up in the near future as part of DOC's NHMS programme.

Forest health monitoring to determine the current health and long-term condition and trends in forest ecosystems has been established at a number of sites, including:

- Kā-Tū-Waewae-o Tū/Secretary Island: 43 forest plots (20 m × 20 m) and 17 Seedling Ratio Index (SRI) transects measuring deer impacts and subsequent forest recovery following their removal (see chapter 2).
- Mauikatau/Resolution Island: 20 SRI monitoring transects measuring deer impacts and subsequent forest recovery with management.
- Pukenui/Anchor Island: 9 forest plots (20 m × 20 m) measuring forest recovery during and after the eradication of deer
- Murchison Mountains: 33 Point Height Index shrubland plots (2 m × 5 m), 5 exclosure plots (20 m × 20 m) and 10 SRI transects measuring deer impacts and subsequent forest recovery with management (see *Management of deer, chamois and goats* – chapter 4).
- Pomona Island: 5 forest plots (20 m × 20 m) monitored by Pomona Island Charitable Trust
- Te Puka-Hereka/Coal Island: 20 SRI monitoring transects measuring forest recovery with management, monitored by DOC Research Associate Jeff Rogers

The permanent camp on an extensive glacial bench near Secretary Lake, showing the variable vegetation pattern looking west across Kā-Tū-Waewae-o Tū/Secretary Island, June 2011. *Photo: Sir Alan Mark.*

One of the 30 grassland monitoring plots on Kā-Tū-Waewae-o Tū/ Secretary Island being surveyed, 2009. *Photo: DOC.*

View southwest from the permanent campsite near Secretary Lake towards All Round Peak, 2011. *Photo: Sir Alan Mark.*

- Central Fiordland: 30 SRI transects located at three sites: Namu, Delta Burn and Camelot-Cozette Burn
- Waitutu forest: 3 paired exclosure plots (20 m × 20 m)
- Wapiti Area: 30 SRI transects at Glaisnock, Catseye and Wapiti River monitored by DOC in partnership with the FWF (see Management of deer, chamois and goats – chapter 4)

Land protection

Three land protection applications have been made by DOC over the period 1998–2013: Dale Bog Pine protection/exchange, Martins Bay section Natural Heritage Fund (NHF) application and Cromarty section NHF application.

The Dale Bog Pine protection/exchange occurred in the late 1980s and early 1990s, and involved the exchange of a parcel of Public Conservation Land in the Oreti River Valley (grazed by Landcorp Centre Hill Station – McLeod's Block) for a parcel of land on Dale Farm (Dale Bog Pine Block). McLeod's Block was rough pasture that had traditionally been grazed by Landcorp, while the Dale Bog Pine Block was the remaining section of a once extensive bog pine shrubland on Dale Farm – and one of the most important areas of bog pine known in New Zealand. This Block complements the Wilderness Scientific Reserve by being in a higher rainfall zone and also has a more intact setting, as it adjoins part of Snowdon Forest. As a notable site, it also has greater ecological diversity, with an associated peat bog.

View over the Redcliffe wetlands, one of the Waiau Fisheries and Wildlife Habitat Enhancement Trust's many wetland restoration and protection projects in the Te Anau basin. *Photo: Mark Sutton.*

Monitoring the impacts of feral deer on vegetation in Fiordland, 1988–2013

It is imperative that we monitor vegetation so that we can determine which species are most at risk from deer impacts and so require the greatest protection.

The most successful and widely applied monitoring method for assessing the impact of deer on forest health is the establishment of permanent 20 m × 20 m vegetation plots and the Recce method for describing New Zealand vegetation. There is a long history of the use of permanent plots throughout Fiordland (45 years in some cases), including on Kā-Tū-Waewae-o Tū/Secretary Island, in the Murchison Mountains and on Pukenui/Anchor Island:

Biodiversity Ranger Dave Crouchley setting up a permanent 20 m × 20 m pen to monitor deer browse on vegetation. *Photo: DOC.*

- Forty-three plots were established on Kā-Tū-Waewae-o Tū/Secretary Island in 1976, just prior to the dramatic increase in the red deer population. These plots were re-measured in 1988, when the deer population was thought to have peaked, and again in 2003/04 prior to the most recent campaign to rid the island of deer. Adrian Monks of Landcare Research reported that the results of the latest re-measurement showed that the presence of red deer since the mid-1960s has 'caused significant changes in the composition and structure of the forest understorey, with restricted presence and regeneration of a suite of deer-preferred plant species. Unpalatable species, such as most conifers and selected tree ferns, appear to be slowly increasing … '.*
- Five exclosure plots were established in the Murchison Mountains in 1969. These were re-measured in 1975, 1980, 1998 and 2004. Sapling densities for all palatability classes were significantly greater within exclosure plots than in control plots by 1998. This difference persisted in 2004. The authors of the study concluded that the greater plant densities within exclosures suggested that deer were still limiting recruitment outside the exclosures. They also noted that the difference between exclosures and controls was greatest for plants highly preferred by deer.
- Nine plots were established on Pukenui/Anchor Island in 2001, prior to the programme to eradicate deer (see *Management of deer, chamois and goats* – chapter 4). These plots were re-measured in 2007 and 2012. The Pukenui/Anchor Island forest understorey showed an increase in palatable species between 2001 and 2007, and this trend is expected to continue, since deer are still absent from the island.

Deer browse on *Celmisia verbascifolia*, Lake Wapiti head-basin, Fiordland, 2005. *Photo: Sue Lake.*

Unfortunately, permanent plot monitoring is a relatively expensive tool, requires over 10 years between sampling periods to show any change and yields data that are complex to analyse. In addition, much of the earlier work in Fiordland was poorly documented, making it less useful for comparisons. Today, data from the vegetation surveys are entered into the Landcare Research National Vegetation Database.

A second method for measuring deer impacts, based on work done by Landcare Research botanist Bill Lee, was developed and tested by DOC staff in Te Anau in 2005; it uses the Fiordland alpine deer browse transects. This method quantifies deer impacts on selected palatable herbs in alpine areas. It is simple to use and assess, cost-effective, and shows a rapid change in the extent of deer browse as the population trends up or down, with repeat measures potentially showing changes over 1–2 years. This short timeframe was particularly important for DOC at that time, as deer numbers had increased rapidly following the cessation of commercial venison recovery in 2002. In 2006, the programme was expanded to include 220 belt transects at 44 sites across alpine habitats in Fiordland. Measurements were repeated in the summers of 2008/09 and 2011/12–2013/14. Since 2006, the amount of deer browse recorded on the selected alpine herbs has reduced significantly to low or very low levels. This reduction coincides with the resumption of aerial control of deer, with approximately 35,000 deer removed from Fiordland during the same time period. This baseline information now provides a very useful tool for assessing any changes in deer impacts that may occur in the future.

Cathy Allan and Ant Kusabs measuring deer browse monitoring transects in an alpine herbfield, Midnight Creek, Glaisnock Valley, Stuart Mountains, December 2000. *Photo: Jane Maxwell.*

The third method uses Seedling Ratio Index (SRI) measurements to quantify deer impacts in forests by monitoring the change in numbers and growth of palatable versus non-palatable seedlings and saplings. This is a simple, cost effective method that can be used to detect large changes over a relatively short timeframe (4–5 years). Furthermore, the data are straightforward to analyse. SRI transects have been established on Secretary Island (17 lines), on Mauikatau/Resolution Island (2009; 20 lines), within the Fiordland Wapiti Area (2010; 30 lines), in the Murchison Mountains (2011; 10 lines) and in central Fiordland (2011; 30 lines). To date, only the lines on Kā-Tū-Waewae-o Tū/Secretary Island have been re-measured showing a significant recovery of deer-palatable species in the forest understorey in 2010, following the removal of 651 deer from the island – and further improvements can be expected if deer remain at low numbers or are eradicated.

The alpine deer browse and SRI methods are particularly valuable in terms of alerting managers to impacts on vegetation that may require intervention. However, all of these monitoring methods require ongoing commitment to make them useful. It is vitally important that the monitoring regimes are maintained as planned – programming work that is not on an annual cycle can be especially challenging in terms of acquiring resources and ensuring that it is actually carried out.

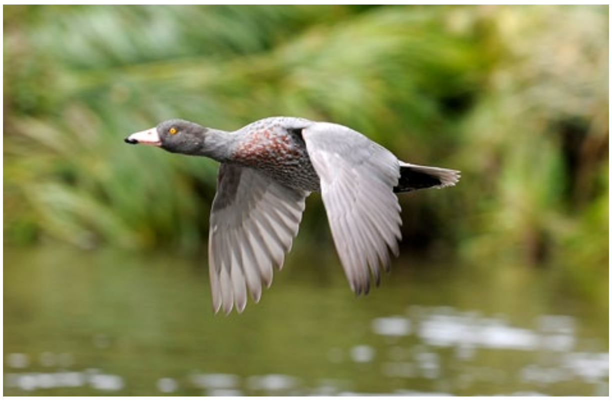
* Monks, A.; Lee, W.G.; Burrows, L.; McNutt, K.; Edge, K-A. 2005. Assessment of forest changes on Secretary Island, Fiordland National Park, from 1975 to 2003, based on long-term plot measurements, in relation to the presence of deer. Unpublished Landcare Research Contract Report LC0506/007.

In 1992, an NHF application was prepared for a 20 ha section adjoining the northeastern shore of Lake McKerrow and the Martins Bay – Big Bay track; however, this application was unsuccessful. In 1997, an NHF application was prepared for a private section at Cromarty within Fiordland National Park, which is of strategic significance. Unfortunately, this application was also unsuccessful.

The QEII National Trust has also been very active in working with landowners to protect land by way of Open Space covenants in perpetuity. Landcorp has been particularly receptive to this and now has many covenants on its properties. The Waiau Fisheries and Wildlife Habitat Enhancement Trust have also been very active, purchasing property (e.g. Redcliffe Wetlands and Home Creek Wetland), managing other areas (e.g. Waiau Mouth Public Conservation Land under concession) and providing riparian protection through their Habitat Enhancement Agreement grants.

Fauna

By far the biggest challenge in Fiordland has been, and still is, providing protection for many native animal species over large mainland areas. In the last 30 years, there has been significant progress in the development of translocation tools (see chapter 3). However, we are only just beginning to understand the scale of protection required for many species. Pest control is working well to protect some species in some areas (e.g. whio in northern Fiordland). However, large-scale ecosystem protection on the mainland is required for some species (e.g. mohua and long-tailed and lesser short-tailed bats, whose survival relies on the control of rats during plague years). The situation is even worse for lizards, with some threatened species not being under any management and the likelihood that other species are yet to be discovered. The following sections outline some of the work that has been undertaken on native fauna in Fiordland.

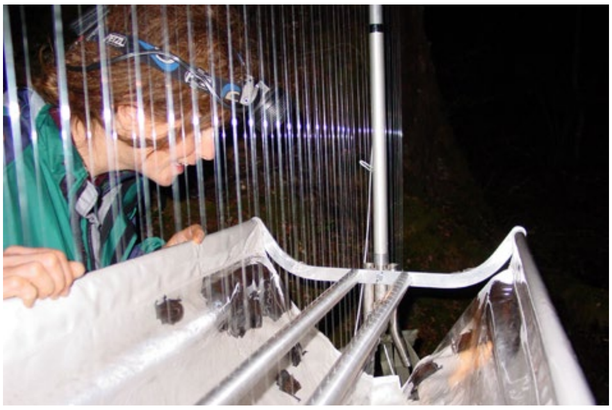

Whio in flight. *Photo: Barry Harcourt.*

Long-tailed and lesser short-tailed bats

Research and monitoring of long-tailed and lesser short-tailed bats in the Eglinton Valley has contributed significantly to most of what we currently know about New Zealand bats. Much of this work has been undertaken by DOC science and technical staff, including Colin O'Donnell, Jane Sedgeley and Moira Pryde, along with several research students, and is undertaken in partnership with DOC staff from Te Anau.

Long-tailed bats

The long-tailed bat study in the Eglinton Valley is the longest-running research project on New Zealand bats, encompassing an intensive mark-recapture study that began in 1993. During that time, researchers have caught

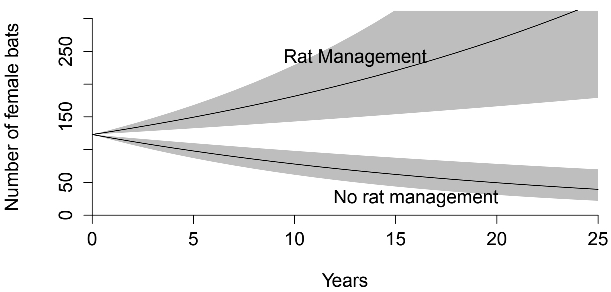


Moira Pryde checks long-tailed bats caught in a harp trap, Eglinton Valley, 2004. *Photo: Colin O'Donnell.*

Jane Sedgeley (centre) working with long-tailed bats in the Eglinton Valley, c. 1990s. *Photo: Colin O'Donnell.*

18,086 bats, including 3360 banded individuals. Early results documented the local extinction of a colony on the Fiordland National Park boundary (known as the 'Boundary Colony'), with remaining bat numbers declining on average by 5% per annum. The survival of bats was found to be dependent on age, sex, winter temperatures and predator levels, with observed declines coinciding with rat plagues. Population modelling of bat survival using Programme MARK confirmed that colonies inhabiting areas with no predator control were heading towards extinction (see graph below). Stoat control alone does not appear to be sufficient to protect long-tailed bats. However, rat control in conjunction with stoat and possum control at Walker Creek in 2009 and 2011 appeared to enhance bat survival, indicating that this management regime may allow the population declines of long-tailed bats to be reversed. Further work is required to determine how applicable these results are to other areas, however (e.g. other bat colonies in the Eglinton Valley, including the Mackay Creek and Knobs Flat colonies, and in other populations, such as the Kepler Mountains), as well as for larger and more-prolonged plague events.

In 2010, long-tailed bats were seen in the Te Anau township and attempts were made to catch bats near the lower reaches of the Kepler Mountains, adjacent to the Waiau River. In 2011, Paddy Stewart and a group of students from Bay of Plenty Polytechnic recorded long-tailed bats in the Iris Burn Valley using bat detectors,



Predicted population trends in the number of female long-tailed bats in the Eglinton Valley over 25 years in the presence and absence of rat control. Shaded areas represent 95% confidence intervals.

following which DOC biodiversity staff from Te Anau (with funding from Distinction Hotels and the Fiordland Conservation Trust) undertook harp trapping in the valley to locate maternity roosts. Initially, five maternity roost trees were located, upstream of Rocky Point and less than 500 m from the Kepler Track Great Walk. A small-scale monitoring programme of the population was then begun using video surveillance and roost emergence counts, and this programme was expanded in 2013 to include banding and mark-recapture methods. There are now 43 known roost trees.

Establishing the presence or absence of bats throughout the region also occurs in conjunction with other species monitoring. For example, work by Bay of Plenty Polytechnic in 2013 picked up long-tailed bat populations in the Murchison Mountains, but none in Tamatea/Dusky Sound.

Moira Pryde climbs among the Eglinton Valley's beech forest to find a bat roost. *Photo: Colin O'Donnell.*

A long-tailed bat showing the numbered metal band used for bat monitoring in the Eglinton Valley, Fiordland, 2008. *Photo: DOC.*

Measuring a long-tailed bat forearm. *Photo: Barry Harcourt.*

Bats (pekepeka) in Fiordland

The long-tailed bat is a small, insectivorous mammal that inhabits the temperate rainforests of New Zealand. It roosts and breeds within large maternal colonies in tree cavities in the summer. Lesser short-tailed bats are slightly larger than long-tailed bats and (unlike many other bat species that catch their prey in the air) they feed on the forest floor, using their folded wings as 'front limbs' for scrambling around. Short-tailed bats are most commonly found in temperate rain forests, where they roost singly or communally in hollow trees.

Both species are vulnerable to predators throughout the year – in summer, when they congregate in large colonies, and during winter, when they may remain inactive (in torpor) within roosts. Rats, feral cats, possums and stoats have all been implicated in the decline of the long-tailed bat, with the southern 'race' being classified as Nationally Critical under the New Zealand Threat Classification system. The southern lesser short-tailed bat is classified as Nationally Endangered, with the population in the Eglinton Valley being the only known population on the mainland South Island.

Long-tailed bat. *Photo: Colin O'Donnell.*

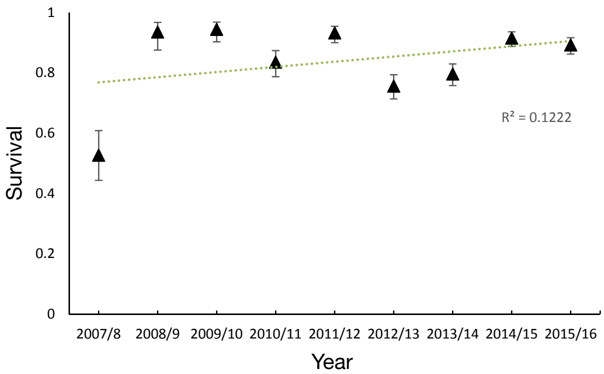
Viewing the wing span of a lesser short-tailed bat, Fiordland, 2008. *Photo: Barry Harcourt*

Lesser short-tailed bats

Lesser short-tailed bats were re-discovered in Fiordland in February 1997 – the first record of these bats in the region since 1871. A juvenile male was captured in a harp trap in beech forest at Mackay Creek during routine live capturing of long-tailed bats for marking. This bat was fitted with a transmitter before release and was radio-tracked to a number of communal short-tailed bat roosts in the upper Eglinton Valley. Initial monitoring of this population soon after its discovery involved taxonomic identfication, echolocation calls, and estimates of the population size, home range and habitat use. 'Fiordland' short-tailed bats were found to be heavier, with larger wings and smaller ears than populations on Codfish Island/Whenua Hou Nature Reserve (near Stewart Island/Rakiura) or the northern population on Te Hauturu-o-Toi/Little Barrier Island; they were also sexually dimorphic, with females larger than males. The echolocation calls were of low intensity (quiet), making them difficult to detect, but were sufficiently different from long-tailed bats to distinguish them using electronic bat detector boxes. In summer, roosting groups numbered from 107 to 279 individuals and the bats ranged over 130 km^2.

From 1997 the Eglinton short-tailed bat population has been monitored using video surveillance cameras and recording equipment. Counts were made of bats emerging from roosts to provide an index of abundance. Lesser short-tailed bats often emerge from several holes in a roost tree and frequently change roost sites – although not as often as long-tailed bats – which makes it difficult to accurately monitor more than one tree at a time. Marking individuals is a more accurate way of monitoring populations; forearm banding with uniquely numbered metal bands is the accepted technique for individually marking long-tailed bats. However, captive trials using a range of bands indicated that this technique caused swelling in the forearm tissue and unacceptable damage to both the forearm and wing in lesser short-tailed bats. In 2005, the use of PIT (Passive Integrated Transponder; i.e. microchip) tags was piloted on short-tailed bats by DOC scientist Jane Sedgeley, Te Anau Area Office staff, Kate McInnes (DOC wildlife vet) and Stu Cockburn (a DOC conservation electronics specialist). This pilot was successful and PIT-tagging is now common practice for this species, allowing an electronic scanner to be placed near the entrance to a bat roost to record the number and identity of individual bats entering and exiting the roost over consecutive nights. To date, 1969 bats have been marked as part of this long-term study. Results have shown that short-tailed bat numbers have increased, with the highest ever emergence count (of 1423 bats) from a single roost recorded in 2015.

Survival estimates of adult females have been calculated using mark-recapture data and Programme MARK, which showed relatively high survival through two moderate rat plague years but a decline following the large plague in 2006/07 (see *Management of possums, stoats and rats* – chapter 4 for further discussion, and graph below). This indicates that stoat trapping may be of benefit to this species in years with low rat numbers. Pulsed rat control appears to have been of benefit to the short-tailed bat population within the Eglinton Valley management area (as has been found for long-tailed bats), but further work is required to assess the required scale of management through a large and prolonged rat plague in this area.



Survival estimates for lesser short-tailed bats in the Eglinton Valley.

What next for Fiordland bats?

Research and monitoring of bats in the Eglinton Valley has not only contributed significantly to our understanding of their biology and ecology, but has also highlighted the need for ongoing large-scale predator control to prevent their demise. Bat populations can be notoriously difficult to detect and intensive monitoring can be required to determine which areas require protection and on what scale. Such monitoring requires skilled operators, particularly for tree climbing, roost assessment, bat handling and PIT-tagging. A best practice manual for bats was produced by DOC in 2012, based on methods (including PIT-tagging) pioneered in Fiordland. Te Anau DOC staff have since worked with DOC staff at Pureora Forest to train them in the use of PIT-tagging and assist them with establishing their own mark-recapture study on a northern population of lesser short-tailed bats.

Looking to the future, it is crucial that the protection of both long-tailed and lesser short-tailed bat populations is considered when planning pest control operations – and it is vital that we highlight the threat status and conservation of New Zealand bats through public awareness. Integral to this education will be developing an understanding that effective large-scale predator control on the mainland is the only option for Fiordland populations, as there is no proven successful technique for translocating bats due to their ability to return to their home areas and the problems of dealing with a communal species.

Mohua

Research, monitoring and management of mohua (yellowhead) populations in Fiordland has resulted in the development of a successful translocation methodology (including managing for the loss of genetic variability) and the establishment of several secure island populations (see chapter 3). We now have a good understanding of why mohua populations have declined or become locally extinct on the mainland, and a secure mainland population has been successfully re-established (through population supplementation) in the Eglinton Valley using stoat and rat control (see *Management of possums, stoats and rats* – chapter 4).

A mohua awaiting release during a Fiordland transfer operation. Mohua Charitable Trust funded translocation of mohua to the Eglinton Valley and Mauikatau/Resolution Island; Peregrine Wines supported by Mountain Helicopters funded the transfer to Mauikatau/Resolution Island (see chapter 2 for full list of mohua sponsorships/partnerships). *Photo: Barry Harcourt.*

Mohua

The mohua (yellowhead) a is a small, insectivorous bird that lives only in the forests of New Zealand's South Island and Stewart Island/ Rakiura. Once widespread throughout the South Island, mohua numbers have been gradually declining due to predation by rats and stoats, with a dramatic reduction in their range since the 1970s. The mohua is classified as Nationally Vulnerable under the New Zealand Threat Classification System.

The late Barry Lawrence (DOC Biodiversity Ranger) with mohua in hand, February 2008. *Photo: DOC*

However, the ability to source adequate funds for effective large-scale pest control in plague years is essential for the long-term protection of this species on the mainland, without which it will continue to decline.

Kākā

Kākā have been monitored in the Eglinton Valley since 1990, when a 50 ha stoat trap trial was established at Deer Flat (see *Management of possums, stoats and rats* – chapter 4). Led by DOC scientist Peter Dilks, the aim of this study was to learn about the breeding biology and ecology of kākā to determine the efficacy of stoat trapping for their protection. Following an expansion of the stoat trapping programme in 1998, kākā monitoring was intensified to include radio telemetry of adult females to study their breeding activity, productivity and survival. Between 1990 and 2014, 42 adult female and 9 adult male kākā have been radio-tagged and monitored, and 110 adults and more than 120 juveniles have been colour-banded.

Tara Leech and Peter Dilks radio track kākā in the Eglinton Valley in spring, 2005. *Photo: DOC.*

Peter observed that kākā in the Eglinton Valley usually only breed when the beech trees flower and seed, at which time they can be highly productive, laying 2–6 eggs per clutch. In some years, kākā may also nest twice within a 6-month breeding season – for example, in 2005/06, all of the monitored pairs had two or more nesting attempts and one female fledged seven or eight young. Kākā have a core home range of approximately 50 ha, but will travel considerable distances for seasonal foods (e.g. tree fuchsia at the 'Divide' and rātā in the Hollyford Valley). More information is still required on juvenile dispersal.

Stoat trapping was found to benefit the Eglinton kākā population, with considerably higher levels of nesting success and chick survival in the Eglinton Valley than in areas without stoat control. Although kākā nested mostly during the beech mast years, they did so when stoat numbers were still at a low level, so that most had completed breeding by the time rodent and stoat numbers irrupted during the following summer. Population modelling of kākā based on the Eglinton data indicates that the population at Knobs Flat is trending upwards, i.e. the current regime of stoat and possum control in the Eglinton Valley is sufficient to protect kākā at this site. Peter predicts that there will be a gradual decline in kākā in areas without predator control, culminating in local extinction. Long-lived males will continue to persist for a long time (with annual

Peter Dilks (DOC scientist) colour banding a young kākā while its parent looks on, Eglinton Valley, 2006. *Photo: Moira Pryde.*

Kākā

Kākā are large, forest-dwelling parrots. The species has a significantly reduced range and abundance in the North and South Islands due to forest clearance and predation by introduced mammals, and is classified as Nationally Vulnerable under the New Zealand Threat Classification system. Kākā are most abundant on offshore islands with no introduced mammals, particularly those without stoats.

Young kākā nestlings in the Waitutu area, Fiordland National Park. Female kākā are at their most vulnerable when nesting because the breeding period, from egg laying to fledging, takes around 3 months, and the female is present in the nest cavity for much of this time. Peter Dilks and his team monitored kākā breeding by periodically climbing to nests to record their contents. In beech mast years, some nests were monitored constantly using video surveillance. *Photo: Terry Greene*

adult survival close to 100%), obscuring the full extent of the species' demise until it is too late, and kākā will eventually vanish from all mainland forests with no predator control.

Whio

Up until 1988, the only work that had been undertaken on whio (blue ducks) in Fiordland was the compilation of opportunistic survey data from 'Blue duck survey cards'. These cards were filled in by DOC staff (and prior to that, Wildlife Service staff), trampers, fishing guides and other recreational users of Fiordland National Park in an attempt to gain knowledge of the distribution and density of whio in the region.

In 1988, the Blue Duck Conservation Strategy was produced by DOC following a national seminar on whio conservation and management. The overwhelming view of workshop participants, as reported by Murray Williams, was that 'blue duck needed active management and that its conservation, before it became another of our extremely endangered species, was warranted as a national and regional priority with the primary objective to determine the present status and distribution of blue ducks nationally'.[12]

In 1997, the first Whio Recovery Plan came into effect, with the long-term goal to 'maintain blue ducks in the wild in sufficient numbers and in sufficient secure catchments so that the species shifts from the category of Endangered to Vulnerable'.[13] During the summer of 1998/99, Greg Coats and Simon Torr undertook a survey for whio based on sightings from the survey cards, which covered 13 rivers and 16 tributaries from Charles Sound in the south to Martins Bay in the north. Survey results showed clearly that the whio population in Fiordland was in serious trouble. A programme of experimental pest control to protect whio (and northern Fiordland tokoeka) in the Clinton and Arthur Valleys was initiated by the Te Anau Area Office the following year. This project was designed using an adaptive management approach and had two key research objectives to investigate:

- Factors influencing survival, productivity and recruitment of whio.
- Whether the establishment of low-cost sustained stoat control would directly benefit whio, especially in terms of the production and survival of young.

DOC Biodiversity Ranger Pete McMurtrie uses radio-telemetry to try to locate whio fitted with transmitters in the Arthur Valley, Milford track, c. 2005. *Photo: Rod Morris.*

[12] Williams, M. 1988: Conservation Strategy for Blue Duck 1988–1992. *Science and Research Internal report 30*. Department of Conservation, Wellington.

[13] Adams, J.; Dunningham, D.; Molloy, J.; Pillipson, S. 1997: Blue Duck (Whio), *Hymenolaimus malacorhynchos* Recovery Plan. *Threatened Species Recovery Plan 22*. Department of Conservation, Wellington.

Whio

The whio (blue duck) is an iconic species of the New Zealand back-country that inhabits clear, fast-flowing rivers. It is now mostly confined to high-altitude segments of rivers in North and South Island mountain regions, and is classified as Nationally Vulnerable under the New Zealand Threat Classification system. Nesting females are especially susceptible to mammalian predators, particularly stoats and possums, while rats and weka have also been implicated in the destruction of nests and eggs.

Whio family. *Photo: Tyronne Smith.*

Staff used mark-recapture, radio telemetry and nest surveillance techniques to follow breeding pairs and their offspring over 6 years. For the first 3 years of the study, stoats were controlled along 33.5 km of river in the Clinton Valley, while the neighbouring Arthur Valley was left unmanipulated (see *Management of possums, stoats and rats* – chapter 4). Following this, in April 2003, stoat control (27.5 km) was established in the Arthur Valley and monitoring continued in both valleys for a further 3 years. The Cleddau catchment was also included in the study in October 2003, following the establishment of stoat control (27 km).

Video monitoring identified stoats as the primary nest predator of whio. Sustained, low-intensity stoat control significantly reduced stoat footprint tracking and capture rates at trapped sites compared with untrapped sites, which resulted in significantly increased nesting success and productivity at the trapped sites. PhD

Whio on nest, with its radio transmitter attached. *Photo: Rod Morris.*

student Amy Whitehead calculated adult survival estimates for whio using the population data from this study and concluded that while low-intensity stoat control is sufficient to improve the productivity of whio populations, the survival rates of adults and the number of pairs was not significantly different between the treatments. Amy also carried out further population modelling of the Clinton/Arthur/Cleddau whio population to assess the value of expanding stoat control into the surrounding tributaries. Radio transmitters that were deployed on juvenile whio from the main study area from 2003 to 2006 indicated that as pairs fill territories in the core (trapped) area, juveniles need to disperse further from their natal area. Overall, this work demonstrated the value of an adaptive management approach whereby the prescribed predator control was rigorously evaluated.

This study was concluded in 2005/06, at which time the objective of the whio recovery programme in Fiordland shifted its focus to securing the population. In 2008, the threat status of whio improved from Nationally Endangered to Nationally Vulnerable. In 2009, a new Whio Recovery Plan was implemented with the goal of ensuring the retention of viable wild whio populations throughout their natural range by protecting this species at eight first-priority 'Security Sites' as well as a number of second-priority 'Recovery Sites'. Fiordland currently has one of the largest and most robust whio security

DOC Biodiversity Ranger, Andrew (Max) Smart, successfully locating whio, with the aid of his dog Téa, in Sinbad Gully, near Milford Sound/ Piopiotahi, c. 2005. *Photo: Rod Morris.*

Whio partnerships

DOC has existing partnerships for whio conservation in Fiordland, ranging from corporate sponsorship (Real Journeys and Downer) to smaller locally-owned businesses (Trips & Tramps) and numerous charitable trusts and foundations (the Fiordland Wapiti Foundation, Gunns Camp Charitable Trust, the NZ Alpine Club, members of the Milford Sound community, the Kepler Challenge Committee). In 2011, Genesis Energy came on board as a national sponsor for the Whio Recovery Programme under the umbrella campaign of Whio Forever. The Genesis Energy Whio Recovery Programme partnership is funding a 5-year management programme for whio, including an additional stoat trap checks in the Murchison Mountains, and upgrading of traps and trap tunnels.

Fiordland Wapiti Foundation project manager Chris Whyte (L) and Southern Lakes Helicopters pilot Brendan Hiatt release 13 whio near the head of Lake Te Anau, February 2011. The Fiordland Wapiti Foundation funded the project, supported by Southern Lakes Helicopters and Placemakers Te Anau. *Photo: Barry Harcourt.*

sites nationally, and a further four recovery sites under management. The key management objective is to achieve 50 pairs within the Northern Fiordland Whio Security Site by 2017. Map 7 (p. 69) shows the location of the Northern Fiordland Security Site (Clinton, Arthur, Cleddau, Worsley, Castle and Sinbad) and the four Recovery Sites (Glaisnock/Nitz, Murchison Mountains, Upper Hollyford and Iris Burn). Stoat control to protect whio has increased from 34 km of river in 2000 within the security site to approximately 150 km in 2013. Including the recovery sites, a total of 286 km of river is currently under sustained stoat control that will ensure the persistence of whio in this region of Fiordland.

Whio have most definitely served as a flagship species for Fiordland, drawing attention to the plight of what was once a common bird throughout the region. However, despite the growing support for whio conservation, maintaining this momentum and awareness is a challenge for DOC. Some people consider that enough has been done to secure the population in Fiordland, but the people responsible for managing the species believe it is crucial to maintain vigilance and not become complacent about whio conservation. Flooding continues to be a major issue for the Fiordland whio population, as floods not only hinder the work of contract trappers and whio monitoring staff (and their dogs) at key times during the breeding season, but can also wipe out an entire season of whio productivity if they occur during nesting and when ducklings are young. Floods are likely to have been the main contributing factor to poor nesting success and productivity in the 2007/08 and 2012/13 whio breeding seasons. Whio also often retreat to small, untrapped side creeks when moulting after the breeding season, and are particularly vulnerable to predation at this time. There is still more work to be done protecting whio in many parts of Fiordland – for example, stoat trapping in the Hauroko Burn and Seaforth River catchment would be a logical next step, but this is likely to require more intensive landscape-style trapping due to the terrain. Finally, the relatively recent arrival in 2004 of the highly invasive freshwater alga didymo (see chapter 7) presents an unknown risk to whio.

Many opportunities for research partnerships exist within DOC and other conservation and scientific institutes to build conservation knowledge for whio and other native species within riverine ecosystems, including research on the impacts of didymo.

Fiordland tokoeka

The majority of kiwi work in Fiordland to date has focused on the northern Fiordland tokoeka, including two noteworthy studies led by DOC staff in Te Anau that assessed the value of stoat trapping to secure mainland populations of this taxon in the Clinton Valley and the Murchison Mountains.

The Clinton Valley tokoeka study ran for 4 years from 2001 to 2005 and was carried out using radio-telemetry, following extensive efforts to capture and band adult birds that had not previously been captured and were therefore naïve in relation to interactions with humans.

A Fiordland tokoeka retreating after having had a transmitter fitted, Fiordland, 2010. *Photo: James Reardon.*

Video surveillance equipment was used to monitor nesting success, and chicks (c. 10 days of age) were fitted with transmitters and continued to be monitored to sub-adulthood using radio-telemetry. Valuable information was obtained regarding the nesting behaviour, genetics, morphology, survival and habitat of northern Fiordland tokoeka, as well as their interactions with other species. Chick survival of monitored birds in the trapped area was 17.6% and population modelling by DOC scientist Hugh Robertson suggested that the population may have been increasing. However, this was based on an extremely high adult survivorship, with adult tokoeka having an estimated lifespan of 63 years based on 63 transmitter-years and only one death – a single extra adult death would have resulted in a declining population prediction, rendering the evaluation of stoat control for kiwi in the Clinton Valley equivocal. The intention was to run this study for 6+ years, but unfortunately it proved extremely difficult to secure a commitment to ongoing funding and pressure was also mounting to direct what funding was available into a similar programme on tokoeka in the Murchison Mountains Special Takahē Area. If the project had run for a longer period, more robust data would have been obtained and the study period would have encompassed a beech mast year (2006/07), two aerial 1080 operations (2005 and 2006) and an expansion of stoat trapping into adjacent valleys.

At the conclusion of the Clinton tokoeka study, a commitment was made to undertake walk-through kiwi surveys in the Clinton Valley at 5-yearly intervals based on best practice developed by Hugh Robertson and Rogan Colbourne in 2003. A territory map was also compiled from all known birds and bands were left on known individuals. This meant that two types of data were available for future comparison: territory occupancy data and an estimate of the proportion of known marked individuals that were still alive. Territory occupancy studies have the advantage of not necessarily requiring birds to be caught (unlike proportion of known individuals, which requires birds to be caught for conclusive identification). This will be of particular use for Fiordland tokoeka, which can be difficult to recapture once they have been handled because they sometimes learn to avoid whistles and tape recordings.

Fiordland tokoeka

Northern and southern Fiordland tokoeka are two of four distinct taxa of tokoeka (also known as South Island brown kiwi), which are geographically divided at Wilmot Pass. While these are not distinct subspecies, they are recognised as Evolutionary Separate Units (ESUs), based on molecular genetic work by Maryann Burbidge and the late Allan Baker of the Royal Ontario Museum in Toronto. Tokoeka were historically widespread throughout Fiordland, but Andreas Reischek's surveys in the late 1880s found few tokoeka in the southern parts of Fiordland, suggesting that their numbers may have been naturally lower in this region. Northern and southern Fiordland tokoeka are classified as Nationally Vulnerable under the New Zealand Threat Classification System. The principal threat to their populations is stoat predation on chicks – subadults and adults are generally not preyed upon. Ferrets are not considered a threat in Fiordland (unlike elsewhere in New Zealand), as they are only known from the Eglinton Valley where kiwi are absent. The potential for feral cats to move into Fiordland kiwi habitat makes them a serious potential threat, with cats and their sign having already been seen in kiwi habitat in the Clinton Valley, as well as on the eastern shores of Lake Te Anau, in Wilmot Pass and on the Kepler Track – although the apparent persistence of kiwi in the presence of cats on Stewart Island/Rakiura indicates that kiwi populations may have some robustness against cat predation.

DOC Biodiversity Programme Manager Murray Willans holding a little spotted kiwi during the transfer from Kapiti Island to Te Kākāhu/Chalky Island in 2009. *Photo: Kara Matheson.*

Kiwi recovery work in Fiordland also encompasses two other taxa: Haast tokoeka and little spotted kiwi. Three predator-free islands (Centre and Bute Islands in Lake Te Anau, and Rona Island in Lake Manapouri) have been used as crèche sites for Haast tokoeka chicks, and populations of Haast tokoeka have been established on two charitable trust-managed islands (Te Puka-Hereka/Coal Island in Preservation Inlet and Pomona Island in Lake Manapouri). Little spotted kiwi were returned to Fiordland in several transfers from Kapiti Island to Te Kākāhu/Chalky Island in Chalky Inlet from 2008 to 2010 and to Anchor Island in 2015 (see chapter 3).

Blair Hoult and Hannah Edmonds release a Haast tokoeka onto Pomona Island, Lake Manapouri, 2011. *Photo: DOC.*

In April 2010, the first walk-through survey was conducted in the 2520 ha survey area in the main Clinton Valley; 51 hours were spent soliciting calls and attempting to catch kiwi by whistling and playing taped calls along the track at night. The walk-through survey detected 42 kiwi, but only 5 were captured, including 2 previously unknown adults and 1 subadult. The walk-through survey proved a useful technique for determining the minimum number of birds present in the area. However, it is likely to have provided an underestimate of the actual number of birds present at the time due to river noise occasionally disrupting listening coverage, the possibility that not all birds called, and the quieter calls of females being audible over a shorter distance than those of males. A very approximate assessment could be made between the 2010 results and those from the previous study, but these are not directly comparable. The walk-through survey was repeated in late March to early April 2015. Forty-nine kiwi were detected during the 37 hours spent surveying. Two juvenile kiwi caught were estimated to be 5–6 months old and therefore close to reaching the 1 kg threshold above which kiwi are presumed to be 'safe' from stoats. Repeat walk-through surveys at 5-yearly intervals using the same method will provide an increasingly accurate predictor of the likely population trend.

In 2003, a similar telemetry study of northern Fiordland tokoeka commenced in the Murchison Mountains, again led by DOC's biodiversity team in Te Anau in collaboraton with Hugh Robertson. The team were able to compare chick survival in trapped areas versus an untrapped area within the Murchison Mountains over 4 years from 2004/05 to 2008/09. They observed a rate of 37% chick survival to 6 months old in the traped areas versus a rate of 19% in the untrapped area. This difference, which is statistically significant, was enough to turn a modelled population decline of 1.6% per annum into a modelled 1.2% per annum gain. These results are slightly more promising for kiwi than those from the Clinton study but ought to be viewed conservatively. Two moderate beech mast events occured during the course of the study (2004 and 2007) in Takahē Valley (one of the trapped study areas) that could have impacted on chick survival in the study period, but neither was as big as the recent event in 2014. It is not possible say what percentage of chick survival the Murchison Mountains kiwi population would need to compensate for significant mast years with correspondingly poorer kiwi chick survival.

Since 2009, stoat trapping in the Murchison Mountains has been expanded and intensified considerably; however, with the cessation of the monitoring study, we are left in a position of assuming that this intensification has also benefited kiwi, but lack any hard data to support this. The inability to use aerially applied toxic baits at takahē sites is a big limiting factor in responding to significant beech mast events (like that of 2014) and in addressing the concern that the trapping programme alone may become less effective over time due to trap avoidance by stoats.

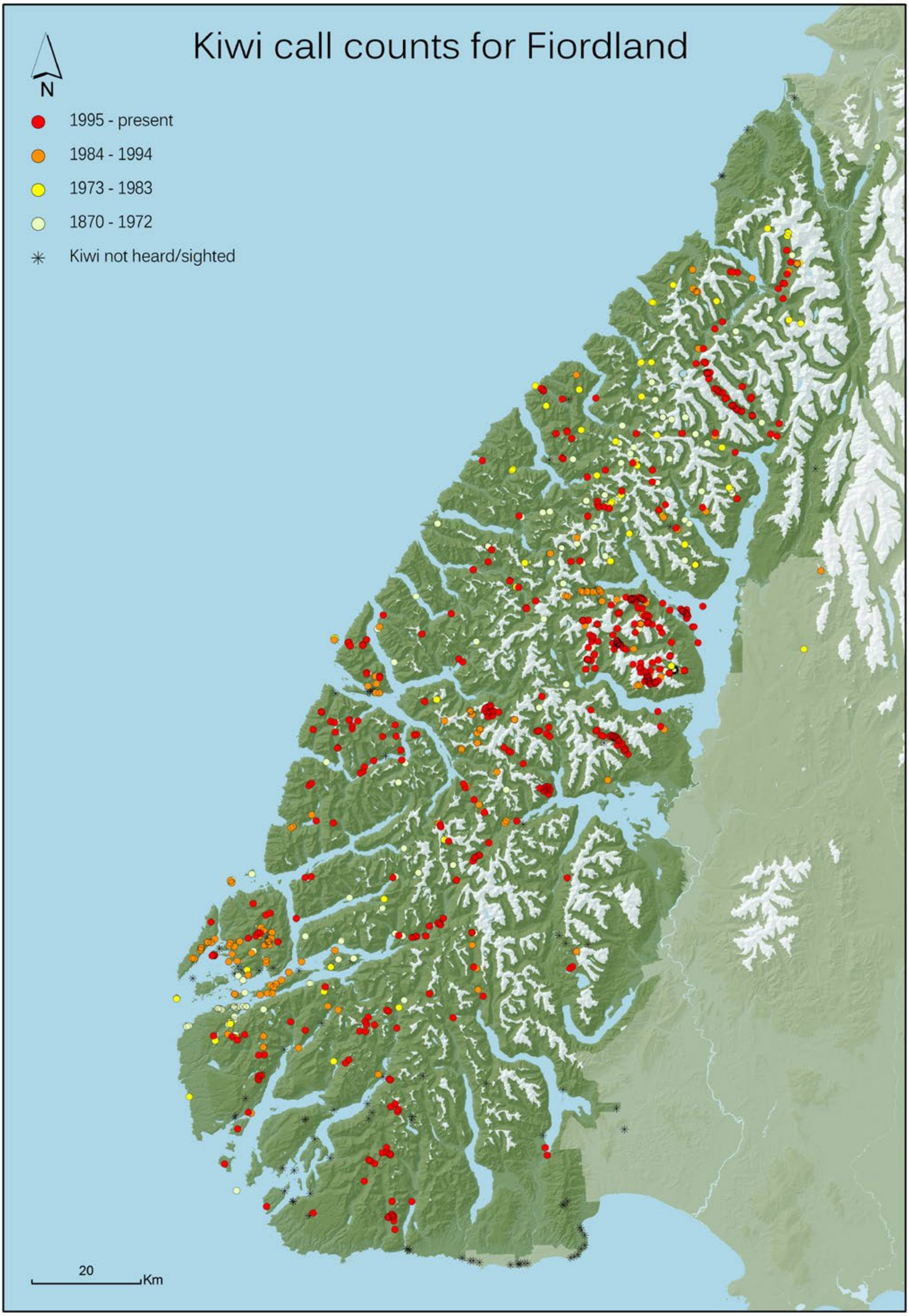
Kiwi partnerships

Kiwi conservation in Fiordland has benefited hugely from partnerships and support, including from The Bank of New Zealand Save the Kiwi Trust (now called 'Kiwis for Kiwi'), Real Journeys, Kirra Tours, Southern Discoveries, Fiordland Conservation Trust, Les Hutchins Foundation, South West Endangered Species Charitable Trust, Pomona Island Charitable Trust and all of the local schools in the Te Anau/Manapouri district.

Real Journeys staff Paul Norris and Richard Parkinson help release little spotted kiwi onto Te Kākāhu/Chalky Island, 2009. *Photo: DOC*

Over the past three decades, numerous distribution surveys have been conducted for southern Fiordland tokoeka (see Map 9 for distribution of both northern and southern Fiordland tokoeka) by DOC staff (including Technical Advisor Rogan Colbourne), volunteers and students from Bay of Plenty Polytechnic. Until recently, the kiwi call count method was used as the standard approach. However, in 2011, acoustic recorders were installed on Te Ra/Dagg Sound Peninsula, representing the first use of these in Fiordland.

Northern and southern Fiordland tokoeka are thought to be secure on Kā-Tū-Waewae-o Tū/Secretary Island (northern) and Mauikatau/Resolution Island (southern), reflecting the success of ongoing work to remove stoats from these islands (see chapter 2). Baseline call count



Map 9. Kiwi counts for Fiordland. Map shows recorded locations of kiwi, including sightings from hunters, trampers and DOC staff.

monitoring was undertaken on both islands prior to the commencement of stoat trapping and has been repeated on Mauikatau/Resolution Island. Unfortunately, the intention to repeat these surveys at 5-yearly intervals has been hindered somewhat by a lack of progress in developing national protocols for the use of acoustic recorders to monitor kiwi populations.

Despite presumed population stability at managed sites, the overall populations of northern and southern Fiordland tokoeka are likely to be declining. Current priority actions from the Fiordland Tokoeka Taxon Plan[14] are to optimise and increase large-scale pest control to benefit Fiordland tokoeka, and to gain an understanding of the population trend and distribution of northern and southern tokoeka throughout Fiordland National Park. Declines in the populations of these taxa have been attributed to predator processes; however, populations continue to decline even with pest control, suggesting that other factors may be at play, such as natural losses of adults, low or moderate productivity, and subadult dispersal beyond managed sites.

Takahē

Up until the 1970s, the conservation of takahē mainly consisted of natural history observations and baseline population monitoring in the Takahē Valley – Point Burn area of the Murchison Mountains. However, a marked decline in this population in the late 1960s forced a major reassessment of takahē research. Consequently, a more wide-ranging study of their breeding success, chick survival, adult mortality and emigration commenced to enable comparisons to be made across regions within their natural range and habitats. In the 1980s, active conservation management of takahē began, building on the research of the previous decade and developing rapidly on several fronts.

Lake Orbell and Takahē Valley blanketed with snow, Murchison Mountains, Fiordland, September 2012. *Photo: DOC.*

From 1981 to the mid-1990s, the Murchison Mountains takahē population remained at between 100 and 160 adult birds. Management for takahē included deer control to minimise deer grazing on alpine tussock grasses (see *Management of deer, chamois and goats* – chapter 4 and *Flora and plant communities* – chapter 5 above), nest manipulation to ensure that most takahē pairs had the opportunity to raise at least one chick, and the release of captive parent-reared and puppet-reared juvenile takahē back into the site (see *Takahe Recovery Programme* – chapter 2). However, there was frustration

A young takahē chick about to be fed by a parent bird. *Photo: Sabine Bernert.*

[14] Edmonds, H. 2015: Taxon plan for northern and southern Fiordland tokoeka (*Apteryx australis australis*) - Strategic plan for the recovery of northern and southern Fiordland tokoeka, for the period 2015–2025 and beyond. Department of Conservation, Te Anau.

Takahē chicks being fed by a hand puppet at Burwood bush, c. 1990s. *Photo: Daryl Eason.*

and concern that the population was not increasing in spite of these efforts, which resulted in a review of takahē management in the Murchison Mountains in 1997 (led by members of the Takahē Recovery Group). This review resulted in a number of new management and research objectives for takahē in the Murchison Mountains:

- A greater investment in deer control and monitoring of the outcomes of this work.
- An assessment of takahē recruitment in the Murchison Mountains, comparing wild-reared and captive-reared birds.
- An assessment of pairing and breeding success, comparing wild-reared and captive-reared birds.
- An assessment of chick survival in the wild population.
- The development of population modelling tools for the Murchison Mountains population.
- An assessment of the effect of continued egg removal on the wild population.
- An evaluation of the significance of predation to takahē.

A preliminary comparison indicated that there was no statistically significant difference in recruitment rates between wild-reared and captive-reared birds into the Murchison Mountains population. However, a subsequent analysis that included additional data suggested that the breeding success of captive puppet-reared birds from Burwood Bush that were released into the Murchison Mountains was significantly compromised (by as much as 50%) when compared with captive parent-reared and wild-reared takahē. Moreover, the continued release of puppet-reared juveniles into the Murchison Mountains was correlated with reduced hatching success in the wild population over time. These results indicated that the presence of puppet-reared birds in the population was potentially reducing its ability to recover from future catastrophic events (e.g. severe storms, heavy predation) that may result in large numbers of adult deaths. One such event occurred in 2007, when approximately 40% of adult takahē died over a period coinciding with a serious stoat plague – although there was very little direct evidence as to the cause of mortality.

University of Otago MSc student Danilo Hegg used a Bayesian population modelling approach and historical data from the Murchison Mountains to assess the impact of current management on tahakē, which led to two key findings:

1. Increased adult survival in the trapped versus untrapped areas, which was assumed to be caused by the stoat trapping itself and not by chance – an assumption that Danilo noted 'still needs to be proven'; and
2. This benefit of the stoat trapping programme appeared to be only minor during the stoat plague in 2006/07, suggesting either that stoats were able to quickly reinvade the trapped area or, more likely, that the traps had become congested with rats and so were no longer able to trap the large number of stoats present.

The 2006/07 stoat plague coincided with the last year in Danilo's analysis, at which time the estimates of survival rate and the re-sighting rate in a mark-recapture model are confounded – i.e. cannot be calculated as individual estimates. This inability to tease the information apart means that the 'survival' estimates calculated for this year may have been negatively affected by a low recapture probability, and that actual survival in the stoat-trapped area may, in fact, have been similar for plague and non-plague years (i.e. the desired result).

Danilo's findings combined with concern that the ineffectiveness of the trapping programme during 2006/07 was due to immigration and in situ breeding of stoats in areas with high rat abundances (i.e. stoat numbers can build up to a level where the trapping regime is not providing control; see *Management of possums, stoats and rats* – chapter 4) resulted in the trapping programme being extended to cover 50,000 ha in 2008.

In 2010–11, the Takahē Recovery Programme underwent a further review, which focused on evaluating the Programme's goals and strategies. The review team highlighted a number of data deficiencies and also stressed the importance of assessing management outcomes against prescribed management goals for

A takahē nest with a temperature data logger dummy egg alongside a real egg, Murchison Mountains, November 1999. *Photo: Jane Maxwell.*

recovering the species, which had been lacking. As a consequence, the following recommended changes to the programme were implemented:

- Development of a new strategy for takahē recovery.
- Monitoring of 40–65 adult takahē in the Murchison Mountains to assess seasonal and annual patterns of mortality (this approach, which uses Sky Ranger technology developed by Wildtech Ltd, replaced the earlier biannual census surveys and has the potential to enable managers to determine the cause of death depending on the frequency of monitoring flights).
- Discontinuation of chick puppet-rearing at Burwood Bush and an increase in the capacity for chicks to be raised by parents/foster parents through the construction of larger pens with lower intensity management.
- Intensification of predator control in the Murchison Mountains (see *Management of possums, stoats and rats* – chapter 4).
- Cessation of juvenile takahē releases into the Murchison Mountains in order to determine whether the Murchison Mountains population can be self-sustaining with deer and stoat control.

The revised adaptive management strategy for takahē, application of smart technology for planning and monitoring, cessation of intensive puppet-rearing at Burwood, better genetic and productivity management of the national meta-population, and a significant national partnership with Mitre 10 (and, more recently, Fulton Hogan) are noteworthy successes for the programme since the last review. The number of takahē pairs (and hence productivity) at secure sites has doubled from 2012 to 2016. While the species remains classified as Nationally Critical, takahē take 3–4 years to mature and then contribute to the breeding population. Currently, there is a large skew towards young birds in the secure population, meaning that the programme is only just beginning to fully realise the population gains that have been made over that time. (Note: In 2017 the takahē was reclassified as Nationally Vulnerable; a two-place inprovement in ranking under the New Zealand Threat Classification System.)

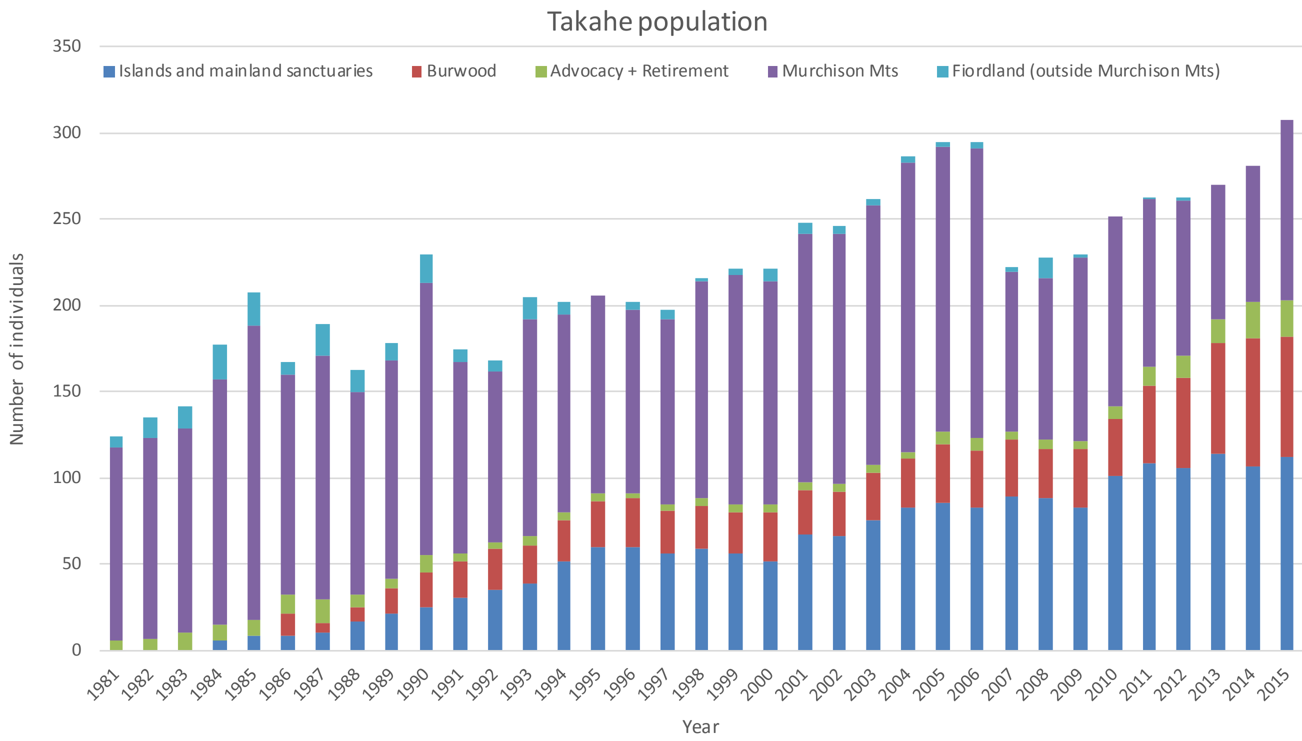
Jenny Christie with a takahē chick at Lake Eyles, Murchison Mountains, November 1999. *Photo: Jane Maxwell.*

Takahē, Tiritiri Matangi Island, Hauraki Gulf, 2000. *Photo: Paul Schilov.*

The current key issues for takahē requiring further work or investigation include:

- The need to establish additional suitable wild habitat (recovery sites) for the species, preferably within their natural range (i.e. the South Island), to substantially increase the national population. These sites will need to be large (to hold at least 30 pairs) and have target pest species controlled to tolerable levels. What should be done in the likely event of takahē dispersing from them also needs to be addressed.
- The relatively high adult mortality and low productivity in the Murchison Mountains population.
- The efficacy of the current stoat trapping regime in the Murchison Mountains. This is currently being assessed, but we do not know what the outcome will be and this uncertainty has implications for assessing future recovery sites.
- How to effectively undertake landscape-scale pest control at takahē sites in light of diminishing resources and the inability to use aerially applied toxins.
- Inbreeding.
- The need to establish why takahē are underperforming at many of the current secure sites.

The following graph shows the composition of the takahe population in New Zealand over the years since active conservation management began in the 1980s.



Status of takahē in New Zealand, as at 2015.

DIY rescue

The locally owned but nationwide co-operative Mitre 10 was attracted to the takahē following a letter written by a young Southlander, Sophie Smith, who pleaded with the NZ National Parks & Conservation Foundation to identify a sponsor that could enable DOC to expand its facilities at Burwood Bush and to employ extra staff for the task of rearing takahē chicks. From 2005 to 2016, Mitre 10 partnered with DOC, via Mitre 10 Takahē Rescue, contributing more than a million dollars. Working together over this time they helped increase the number of takahē living at secure sites from 115 to 225 birds, laying the foundations to reverse the decline of this iconic species. After signalling in 2015 that they wanted to step back from the role of national partner, but were still keen to stay involved, Mitre 10 then signed a new 3-year sponsorship agreement for an annual donation of building materials to the recovery programme.

Sophie-Rose Smith (in Mitre 10 uniform) helps to release nine takahē onto Motutapu Island in 2012 after having successfully lobbied for takahē sponsorship from Mitre 10. *Photo: Mitre 10.*

In July 2016, Fulton Hogan signed a 5-year agreement with DOC to become the new National Partner for the Takahē Recovery Programme .

Rock wren

The rock wren (or tuke) is a small, ground-feeding bird that is found in the Southern Alps/Kā Tiritiri o te Moana. Rock wrens remain above the bush line throughout their lives and are the only truly alpine birds in New Zealand. The species is ranked as Nationally Endangered under the New Zealand Threat Classification System. Limited information is available on the abundance and distribution of rock wrens throughout their range, which partly reflects the isolation and relative inaccessibility of the birds' preferred habitat of alpine basins. The birds' habit of hole-nesting on the ground leads to predation by mice and stoats, making the species vulnerable to local extinctions. Presently, there is no recovery plan for the rock wren; however, we are now aware that the species is in decline, and that very little is known about these astonishing and rather special birds. New Zealand wrens belong to the family Acanthisittidae and are part of an ancient and endemic bird lineage that up until 1000 years ago included seven species in five genera; however, only the rock wren and the rifleman (tītipounamu) survive today.

Sue Michelsen-Heath's study of rock wrens in the Murchison Mountains (1984–85) provided an invaluable benchmark for research into this species in Fiordland. Over the following 20 years, anecdotal reports of rock wren distribution were collated (many of which came from geologist Ian Turnball, who undertook extensive geological mapping across the region). Beginning in December 2004, DOC staff from Te Anau repeated several aspects of Sue's 1984 study, including surveying and monitoring rock wrens in the Mystery Burn, Lake Creek and Point Burn head basins. Of 12 nests monitored, ten successfully fledged chicks and another family group was located after fledging. Twenty-eight birds (including six family groups) from the study population were also transferred to Pukenui/Anchor Island in Tamatea/Dusky Sound in a first-ever attempt to translocate this species (see chapter 3 for a full description of translocations involving rock wrens from the Murchison Mountains to Pukenui/Anchor and Kā-Tū-Waewae-o Tū/Secretary Islands). Two years later, an intensive rock wren survey and predator impact study was carried out in the McKenzie Burn, the results of which showed that rock wren numbers in the surveyed areas had undergone a 44% decline since Sue's study in 1984–85. Seventeen nests were monitored, of which 14 were successful, 2 failed due to predation and 1 failed due to an unknown cause.

Rock wren in the Sinbad Sanctuary, Llawrenny Ranges, Northern Fiordland. *Photo: James Reardon.*

What's hidden in rock wren genes?

For her PhD thesis, Kerry Weston took blood samples from 221 rock wrens (tuke) from throughout their range. Using nuclear and mitochondrial DNA sequence data and microsatellite markers, Kerry was able to describe a deep north–south genetic divergence between populations of rock wren. She showed that estimates of the long-term effective population sizes of rock wrens were dramatically larger than previously estimated, suggesting that they were once much more abundant than they are today. Kerry also found evidence for a recent population bottleneck coinciding with an increase in human-induced disturbance in the south (i.e. the past c. 100 years), signifying that while natural fluctuations in climate probably determined their abundance in the past, these impacts are now being compounded by (most likely) predation by introduced mammalian predators. Significant fine-scale spatial genetic structure in the species was also detected, which has important implications for rock wren conservation management, as it helps with identifying populations where management efforts, such as predator control, should be prioritised.

Further evidence of nest predation of rock wrens in Fiordland was obtained from research led by DOC scientist Jo Monks in summer 2012/13. While the focus of Jo's study was on validating monitoring techniques for the rock wren, her team recorded an alarming level of nest predation in the untrapped head basins of the Homer and Gertrude Valleys in northern Fiordland. Complete nest failure was recorded for all 20 rock wren nests monitored, 10 of which were attributable to stoat predation (the cause could not be determined with certainty for the remaining 10). Adult birds were killed on the nest in at least three (up to seven) predation events and yet, interestingly, only low numbers of both stoats and mice were detected through tracking tunnel monitoring throughout the study. Jo concluded that these results indicated the episodic nature of predation on rock wrens, which can occur even when predators are at low density. One outcome of this work was the expansion of nearby stoat trapping further up the valleys, which is now run by the New Zealand Alpine Club (see

Rock wren partnerships

Rock wren (tuke) work in Fiordland has been achieved with the support of Fauna Recovery New Zealand and Fiordland (the conservation arm of The Sue Freitag and Barry Dent Charitable Trust) and Fiordland Helicopters, who contributed to the translocations of rock wrens to Pukenui/Anchor and Kā-Tū-Waewae-o Tū/ Secretary Islands.

DOC Biodiversity Ranger Megan Willans checks for translocated rock wrens on the summit of Kā-Tū-Waewae-o Tū/Secretary Island, at the mouth of Doubtful Sound/Patea, January 2009. *Photo: Rod Morris.*

Monitoring methods for rock wrens

Research initiated in 2012 and led by DOC Science Advisors Jo Monks and Colin O'Donnell is comparing a range of counting techniques for rock wrens (tuke), trialled at different times of the year. They are comparing territory mapping (the 'gold standard') with other indices (NOREMARK, Distance sampling, Site Occupancy and simple indices) and have included one study site in Fiordland: Homer/Gertrude Cirque.

The project is still underway; however, early indications from the Haast Range population are that simple indices (number of rock wrens counted along random 250 m transects) correlate well with population estimates obtained from more effort-intensive territory mapping, but results from distance sampling were poor.

Colin indicated that the best time of year for long-term monitoring seems to be February–March, as birds are more conspicuous and counts least variable at that time of year. He also noted that November–December may also work, but that results at this time are more variable. From mid-March onwards, detection rates drop right off.

Management of possums, stoats and rats – chapter 4). In the season following expansion of the trapping network, a significant increase in nesting success of rock wrens at the Homer and Gertrude site was observed.

David Webb, a postgraduate Masters of Wildlife Management student from the University of Otago, monitored rock wren nests at three sites across their distributional range, including the Homer and Gertrude site (trapped) and at Lake Roe in Merrie Range, southern Fiordland (no predator control). From October 2014 through to February 2015, David used surveillance cameras and direct observations to determine the fate of nests within these study sites. Additional sites included the Grange Range in Kahurangi National Park and the Haast Range in Mt Aspiring National Park. The Grange Range site received aerially applied 1080 baits as part of 'Battle for our Birds' pest control in November 2014; the Haast Range site is not trapped but a trapping network is in place below the bushline to protect the Haast Tokoeka kiwi. David found that the factor with the greatest effect on rock wren nest survival was whether or not a nest was within a 1080 application area (within: 71.14% nest survival; outside: 27.84% nest survival). He concluded that trapping needs to occur within the rock wren territory to be beneficial, but trapping can only provide protection to small areas of rock wren habitat. He commented that 'the application of 1080 appeared to improve the nest survival of rock wrens and is a cost-effective method that can be used at the landscape level, but further study would be required to separate out the influence of specific site features'.[15]

Ensuring the security of rock wrens on the mainland is a priority for conservation management of this unique species. Successful protection will require effective low-cost monitoring and alpine pest control methods, the availability of capable and experienced field staff who can work with rock wrens, as well as advocacy to increase awareness and recognition of the species.

Despite the successful translocation of rock wrens to Kā-Tū-Waewae-o Tū/Secretary Island, genetic considerations

A rock wren. *Photo: Liz Whitwell.*

[15] Webb, D. 2015: The effect of management on rock wren nesting success. A thesis submitted in partial fulfilment of the requirements for the degree of Masters in in Wildlife Management, University of Otago. Dunedin. 45 p.

are not currently a part of management practices for the species (c.f. *mohua and tīeke*; chapter 3). These concerns were the research topic of PhD student Kerry Weston, who investigated the role of genetic factors in the conservation management of rock wrens, with the desired outcome of improving understanding of the species' ecology and informing future management efforts.

Kakaruai

The kakaruai (South Island robin) is a small, endemic passerine that is classified as Not Threatened. This species is still relatively common in some areas of Fiordland but has become locally extinct from others. Its decline has been attributed to habitat destruction and predation by mammalian predators.

Kakaruai are secure on several predator-free islands throughout Fiordland (see chapter 3). Ensuring the security of mainland populations of kakaruai presents an ongoing challenge. Although we can assume that their numbers are stable where rat and stoat control is in place, in all likelihood they are in decline elsewhere. Furthermore, we know very little about the wider distribution of kakaruai populations across Fiordland.

DOC Biodiversity Programme Manager, Murray Willans carefully carries kakaruai for release during their transfer to Kā-Tū-Waewae-o Tū/Secretary Island, 2008. *Photo: Barry Harcourt.*

Kakaruai partnerships

The opportunity to work with and support DOC in the translocation of kakaruai (South Island robins) has led to a number of very significant biodiversity partnerships, including work with the Fiordland Conservation Trust, Chalky Digits, Fiordland Ecology Holidays, Trips and Tramps, the Pomona Island Charitable Trust, Fiordland Lobster Company, Eco Tours, and Real Journeys.

A kakaruai flies free after its release onto Kā-Tū-Waewae-o Tū/ Secretary Island, 2008. *Photo: Barry Harcourt.*

Hannah Edmonds releases a kakaruai on Pukenui/Anchor Island, 2004. *Photo: Graham Dainty.*

Tawaki

Tawaki (Fiordland crested penguins) are endemic to New Zealand, breeding in small colonies on inaccessible headlands and islets along the shores of southwestern South Island and Stewart Island/Rakiura. Historically, tawaki appear to have been present in much greater numbers around the Fiordland coastline, although descriptions of relative abundance are difficult to interpret. This species is classified as Nationally Endangered, with immediate threats including fisheries bycatch, introduced predators and human disturbance.

In the late 1980s, DOC considered conservation actions for tawaki, and determined that research was required to learn more about breeding locations, colony sizes, and the overall population size and trend. To help achieve this objective, baseline population monitoring of tawaki was initiated in 1994 for a 4-year period on the Fiordland coast. Three locations were selected to provide comparisons between colonies affected by different threats: Martins Bay (predators present), and East and West Shelter Islands in Doubtful Sound/Patea (weka present – otherwise predator-free). In 1995, the population on Te Au Moana/Breaksea Island was also included (predator-free).

In 1998, monitoring of tawaki was temporarily suspended for 5 years with the intention of recommencing for 3 consecutive years in 2003 – this was considered sufficient to identify declines if they were occurring and to instigate conservation management action if required. The Fiordland programme did not recommence until 2006, however, at which time biannual visits were conducted by DOC staff from Te Anau to coincide with an August nest count and October chick count. In 2009, the monitoring data and programme were reviewed, which showed that the monitoring method that had been used up to 2009 was prone to inconsistency and observer error, and needed to be standardised and refined in order to increase the level of confidence in the observed population trends. As a result, the double-count monitoring method was introduced for all key DOC tawaki monitoring sites in 2010 and has been carried out annually to 2015. This method provides more accurate results, and therefore a better understanding of the population status and trends at monitored sites. To date, there is no observable trend in tawaki numbers at either individual sites or across all of the sites monitored in Fiordland.

In 2012, a tawaki 'work-plan' was developed, which outlined prioritised management actions and the research required to assess an actual decline of the species. The plan also addressed the need to determine influences of population decline, outlined the survey and monitoring required, and highlighted outstanding knowledge gaps.

Current management priorities for tawaki are to:

- Maintain the predator-free status of islands with tawaki.
- Monitor population trends at predator-free islands and mainland sites across the geographic range of the species.
- Increase advocacy, create partnership opportunities and, ultimately, achieve a greater level of conservation for this species.

The remoteness and inaccessibility of tawaki colonies, susceptibility of individual birds to disturbance and a lack of resources to undertake monitoring and research have all been significant challenges for the programme. Moreover, conservation of tawaki is compromised by our lack of understanding about changes at sea and how these may be impacting on a species that is entirely reliant on the ocean for its survival. In 2015, collaboration between DOC, Otago University, the Global Penguin

A pair of tawaki (Fiordland crested penguins) on the Fiordland coast. The distinctive crest above their eyes gives rise to these penguins' common name. *Photo: Barry Harcourt.*

Society and the West Coast Penguin Trust was established. 'Project Tawaki' is led by independent researchers Thomas Mattern and Ursula Ellenberg and aims to investigate the foraging movements and diving behaviour of tawaki across their entire breeding range, with Harrison Cove in Milford Sound/Piopiotahi being one of three study sites. Thomas and Ursula hope to identify sea-based factors that influence the penguins' foraging success and, subsequently, their reproductive output and population dynamics. As such, the project will provide baseline information to inform future conservation management. The work in Milford Sound/Piopiotahi has received logistical support from tourism operator Southern Discoveries.

Lizards

The lizard fauna of Fiordland and the surrounding region is largely undiscovered. In 2004, the outdoor clothing and equipment company Kathmandu funded survey work for lizards in the region. In the same year, the Sinbad skink was formally discovered by researchers, following a report from climber Craig Jefferies who had seen a Cascade gecko on the rock wall in Sinbad Gully. In addition, the first report of Fiordland skinks on Secretary Island was made by DOC staff undertaking lizard surveys prior to the campaign to remove stoats from the island. The Sinbad skink, Te Kākāhu skink, Takitimu gecko and Eyre Mountains skink have all been formally described only in the last 10 years.

A Sinbad skink showing off its striking orange belly on an alpine hebe. *Photo: Tony Jewell.*

Key management and research objectives for most lizard species in this region are still seriously lacking, as lizards simply have not attracted the attention and resources required to do the kind of work that has been undertaken

New lizard discoveries

The discovery of new lizard species and of new locations for known lizard species in Fiordland have been aided significantly by reports from alpine climbers. Posters asking for reports of lizards in alpine environments and articles in the The Climber (New Zealand's premier magazine for the climbing community) have been great advocacy tools.

Te Kākāhu skinks were found on Te Kākāhu/Chalky Island in 2003. *Photo: Hannah Edmonds.*

A close-up view of a Cascade gecko, a species found by climbers in Sinbad Gully. *Photo: James Reardon.*

A cryptic skink (also known as a 'mahogany skink' because of the species' unique colouration), Sinbad Gully, Fiordland. *Photo: James Reardon.*

Sinbad Gully

Sinbad Gully is the main location for active lizard research and conservation management in Fiordland. Located at the base of the world famous Mitre Peak, Sinbad Gully is characterised by extremely steep glacially-carved side walls with near-vertical granite cliffs covered in dense silver beech forest. This extreme topography is not only stunning to look at but also provides a level of ecological isolation that may have contributed to it being one of the last places in Fiordland where kākāpō were found on the mainland in the 1960s and 1970s.

Sinbad Gully, with Milford Sound/Piopiotahi in the far distance. *Photo: James Reardon.*

A great attribute of Sinbad Gully is its proximity to the tourist hub of Milford Sound/Piopiotahi, which has provided the opportunity for DOC to partner with New Zealand-based tourism company Southern Discoveries and the Fiordland Conservation Trust to undertake pest control and species monitoring in the Sinbad area. In 2009, the Sinbad Sanctuary project was established, the key purpose of which has been creating an opportunity to demonstrate the pressures on mainland forest ecosystem health, as well as educating the public about the tools and techniques that are available to mitigate these pressures.

Two rare lizards are found in the valley: the Sinbad skink (Nationally Endangered) and the Cascade gecko (At Risk). The site is also home to a morphologically distinct population of the cryptic skink (Declining). Hannah Edmonds, a lizard technical specialist at DOC in Te Anau, described the area as 'the only reptile "community" of species known from Fiordland's alpine ecosystem'.

A Sinbad skink at home on the steep cliffs that line Sinbad Gully near Milford Sound/Piopiotahi. These rare skinks were discovered here in 2004 by herpetologist Tony Jewell. *Photo: James Reardon.*

In 2010, in recognition of an urgent need for research on and conservation of the Sinbad skink, biodiversity staff at DOC's Te Anau Area Office, supported by DOC science and technical staff, led an investigation into the population biology, ecology and threats to this species. The aim was to enable effective management of the species and to classify its threat status which, at that time, was listed as Data Deficient, with it only being known from one small area of rocky cliff habitat in the alpine cirque at the head of Sinbad Gully. Sinbad skinks are difficult to observe, as their known habitat consists of small pockets of grasses and herbs on near-vertical rock walls, and consequently, prior to the 2010 study, only ten Sinbad skinks had ever been captured. While only two Sinbad skinks were captured during the 2010 study, this valuable pilot project led to a refinement of the research and management strategy for Sinbad skinks, as well as ongoing research and management funded by Southern Discoveries. Although surveys for new populations were unsuccessful in locating Sinbad skinks outside Sinbad Gully, the results placed a higher priority on protecting the only known population at this site. Annual monitoring of the Sinbad skink population has continued since 2010, using low-cost and 'coarse' monitoring methods which will detect a 'catastrophic change' in the population.

Climber and Director of Abseil Access Ltd, Martin Wilson, searches for Sinbad skinks on the Sinbad face in Fiordland, February 2012. *Photo: Dave Vass.*

In February 2012, two climbing contractors, Martin Wilson and Dave Vass, abseiled approximately 180 vertical metres of the cliffs above the area known to contain Sinbad skinks, and saw several lizards, including Sinbad skinks, cryptic skinks and a Cascade gecko. Cryptic skinks and Cascade geckos were also seen on the relatively flat ground on top of the wall. In 2013, a mature male Sinbad skink was observed maintaining a territory some significant distance away from the rock wall. This finding is significant and potentially lends weight to the theory that the Sinbad skink is restricted to the known site not because of highly specialised niche requirements, but because of the impacts of invasive pests such as stoats and mice.

A Barrier skink, first discovered in Fiordland in 1966.
Photo: Hannah Edmonds.

A Cascade gecko, another rare lizard found in Sinbad Gully.
Photo: James Reardon.

on threatened birds. Significant research and partnership opportunities abound for lizard work, although further capability would need to be developed to undertake some of the highly specialised tasks required.

A recent population estimate of the critically endangered Te Kākāhu skink suggests that the population may be able to withstand harvesting for translocation. The National Lizard Technical Advisory Group recommended that Pukenui/Anchor Island be evaluated as a priority to assess its suitability for the translocation of this species.

In 2014 Luke Johnson, a postgraduate Diploma of Wildlife Management student from the University of Otago, completed a pilot study to determine the distribution of Barrier skinks within microhabitat types and to test remote camera monitoring techniques. Luke found that the type of camera used for his study (Kinopta's Blackeye 2W) is not suitable for alpine skink monitoring, but that camera trapping in general has potential as a valuable tool in monitoring alpine skinks. Most importantly, Luke's study showed that photo-identification is likely to be a viable option for use in Barrier skink monitoring and population estimates. Moreover, Luke also found that modelling of Sinbad skink observation rates based on weather variables is a promising tool for guiding future field efforts and for understanding the ecology of alpine skinks.

DOC Biodiversity Ranger Hannah Edmonds searching for lizards on the Sinbad Faces, February 2008. *Photo: DOC.*

Invertebrates

Despite multiple episodes of glaciation overwhelming the Fiordland area in ice during the Quaternary Period, several examples of anciently evolved (pre-Quaternary) and uniquely associated invertebrates have been described in the last 20 years in Fiordland, including many examples of land snails, caddisflies, wētā, leaf-vein slugs, beetles, moths and many other insect taxa. A range of insect and snail taxonomic studies have demonstrated old local species associations or interesting episodes of speciation. For example, grasshoppers are largely absent from Fiordland, but two unique grasshopper species of very limited distribution have recently been described by Simon Morris (an independent researcher and associate of the Canterbury Museum) – one from the Murchison Mountains (*Sigaus takahe*) and another from a few tiny populations in the upper Hollyford Road catchments of the Milford Road (*Sigaus homerensis*).

Rodent-free islands in the west of Fiordland are home to two celebrated relict giant weevil species, which have been lucky not to have been entirely lost to rodent invasion given their flightlessness. Biosecurity actions to protect birds and invertebrates such as these from ship rats and mice completing their invasion of Fiordland are some of the most significant insect and snail conservation actions currently being carried out. In one case, this management has even been complemented by a pioneering trial to re-establish flax weevils and knobbled weevils on Te Au Moana/Breaksea Island following the removal of Norway rats (see chapter 2).

Powelliphanta fiordlandica

One of the most interesting Fiordland endemics is the large landsnail, *Powelliphanta fiordlandica*. It has a patchy distribution on the southern coastal mountains between Chalky Inlet and Secretary Island and appears to have been isolated from other *Powelliphanta* for millions of years, having developed highly distinctive genetics and morphology.

Large landsnail, *Powelliphanta fiordlandica*. *Photo: Kath Walker.*

The most widely celebrated or interpreted invertebrates in the region are the glowworms of Te Anau caves, Lake Te Anau – indeed, the economic importance of glowworms within the national park has been the subject of independent research. Neville Peat and Brian Patrick's 2006 book *Wild Fiordland*[16] provides excellent advocacy for the invertebrate fauna of Western Southland and Fiordland and its conservation.

Fiordland is also home to some pest invertebrate species. For example, exotic common and German wasps occur in fringing hardwood honeydew shrublands and forests among the fiords and northern Hollyford/Pyke catchments. These are known to cause problems in forest honeydew systems elsewhere in New Zealand, but their impacts in Fiordland have not yet been assessed.

When considering the region around Te Anau, and the hinterlands of the Livingstone Mountains, the Fiordland lakes and beyond, it appears that invertebrate conservation has only been a minor component of environmental- or ecosystem-focused management and protection over the last 30 years. Much of the specific work on invertebrates has been undertaken by external researchers, including postgraduate students, although invertebrate surveys for land development and land protection proposals have generally been carried out by DOC science and technical staff, including Eric Edwards and local biodiversity staff .

Very few studies of invertebrates have been undertaken with the aim of directing or influencing management decisions. Some insightful studies have been carried out, however, including those examining the interaction between invertebrates and tussock seeding. In many years, tussockland seed set is occasional, but in some years synchronised abundant seed set, or mast seeding, occurs – like that seen in beech forests. This mast seeding has been studied in the Murchison Mountains, Borland Saddle and, occasionally, elsewhere in Fiordland. Studies of seed predators (tiny cryptic but abundant flies belonging to the family Cecidomyiidae) and tussock-dwelling ground wētā have made significant contributions to our understanding of the ecology of Fiordland's grassland systems. This has included, for example, research on the effect of climate change and specialist (insect) seed predators on mast seeding species (undertaken by Landcare Research), and their interactions with mice, stoats and other pest animals (e.g. Des Smith's MSc project on stoat diet in the Murchison Mountains).

Long-term ecological studies of beech forest ecosystems in the Eglinton Valley are ongoing and also investigate key species interactions associated with beech mast seeding. However, the ecosystem-level interactions of invertebrates during these events, and the tree root and foliar browsing interactions of invertebrates have generally not been explored in depth. Exceptions include work carried out in the early 1980s by the New Zealand Forest Service and, more recently, by Colin O'Donnell in his investigation of the influence of season, habitat, temperature and invertebrate availability on nocturnal activity of long-tailed bats.

West Fiordland and its islands provide a rare and valuable opportunity to gain an insight into the nature of ecosystem-level impacts from rodents. However, scientific investigations comparing community

A newly described species of grasshopper, *Sigaus homerensis*, from the Upper Hollyford area in Fiordland. *Photo: Simon Morris.*

[16] Peat, N.; Patrick, B. 2006: *Wild Fiordland*. Otago University Press. 144 p.

assemblages of invertebrates dwelling on rodent-free islands with those on islands with either mice or ship rats and/or Norway rats present and those on the mainland with assemblages of rodents are yet to be carried out across alpine, wetland, forest and coastal environments.

While very few land development proposals have been assessed for changes to any indigenous fauna, the assessment of invertebrate fauna has played a small contributing part in both land development and land protection proposals. Examples include excavation of a tunnel from Hollyford Valley, changes in the management of Mount Prospect Pastoral Lease and Milford Road / Milford village activities. The most detailed and quantitative studies are those associated with the Manapouri and Monowai hydroelectric power operations. This work has been overseen and/or carried out by a number of agencies, or independent researchers contracted on their behalf. The agencies include the Waiau Working Party (representing concerned agencies and energy companies), the Guardians of the Lakes Manapouri, Monowai and Te Anau (a legislated entity), the Waiau Fisheries and Wildlife Habitat Enhancement Trust, Genesis Energy, Meridian Energy, Environment Southland, Fish and Game, and the National Institute of Water and Atmospheric Research (NIWA). Many quantitative aquatic invertebrate studies have been published and are still ongoing for each of these schemes. The impact of the invasive freshwater alga didymo on stream invertebrates has also been analysed in detail in the Mararoa and Waiau Rivers by researchers from Biosecurity New Zealand Ltd (see chapter 7).

Wētā as indicators of forest health

DOC scientists Colin O'Donnell, Jo Monks and Eric Edwards are currently developing methods for monitoring ground wētā as a potential indicator of the health of forest-floor invertebrate populations before and after pest control programmes aimed at controlling rodents and stoats, in particular. They monitored four 100 m × 100 m sampling grids in the Eglinton Valley to develop methods for identifying wētā footprints, sampling techniques using tracking tunnels and spot-light transects at night, and mark-recapture methods. Preliminary results are promising, with the monitoring indices being correlated with each other, which provides 'proof of concept' in terms of the approach the team is using. The relationship between these indices and the actual density of wētā remains unclear at this stage, however.

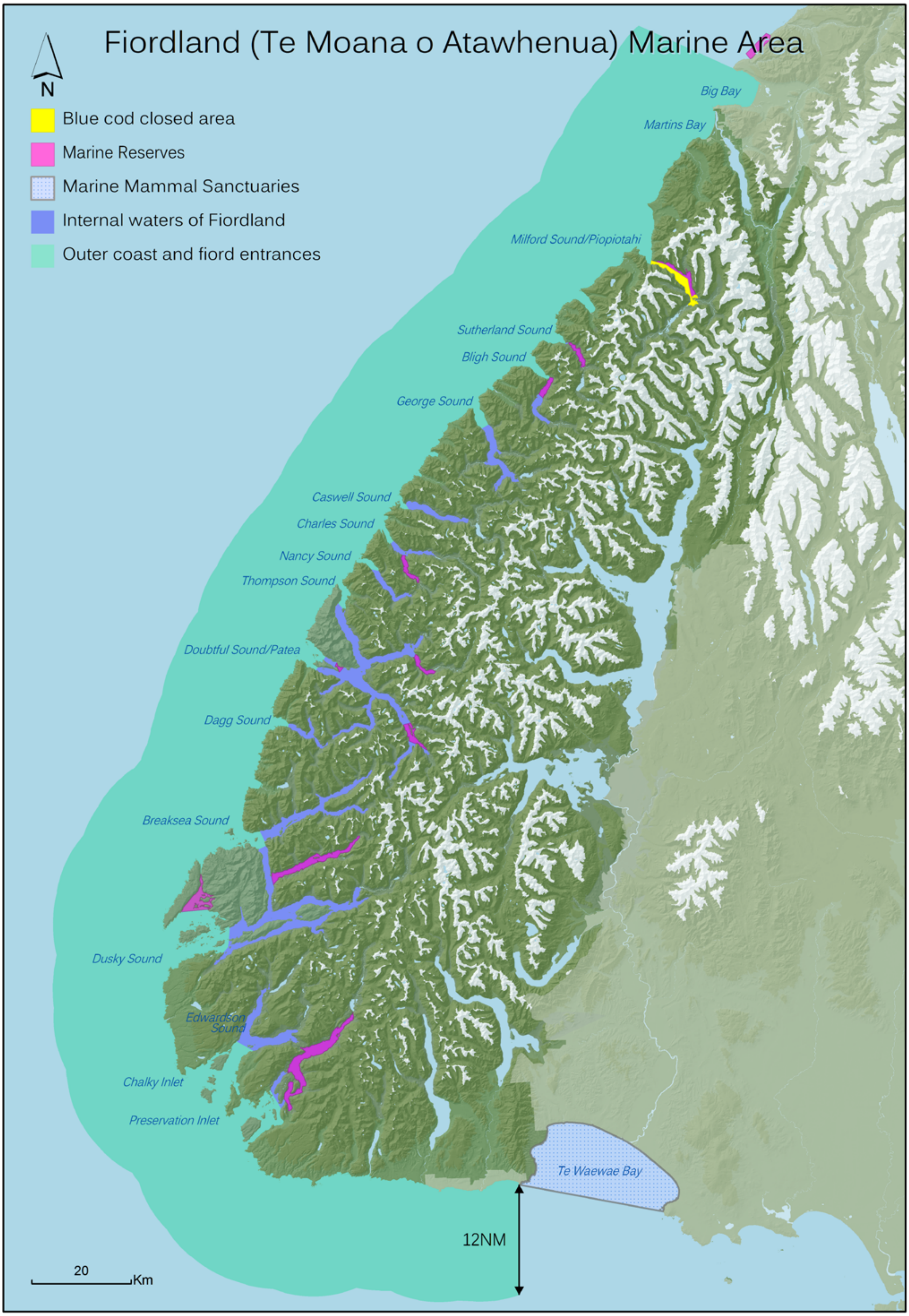
Juvenile cave weta, *Talitropsis sedilloti,* Eglinton Valley, Fiordland National Park. *Photo: Eric Edwards.*

Ground weta, *Hemiandrus maculifrons*, at Walker Creek, Eglinton Valley. *Photo: Eric Edwards.*

Colin O'Donnell and Jo Carpenter searching for cave weta in the Eglinton Valley. *Photo: Eric Edwards.*

Fiordland's iconic landscape and terrestrial biota are matched by an equally distinctive marine environment.

A poupou is installed on the east side of Kahukura (Gold Arm) Marine Reserve in Charles Sound, February 2014.
Photo: DOC.



Map 10. Fiordland (Te Moana o Atawhenua) Marine Area.

Monitoring and management of Fiordland's marine environment

Fiordland's distinctive marine ecosystems

Fiordland's iconic landscape and terrestrial biota are matched by an equally distinctive marine environment. Deluged with an annual rainfall in excess of 7 m, numerous rivers and streams pour a layer of brown (tannin-stained) freshwater into the fiords, which blankets the oceanic water and significantly reduces the amount of light that is able to penetrate their depths. In turn, this severely limits the depth to which light-loving seaweed can grow and allows species of deep sea corals to grow in much shallower water than normal – a phenomenon that creates a marine flora and fauna unlike any other in New Zealand, or the world.

DOC has the responsibility under many sections of legislation (i.e. the Marine Reserves Act and the Marine Mammal Protection Regulation) to protect the marine environment and individual species of marine organisms, and leads attempts to prosecute any offences under the Marine Reserves Act. Since the inception of the Fiordland (Te Moana o Atawhenua) Marine Management Act (FMMA) in 2005, DOC has also been responsible for leading all of the monitoring work that is carried out under this framework in the Fiordland (Te Moana o Atawhenua) Marine Area (FMA; Map 10). This work is primarily biological monitoring, but also includes social monitoring.

Diver in the shallows, Fiordland Marine Area, 2013. *Photo: Richard Kinsey.*

Deep water species at shallow depths

Rare and protected species of black and red corals, normally found only at great depth, are able to live at shallower water depths in Fiordland because of the light-limiting layer of freshwater on the water surface in the fiords.

Photo: NIWA/DOC.

Marine work in Fiordland from 1987 to 2015 can be broadly split into two categories: site-led marine ecosystem monitoring, and marine mammal monitoring and research. Marine ecosystem monitoring includes research that is undertaken within the marine environment, excluding that on marine mammals, and is further split into pre-FMMA (i.e. before 2005) and post-FMMA (from 2005 onwards). This distinction is appropriate given the significantly greater level of government funding to carry out marine monitoring and the subsequent higher level of reporting that has occurred since 2005. Recent work also includes a greater emphasis on marine biosecurity and social research. Marine mammal research and management has focused predominantly on bottlenose dolphin populations in the fiords, but also encompasses other research and DOC's legislative commitments. The following discussion gives a brief overview of the larger pieces of work that have been carried out or supported by DOC in these two areas.

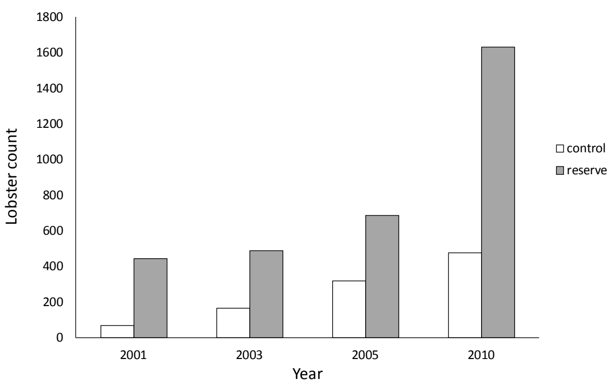
Marine ecosystem monitoring

Monitoring before the FMMA (2005)

Prior to 2005 the most comprehensive monitoring undertaken by DOC staff in Te Anau was of the red or spiny rock lobster or 'crayfish' and the green or packhorse rock lobster at the two marine reserves gazetted in 1993 – Piopiotahi (Milford Sound) Marine Reserve and Te Awaatu Channel (The Gut) Marine Reserve in Doubtful Sound/ Patea. These surveys focused on developing a baseline for abundance in both of these marine reserves compared with the surrounding marine area and the reserves are periodically re-surveyed to see how the numbers of rock lobsters are changing over time. The most recent survey was carried out in 2010 (see graph below) and showed a large increase in the abundance of rock lobsters in the reserve and a lesser increase in the control sites.

In response to a kina (sea urchin) fishery opening in Tamatea/Dusky Sound in the early 1990s the Ministry of Agriculture and Fisheries (MAF) started studies on the sustainability of the kina resource in that area. An impact assessment of this fishery on the benthic community was also commissioned to the former Science & Research (S&R) Division of DOC and carried out by Marine Scientists Eduardo Villouta (Project Lead), Cameron Hay, and Chris Pugsley. From October 1992 to April 1995 they conducted a large kina removal experiment in Tamatea/Dusky Sound. The work was supported by a team of 15 DOC and volunteer divers, including Lindsay Chadderton from Southland Conservancy (who also contributed significantly to the data analysis and report writing). Their aim was to investigate potential ecological changes in the benthic community following the removal of large numbers of kina. Results confirmed a causative relationship between the abundance of kina and the abundance of algae and invertebrates from subtidal habitats in Tamatea/Dusky Sound. MAF's surveys (quantitative sampling) confirmed this relationship. Overall, this research showed that despite the colder waters and the influence of a low-salinity layer in this southern fiord, kina has a strong influence in subtidal communities. The kina fishery collapsed by 1994 and funding for further research was no longer available.

Spiny rock lobster or 'crayfish' in Fiordland waters. *Photo: NIWA/DOC*



Actual counts of rock lobster (*Jasus edwardsii*) in Te Awaatu Channel (The Gut) Marine Reserve 2001–10.

DOC's S&R Division also contributed to an impressive study lead by NIWA scientist Wendy Nelson describing Fiordland's macroalgae. To this end, Eduardo Villouta co-authored a paper describing records of macroalgae from Milford Sound/Piopiotahi to Puysegur Point, compiled primarily from specimens housed in the herbarium of the Museum of New Zealand Te Papa Tongarewa which is published in Tuhinga: Records of the Museum of New Zealand Te Papa Tongarewa[17].

The Fiordland Marine Guardians process

Increasing concern about the escalating pressures on the FMA in the early 1990s and a desire for the local community to be more involved in the management of Fiordland's marine environment led to the formation of 'the Guardians' in 1995. Formally the Guardians of Fiordland's Fisheries Inc. (later known as the Guardians of Fiordland's Fisheries and Marine Environment Inc.), stakeholders included tangata whenua (Ngāi Tahu), commercial and recreational fishers, charter boat and tourism operators, environmentalists, marine scientists and community representatives.

Guided by their vision to protect the marine environment and fisheries for future generations, the Guardians developed the Fiordland Marine Conservation Strategy[18]. Gaining stakeholders' agreement to proposals for the integrated management of the Fiordland marine environment was the first major success in this journey. Stakeholder groups were required to relinquish their interests for the good of ensuring the quality and

[17] Nelson, W.A.; Villouta, E.; Neill, K.F.; Williams, G.C.; Adams, N.M., Slivsgaard, R. 2002: Marine Macroalgae of Fiordland, New Zealand. *Tuhinga 13*: 117–152.

[18] Guardians of Fiordlands's Fisheries & Marine Environment Inc. 2003: Fiordland Marine Conservation Strategy. 138 p.

Red coral. One notable proposal agreed upon by the Fiordland Marine Guardians was for the protection of small, discrete areas containing items of special significance. These areas have become known as 'China Shops' because of their fragility. *Photo: Steve Wing.*

sustainable management of the Fiordland marine environment and fisheries – a process referred to as the 'gifts and gains'.

During the initial stages of developing the Fiordland Marine Conservation Strategy, a number of supporting documents were produced to help inform the decision-making process. Steve Wing, Professor of Marine Ecology at the University of Otago, was responsible for developing the three-volume study entitled Analysis of biodiversity patterns and management decision making processes to support stewardship of marine resources and biodiversity in Fiordland – a case study[19]. This study characterised the bathymetry, oceanography, habitat types, biological distribution of key species and many other aspects of the Fiordland marine environment, which helped to inform the Guardians. DOC was heavily involved in helping to develop the conservation strategy, and provided a number of resources for the project and a great deal of support to the Guardians.

In 2004, the finalised Fiordland Marine Conservation Strategy was presented to the Minister of Fisheries and the Minister for the Environment, who made a commitment to implement the strategy by September 2005. Representatives of central and regional government and the Guardians were appointed to an Investigative Group by the Government to report on how best to implement the strategy, and in September 2004 the Government accepted a review of the strategy recommendations and agreed to:

- Develop special legislation to give effect to many of the recommendations.
- Amend fisheries regulations for non-commercial harvesting.
- Exclude commercial fishing from large areas of the internal waters of Fiordland.
- Implement a range of other non-legislative measures.

All of these recommendations were realised with the enactment of the FMMA.

The Fiordland (Te Moana o Atawhenua) Marine Management Act 2005 (FMMA)

The FMMA formalised the original Guardians of Fiordland's Fisheries and Marine Environment process mentioned above and created the Fiordland (Te Moana o Atawhenua) Marine Area (FMA), which extends from Awarua Point on the West Coast (just north of Big Bay) to Sandhill Point (western point of Te Waewae Bay), and 12 nautical miles out to sea. Most importantly, however, the FMMA also gave formal recognition to the 'Fiordland Marine Guardians', who have been appointed by the Minister for the Environment as an advisory body to advise management agencies on the management of the FMA.

The FMMA identifies the various agencies that are responsible for administering all of the different parts of legislation that fit into the FMA and also highlights which agency is responsible for leading the different parts of management:

- Ministry for the Environment (MfE) – overall lead agency for administering the FMMA and the Fiordland Marine Guardians.
- Department of Conservation (DOC) – Lead agency for monitoring.
- Ministry for Primary Industries (formerly Ministry of Fisheries) (MPI) – Lead agency for compliance.
- Ministry for Primary Industries (formerly MAF Biosecurity NZ) (MPI) – Lead agency for biosecurity.
- Environment Southland and Ministry for the Environment – Lead agencies for communication.

It was clear from the start of the process that the successful implementation of such a varied package would require all of the management agencies and the Guardians to work closely together. Therefore, the Guardians were given the role of facilitating and promoting the integrated management approach, with the central desire for all groups to work as closely together as possible and to make sure that the integrated approach is at the forefront of the management of the FMA.

It is rare for a community-led group such as the Guardians to be in a position to statutorily advise and make recommendations to the managing agencies, but this 'bottom up' approach to managing such a resource has been fundamental to the whole process.

[19] Wing et al. 2003, 2004, 2005: Analysis of biodiversity patterns and management decision-making processes to support stewardship of marine resources and biodiversity in Fiordland – a case study. Unpublished contract reports prepared for the Department of Conservation. University of Otago, Dunedin.

The FMMA not only formalised the FMA, but also made a number of management changes to it, most notably:

- Eight new marine reserves totalling over 9500 ha in area were established. This increased the area protected by marine reserves in the inner fiords from less than 1% to 13%, and was a significant conservation achievement.
- The creation and formalisation of 23 'China Shops' (unique and fragile areas of high biodiversity value) throughout the FMA. Many of these high-value areas are also listed as no anchoring areas so that the fragile species below are not damaged by anchoring vessels.
- The passing of new recreational fisheries regulations that reduce the daily bag limits for some species (e.g. groper (hāpuku), blue cod (rāwaru) and prohibit accumulation of daily catch limits.
- Placement of a temporary closure on blue cod fishing in Doubtful Sound/Patea[20] and Milford Sound/ Piopiotahi to allow the species to recover from fishing pressure.
- No longer allowing commercial fishers to fish in the internal waters of Fiordland.

The Fiordland Marine Guardians process is an ongoing adaptive management framework that is always being updated and refreshed. It is hoped that by having agencies and local stakeholders working together the FMA will be safe-guarded for many generations.

Biological monitoring since the FMMA (2005)

In 2006 and 2007, marine surveys collected baseline data from sites across Fiordland for future biodiversity monitoring. This work was contracted by DOC to Steve Wing, who worked with a combination of University of Otago and DOC marine staff to carry out the 2-week-long surveys onboard the DOC vessel *MV Southern Winds*. These surveys covered a range of habitats, including inner and outer fiords, marine reserves and commercial exclusion zones. Biological and physical parameters were measured and mapped to define broad-scale patterns and parameters within which all current and future study sites can be assessed for environmental representation. Biological data encompassed species distribution, abundance and community structure and diversity. Reef fish, kina, common kelp, macro-invertebrates and permanently attached rock wall invertebrates were all assessed at their respective survey sites.

The Fiordland Marine Guardians, 2013. L to R: Rebecca Mcleod, Malcolm Lawson (Chair), Jerry Excell, Jonathan Clow, Mark Peychers, Anne McDermott, Ken Grange, Stewart Bull (Ngāi Tahu representative). More information about the Guardians and the FMA is available at www.fmg.org.nz. *Photo: Fiordland Marine Guardians.*

Doubtful Sound/Patea from the bow of the DOC vessel, *MV Southern Winds*. *Photo: Richard Kinsey.*

By 2007, there was a focus on key species as indicators of ecosystem health. In addition to the groups of species mentioned above, the distribution and abundance of rock lobster and blue cod populations were surveyed in order to assess the effectiveness of the changed management strategy post-2005.

This baseline monitoring is currently the single most important piece of work that has been carried out since the inception of the FMA, as it is anticipated thet it will allow broad-scale changes to the area to be detected over time. It will also inform the Guardians and DOC as to whether or not the suite of management changes made in 2005 have been effective.

'China Shops'

During the development of the FMMA, 23 sites were identified as holding distinctive and fragile benthic communities, and formally recognised as 'China Shops'. Ten of these were within marine reserves and seven of which were designated as 'no anchoring' areas in the Regional Coastal Plan for Southland[21].

[20] This temporary closure for recreational blue cod fishing in Doubtful Sound/Patea was lifted in December 2015. Recreational fishers are now permitted to catch one blue cod per person per day in the internal waters of the Doubtful/Patea, Bradshaw and Thompson Sound complex with no accumulation.

[21] Environment Southland 2013: Regional Coastal Plan for Southland. Environment Southland. Publication No. 2014/02, Invercargill. 134 p.

New species

These colony-forming ascidians (sea squirts) were one of the 'new species' found during 'China Shop' baseline data gathering in Fiordland. Many of the 'China Shops' identified contained communities that, while only found in Fiordland, are not necessarily unique to that one site. Potential exists for many similar, unprotected and potentially high-value sites within the Fiordland marine environment.

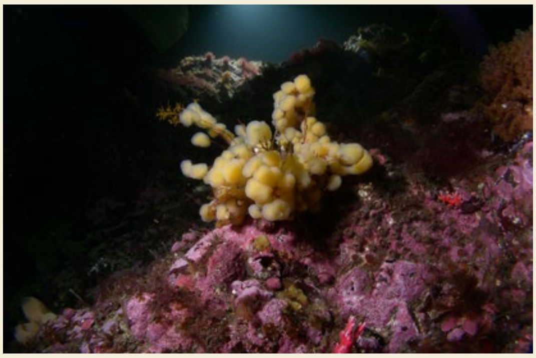
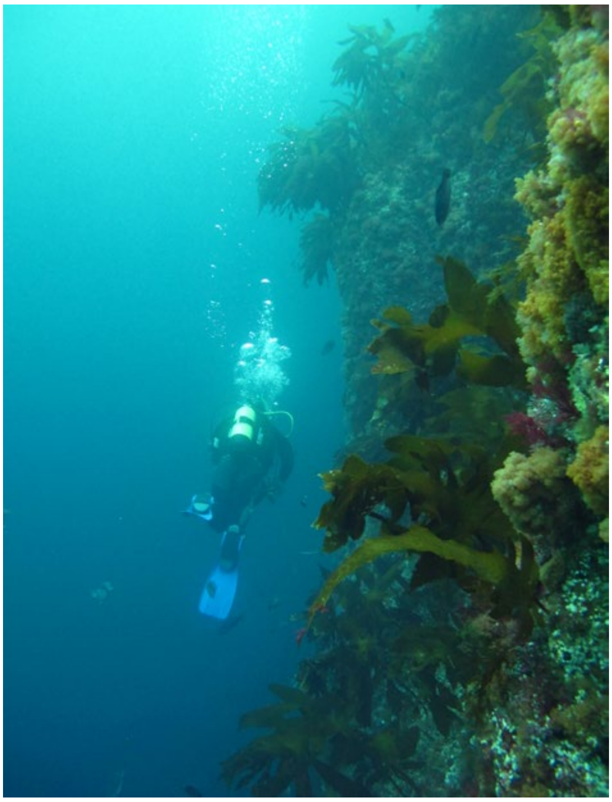


Photo: NIWA/DOC.



A diver passes a typical steep-sided rock wall in Fiordland.
Photo: Richard Kinsey.

In 2009, DOC contracted NIWA to gather baseline data at many of these sites to create a full species inventory, characterise community structure, and assess levels of current and potential future human-induced disturbance (versus natural changes) to these sites. These surveys were slightly limited by the incomplete knowledge of Fiordland marine biota – many species have not yet been described, hindering identification to the species level. However, several algal taxa and ascidian (sea squirt) species that were previously unrecorded in New Zealand and possibly new to science were discovered.

Deep reef surveys

A typical fiord environment consists of steep-sided walls that drop almost vertically to deep sea habitat at a depth of 200–400 m. The vast majority of this deep habitat consists of either mud and fine silt (due to the lack of water movement) or deep reef that is composed of harder substrate. The deep reef fauna of Fiordland is still relatively unknown – scientists actually know more about the marine environment in Antarctica than in Fiordland. Prior to 2009, all knowledge of this fauna stemmed from submersible surveys of Tamatea/Dusky Sound and Milford Sound/Piopiotahi in the 1980s, but these were also very limited.

In 2009, DOC contracted NIWA to visit Fiordland in the DOC vessel *MV Southern Winds* and survey some of the deep reef habitat. NIWA used one of their remotely operated vehicles (ROVs) to survey at different depths in the fiords. These surveys revealed that marine life was more abundant and diverse in the deep waters of the fiords than previously thought. Several new species were seen, including a fish and sea pen, and many of the invertebrates could not be fully identified, suggesting that they may also have been new species. The black coral *Antipathies fiordensis*, the gorgonian (sea fan) *Acanthogorgia* sp. and sponges were more abundant at shallow depths of less than 80 m. When the ROV travelled to depths greater than 80–100 m, species diversity decreased slightly, but increased again close to the entrances of the fiords, with the greatest species diversity being found in the lighter, shallower waters of the fiord entrances, where light is able to penetrate to greater depths due to the reduced amount of freshwater.

Baited underwater video surveys

Part of the contract with NIWA in 2009 (see above) included surveying the fish life in deeper fiord habitats using a baited underwater video (BUV) system. BUV equipment was deployed simultaneously in the same areas as the ROV – near reefs and fiord basins down to a depth of 200 m. The BUV consisted of a video camera facing a baited container so that any species that came to investigate the bait would be caught on camera.

Footage detected differences in fish assemblages between Doubtful Sound/Patea and Tamatea/Dusky Sound, with hagfish and sea perch more abundant in Doubtful Sound/Patea, and spiny dogfish more common in Tamatea/Dusky Sound. The inner fiords were generally characterised by hagfish, but species richness increased towards the mouth of the fiords, as would be

A snake star on a gorgonian (sea fan) usually found at shallower depths. *Photo: Richard Kinsey.*

A six or seven gill shark captured by the baited underwater video (BUV) in the inner fiord habitat, 2009. *Photo: DOC.*

expected. Large fish such as broadsnouted seven gill sharks, six gill sharks, school sharks and rough skates were also seen, as were many large groper (hāpuku).

Marine reserves

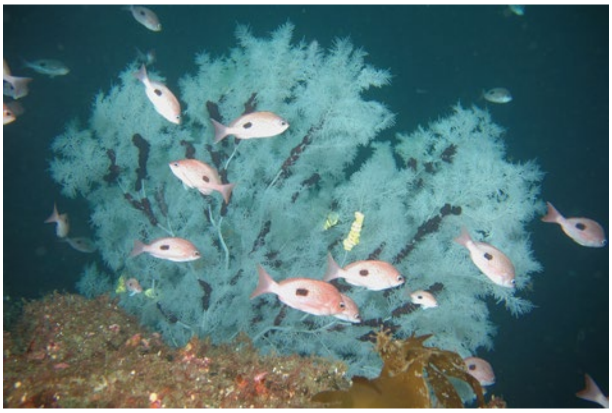
In 2005, eight new marine reserves were established under the FMMA, giving a total of ten in the FMA. These new reserves are situated in areas of high representative value, including inner fiord habitats and fiord entrance habitats that support significant national and international values. They were established to ensure that the community structure and biodiversity value of these areas were not unduly impacted by human disturbances.

The new marine reserves outside of Doubtful Sound/ Patea were marked with individually carved wooden Te Poupou o Rua o Te Moko (poupou) marine reserve markers. Poupou are carved figures that represent significant Māori ancestors from the area and they provide kaitiaki or guardianship over the reserves. These pou pou are more in keeping with Fiordland's wilderness values than the traditional white triangles (which are still used for the reserves in both Milford Sound/Piopiotahi and Doubtful Sound/Patea) and provide the local tangata whenua, Ōraka Aparima Rūnaka, with the kaitiakitanga/ guardianship that is so significant to their cultural ties with the fiords. The installation of the poupou represented a significant milestone for the Guardians and DOC, as the culmination of several years' worth of collaborative planning and effort.

All ten marine reserves contain biological monitoring sites that were put in place during 2006 and 2007 baseline surveys carried out by the University of Otago. These sites (and many other sites outside of the marine reserves) were established to inform DOC and the Guardians of any broad-scale changes in the fiord systems as a result of the new management regime. A further survey was carried out by Otago University in 2010 to resurvey a subset of the sites from the 2006 and 2007 to provide an ongoing time series.

The baseline monitoring allowed trends across the marine environment and through time at many of the monitoring sites to be analysed, particularly with regard

Individually carved poupou were created to mark the eight Fiordland Marine Reserves established in 2005. *Photo: DOC.*



Butterfly perch swim by the precious black coral in Fiordland waters. *Photo: Steve Wing.*

Blue cod (rāwaru). *Photo: Richard Kinsey.*

to the key indicator species that had been decided upon initially (such as blue cod, rock lobster, kina and black coral). Fiordland in its entirety comprises a very large expanse of habitats, so sites monitored in the initial baseline surveys in 2006/07 were spread quite thinly to cover the entire FMA. Unfortunately, this approach meant that a comparison of habitats inside and outside the marine reserves could not be made. Therefore, in 2009, NIWA was awarded a contract to survey a number of marine reserves within the FMA so that it was possible to gain a better understanding of any changes that may be occurring over time.

In 2013, NIWA was again contracted to collect more specific data from a number of equivalent habitat sites inside and outside a selection of marine reserves. A more fine-scale monitoring programme was initiated (and is still ongoing) at four marine reserves: Kahukura (Gold Arm) Marine Reserve in Charles Sound, Kutu Parera (Gaer Arm) Marine Reserve in Doubtful Sound/Patea, and Moana Uta (Wet Jacket Arm) and Taumoana (Five Fingers Peninsula) Marine Reserves in Tamatea/Dusky Sound. It is hoped that this scale will allow any specific changes that occur within a smaller area to be detected.

Blue cod (rāwaru)

During the initial development of the FMMA, the former Ministry of Fisheries was tasked with studying important fisheries species. Blue cod is a key indicator species of fisheries health, so significant effort has gone into monitoring this species in the FMA. In 2007, a survey utilising count-per-unit-effort (CPUE) and video-mounted lasers (VML) combined with baited underwater videos (BUVs) was implemented to assess the size, structure and abundance of indicator species. Analysis of these data in relation to population estimates from 1985 indicated a long-term decline in blue cod numbers across Fiordland, with some recent increases from 2005 to 2007 .

A report commissioned by DOC and produced by NIWA in 2009 found no significant difference in the density of blue cod between a number of Fiordland's marine reserves and fished areas; however, estimates indicated that the reserves held a greater number of fish in the larger size classes than the nearby fished areas. The following baseline resurvey in 2010 by Otago University built on the 2006 and 2007 surveys and showed positive changes in the relative abundance of blue cod in three of the reserves that had been established in 2005 – Kutu Parera (Gaer Arm) in Bradshaw Sound, Te Tapuwae o Hua (Long Sound), and Moana Utu (Wet Jacket Arm). This change was not observed anywhere else and there was no difference between other fisheries zones in Fiordland.

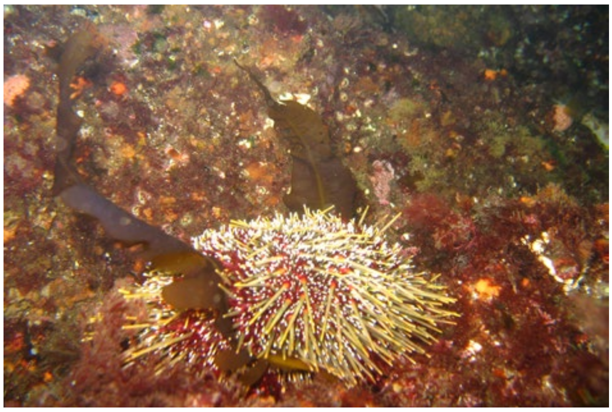
Biosecurity

Each year, hundreds of boats from all over New Zealand and around the world travel to Fiordland for recreational or commercial purposes. These vessels not only risk introducing unwanted pests into terrestrial environments, but also have the potential to introduce unwanted marine organisms into the fiords. Once established, these pests can quickly spread to new locations and seriously impact upon marine habitats, food chains, fish stocks, recreational activities and commercial fishing activities.

The majority of major ports around New Zealand contain unwanted marine pests, ranging from Asian kelp (undaria) , to the Mediterranean fan worm and a sea squirt (*Styela clava*). Once established, these pests are virtually impossible to eradicate. Bluff harbour is the nearest port to the FMA and only has undaria present at this stage. DOC's role, and particularly that of DOC staff at Te Anau, has been to work as part of a joint-agency team undertaking marine compliance and surveillance work throughout Fiordland.

In April 2010, a single specimen of the highly invasive seaweed Asian kelp (*Undaria pinnatifida;* also called undaria) was found on the mooring line of a fisherman's barge in Sunday Cove, Te Puaitaha/Breaksea Sound, during one of the joint agency compliance trips. This plant had only recently been introduced, but given its life

Fishing boats in Luncheon Cove, Dusky Sound. *Photo: DOC.*



Kina on an undaria plant. *Photo: Richard Kinsey.*

stage, was likely to have reproduced in the surrounding environment. It was believed that the most probable pathway for the plant's introduction to Fiordland was through bio-fouling on a vessel hull or by transfer from other marine equipment such as mooring rope, rather than from ballast water.

A joint-agency eradication response followed, led by Environment Southland (overall response managers) in association with DOC (operations lead) and the former MAF Biosecurity New Zealand (planning and intelligence lead). After gathering information on the life history of undaria and the likely timing of finding juvenile undaria from the mature specimen, the three agencies revisited the site and surrounding areas in July 2010 to carry out a delimitation survey.

During the delimitation survey, searches were carried out at high-risk sites in Te Puaitaha/Breaksea Sound, Tamatea/Dusky Sound and Te Ra/Dagg Sound, including Stevens Cove, Luncheon Cove and Beach Harbour. Undaria was only found in Sunday Cove, but approximately 300 juvenile undaria were removed from here, confirming that the mature specimen found initially had released a number of spores. To eliminate the risk of microscopic stages continuing to grow, the response team replaced all mooring lines and other redundant rope from the barge, and attempted to kill any as yet invisible plants from the seabed underneath the barge by applying granulated chlorine and covering it with plastic tarpaulins.

Following the delimitation survey in June 2010, the agencies decided it was feasible to try to eradicate the incursion of undaria from Sunday Cove. The decision was made to use teams of divers to remove any undaria found. In the same year the search area was determined and a number of transect lines installed to aid divers. Any undaria specimens found during the surveys were removed by hand and placed in plastic bags to be disposed of. Due to the life history of undaria and the fact that it can reach maturity in less than 6 weeks, searching trips were undertaken every 4 weeks.

Although several approaches have aided this eradication programme (including the use of tarpaulins and chlorine to treat suspected 'hot spots' of spores, and clearing areas of seaweed to help with searching) it has been the effort of the approximately 35,000 kina present in the area that have made the biggest difference in helping the eradication team keep undaria in check.

In 2011, the eradication team collected a large number of kina from the outer coast of Te Puaitaha/Breaksea Sound and placed them in areas of Sunday Cove. The kina were applied for two reasons – to physically consume any undaria that they came across and, more importantly, to eat their way through all of the available seaweed. This enabled the team to search areas previously covered in dense algae with much more efficiency and to identify small undaria plants.

By September 2016, the eradication attempt had removed a total of 1906 individual undaria specimens from Sunday Cove. Monthly dive surveys to search for undaria will continue until there has been a continuous 18-month period of no undaria detections, prior to moving to a 3-year monitoring programme. Should the site be declared undaria free following the monitoring period, this will be the first ever successful eradication of undaria from any natural substrate in the world[22].

Social monitoring – user studies

Part of managing the monitoring programme in the FMA involves consideration of its social values. In 2007 and 2010, DOC commissioned social studies that were carried out by Kay Booth and Associates (2007) and Lindis Consulting (2010). These studies were designed to assess what people thought of the FMA, and the perceived values and threats across a number of demographics. They also included interviews with local stakeholders to

[22] In May 2017, much to everyone's disappointment, a new large incursion of undaria was found in Te Puaitaha/Breaksea Sound. At the time of writing the full extent of the incursion was still being be determined; options for slowing the spread of undaria throughout Te Puaitaha/Breaksea Sound and into Tamatea/Dusky Sound were being considered.

Keeping undaria at bay

The first established populations of the Asian kelp *Undaria pinnatifida* (undaria) in New Zealand were recorded in Wellington in 1987. From there, the species spread steadily around New Zealand's coast and was discovered in the Southland area at Big Glory Bay, Stewart Island/Rakiura, on 13 March 1997. Attempts to eradicate this founding population were initiated by DOC in late April, on the advice of recognised national algal and pest management experts. The aim was to prevent establishment and further spread around Stewart Island/Rakiura, and into Fiordland and the subantarctic islands. The eradication programme was extended to Bluff Harbour in 1999 and Halfmoon Bay, Stewart Island/Rakiura, in 2000 following the discovery of new founding populations. The programme successfully controlled the original founding population of undaria to low densities, and prevented spread from Big Glory Bay. However, eradication was not achieved, primarily due to two new incursions arising from independent founding events at Bluff Harbour and in Halfmoon Bay. Ongoing costs of control at all three sites could not be sustained without central government funding, and the development and adoption of a national undaria management programme. Central government support was withdrawn in 2004 when the former Southland Conservancy was unable to convince the funding agency (Biosecurity New Zealand) that the ongoing eradication/control programme was justified, particularly when prioritised against other biosecurity projects, and the programme ceased on 30 November 2004.

Immature *Undaria pinnatifida*. Photo: K. Blakemore.

gather their views on the implementation of the FMMA and the associated change in management strategies.

The 2007 and 2010 studies had very similar findings, with little apparent change in user perceptions over the 3-year period. It was found that users valued the FMA for multiple reasons, with nature-related themes dominating, and with economic and recreational reasons also being important. While there was widespread awareness of subjects such as marine pests and marine reserves, more in-depth knowledge was generally lacking. Similarly, the rules of marine reserves were generally well understood, yet there was a lack of detailed knowledge about marine reserves – although there was a perception that they provide adequate protection.

In general, it was found that the current management regime was having no positive or negative impact on people's experience or use of Fiordland, and most did not want a change in management, despite most users not feeling informed about FMA management. Overall awareness and knowledge of the Fiordland Marine Guardians was reasonably sound. The intention is to repeat the monitoring every 5 years, or whenever the Guardians or agencies detect changes associated with FMA use that demand attention.

Research by other agencies

Considerable research has been undertaken in the Fiordland marine environment that has not been directly related to or involved DOC and is therefore not described here. The University of Otago, for example, runs an ecology field trip in the fiords, and many other researchers have worked on the indicator species, habitats and ecological processes referred to in this report. Likewise, many other research establishments such as NIWA and the Cawthron Institute have carried out a number of projects, the largest of which is Cawthron's work to fulfil Meridian Energy's resource consent for their freshwater discharge into Doubtful Sound/Patea.

Marine mammal monitoring

Bottlenose dolphins

The University of Otago has been responsible for the majority of research into bottlenose dolphins in Fiordland, although in recent years DOC has worked collaboratively with them (aided by funding from the tourist operators who hold marine mammal viewing permits and Meridian Energy) to increase the research capabilities of both organisations.

The bottlenose dolphins found in Fiordland are thought to be the southernmost population of this species in the world. The total population in Fiordland is estimated at around 250–300 individuals, and is believed to be the most geographically discrete bottlenose population anywhere in the world. There are three (potentially four) subpopulations of bottlenose dolphins in Fiordland that form what appear to be discrete, separate breeding groups:

- The northern Fiordland subpopulation ranges from Jacksons Bay and Martins Bay in the north to Caswell Sound/ Charles Sound in the south. Interestingly, their range also incorporates the whole of Lake McKerrow/ Whakatipu Waitai in the Hollyford Valley, something that is unique worldwide for a predominantly marine species.
- Two well known subpopulations are found in the Doubtful Sound/Patea Complex and the Tamatea/ Dusky Sound Complex, and it is these groups that have received the majority of research attention over the years, mainly due to the ease of studying them inside a fiord.
- A fourth, little-known transient subpopulation ranges from Chalky Inlet, Bluff and Stewart Island/Rakiura to Dunedin – a range that has only recently been confirmed (2014) through incidental photographic identification during other monitoring activities. This subpopulation is very wide ranging when compared with the other fiord populations and more like the bottlenose population in the Bay of Islands.

Both the Milford Sound/Piopiotahi-Martins Bay and Taiari/Chalky Inlet-Dunedin Harbour subpopulations spend a lot more time on the open coast rather than in the calmer fiord waters, making them much more difficult to study due to the logistical constraints of weather, sea conditions and environmental factors – and, consequently, little is known about them.

Bottlenose dolphins found in the FMA have distinctive features compared with those found elsewhere. They have a larger body size and proportionally smaller flippers (presumably to conserve heat), with male animals reaching over 4 m in length and 350 kg in weight. The females have a longer-than-average calving interval and only breed during the summer months rather than year-round like many populations elsewhere in the world. They also have a very high calf mortality as a result of living at such geographical extremes.

Bottlenose dolphins leaping high in Tamatea/Dusky Sound, Fiordland. *Photo: Chloe Corne.*

Historically, the majority of research on bottlenose dolphins in Fiordland has been carried out in Doubtful Sound/Patea, mainly due to the ease of studying the population for researchers in a small vessel. The University of Otago started studying this subpopulation in the early 1990s and there is now over 20 years of data available – and long-term monitoring of this population still continues, with three surveys undertaken each year by DOC and the University of Otago.

Bottlenose dolphin, showing off its flippers. *Photo: Chloe Corne.*

Bottlenose dolphins in Doubtful Sound/Patea rarely leave the group – emigration from Doubtful Sound/Patea is extremely rare (only having been observed twice – once in 2005 and once in 2014) and the arrival of a new member has never been observed. There is a real risk, therefore, that we could lose bottlenose dolphins from this area.

Behavioural research by David Lusseau in 2005 identified key habitat areas for bottlenose dolphins in Doubtful Sound/Patea, as well as risks posed by the tourism industry. David's research led to one of the most significant advancements in the protection of marine mammals in Doubtful Sound/Patea, with the implementation of a voluntary Code of Management (COM) 2008, which all commercial dolphin-watching operators in Doubtful Sound/Patea are signatories to.

Under the COM, 200-m-wide Dolphin Protection Zones were designated, limiting vessel traffic to protect key resting and socialising areas for dolphins – behaviours that are considered crucial for survival and therefore population persistence. One of the most significant changes brought about by the COM was the agreement of all signatories to forgo their right to actively seek dolphin encounters despite holding marine mammal viewing permits, instead leaving such encounters to chance.

Bottlenose dolphins, Doubtful Sound/Patea. *Photo: S. Hayes.*

The COM also provides other guidelines for vessels operating in the Doubtful Sound/Patea Complex. It encourages education and public awareness with regard to bottlenose dolphins, and supports a research and monitoring programme to attempt to determine the cause of population decline. Although the COM cannot be used to manage other causes of human disturbance (e.g. freshwater discharge from the Manapouri hydroelectric power scheme, boat strikes, competition with fishermen for food sources, disease, potential lack of genetic diversity and climate variability); it is, nevertheless, a crucial step towards a collaborative stakeholder-based approach to the conservation of this subpopulation of dolphins.

Long-term monitoring of the bottlenose subpopulation in Tamatea/Dusky Sound commenced in 2007, with the aim of estimating survival rates of adults, subadults (1–3 years) and calves. The initial population estimate was twice the size of the Doubtful Sound/Patea subpopulation. Between 2009 and 2012, three field trips per year were undertaken to conduct systematic surveys of the sound, and all dolphin groups encountered were photographed for future identification. Between 2007 and 2011, 97 adults were identified and a preliminary estimate suggested that adult survival was extremely high (99.8%). By contrast, calf survival rate was estimated at 72.2%, which, though greater than the current calf survival rate in Doubtful Sound/Patea, is lower than any other reported survival rate for a wild population of bottlenose dolphins. Further work is needed to estimate the subadult survival rate and monitoring of this subpopulation continues with three field trips per year.

New Zealand fur seals

Before the arrival of people to New Zealand shores, the population of New Zealand fur seals (kekeno) was estimated at two million, many of which lived around the rugged coast of the fiords. During the early years of European settlement, fur seals were hunted to near extinction, but since their protection in 1978, numbers have been slowly recovering. Fiordland has always been considered a stronghold for New Zealand fur seals, with an estimated 40% of the national population living here, mostly in the fiords.

Little specific work has been carried out on New Zealand fur seals in the fiords themselves, but rudimentary estimates of abundance have been made periodically. In 2009, a Tasmanian environmental consultancy company, Latitude 42, was contracted to undertake a population survey of New Zealand fur seals along the entire west coast of the South Island (including the fiords and Solander Island (Hautere)). They conducted aerial surveys over a 3-day period in January to estimate the total number of seals present at the major colonies and haul-out areas. Three permanent monitoring sites on the West Coast were also surveyed using ground counts to test the efficacy of the aerial surveys. The final census figure was approximately 20,000 animals, which was considered a massive underestimate of numbers along the coast. In the future, a more robust study may be carried out to gain a much more accurate picture of fur seal populations.

The diet of New Zealand fur seals has also been a topic of interest, especially in terms of whether they clash with the recreational or commercial fishery sectors. Consequently, a great deal of research on fur seal diet has been conducted throughout New Zealand and it is now well established that they generally feed off the continental shelf in deeper water. However, the only diet study that has touched on the Fiordland environment was an MSc study by James Holborow, which focused on Long Reef in Martins Bay and not the fiord environment

Fur seal (kekeno) pup. *Photo: John Barkla.*

specifically. James was able to describe the diet of this population using information from scats and regurgitates. His results were consistent with those from previous studies of New Zealand fur seal diet. James concluded that information on diet and foraging indicates that New Zealand fur seals do not compete with inshore commercial or recreational fisheries. However, overlap does occur with two of New Zealand's largest offshore fisheries – for hoki and arrow squid: 'Whether this constitutes significant competition is difficult to demonstrate, partly because of uncertainties about seals (e.g. abundance), but more because the consumption of fisheries species by other predators is unquantified.'[23]

There is a desire to complete a more thorough and specific diet study in the fiords themselves to create a much clearer picture of what New Zealand fur seals feed on.

General sightings

As of February 1996, tour boat operators with marine mammal viewing permits have recorded cetacean sightings in Fiordland for DOC. The first 10 years of sightings data have been collated and analysed, with a total of 4617 cetacean sightings within the fiords and on the open coast. The majority of sightings have been in Doubtful Sound/Patea and Milford Sound/Piopiotahi, where the survey effort has been the highest. Eleven species were observed, with bottlenose dolphin sightings being the most common. Other species included dusky dolphin, common dolphin, humpback whale, sperm whale, long-finned pilot whale, southern right whale, minke whale, orca, Hector's (New Zealand) dolphin and strap toothed whale. These were the first official records of the latter two species in Fiordland waters. Subsequently, Arnoux's beaked whales, southern elephant seals and leopard seals have also been recorded. Overall, more than a quarter of the world's cetacean genera and one-third of all cetacean families have been recorded in Fiordland.

Southern right whale (tohorā) breaching in Fiordland. *Photo: Richard Kinsey.*

[23] Holborow, J. 1999: The diet of New Zealand fur seals (*Arctocephalus forsteri*) in southern New Zealand. Thesis submitted in partial fulfilment of the requirements for the degree of Masters in Marine Science, University of Otago. Dunedin.

Many of the freshwater ecosystems within Fiordland are considered to be among the most pristine in New Zealand.

Mirror Lakes, Eglinton Valley. *Photo: Les Molloy.*

Monitoring and management of Fiordland's freshwater ecosystems

Freshwater ecosystems in Fiordland

Many of the freshwater ecosystems within Fiordland, particularly those west of the Main Divide, are considered to be among the most pristine in New Zealand. There have been very few human-related influences on these systems throughout Fiordland, which means that many areas are relatively intact. The introduction of trout (brown trout and rainbow trout) will have had some impact on the community composition and structure of both native galaxiids and freshwater invertebrates, but many streams and rivers are still representative of those that occurred before human settlement.

East of the Main Divide, the Southland lakes and many of the catchments that feed into them are more modified environments, and have been subject to a much higher level of human interference in recent years.

Reactionary 'pest management' work represents the bulk of DOC's work in freshwater ecosystems in Fiordland. The impact of didymo, which was introduced into Southland in 2004, has been a particular focus, along with the threats of other invasive species such as the aquatic weed *Lagarosiphon major* (lagarosiphon). Some intermittent, ad-hoc monitoring has also been carried out in Fiordland.

Didymo

The invasive freshwater alga *Didymosphenia geminata* (didymo or 'rock snot') was first discovered in New Zealand in 2004, in Southland's Waiau River. Surveying for didymo was subsequently initiated in Southland rivers in 2005. Fish and Game are contracted by DOC to undertake water sampling from more accessible sites at the same time as they carry out fishing

The Eglinton River and Valley, Fiordland National Park. *Photo: Martin Sliva.*

Didymosphenia geminata (didymo) debris on a river bank. *Photo: DOC.*

licence checks and general advocacy work, while DOC carries out a yearly sampling flight into the more remote parts of Fiordland. To date, water samples have been collected from over 248 sites in Southland by DOC and Fish and Game New Zealand, over 120 of which are in Fiordland – although some of these are from the same catchment. Many of these sites have been visited just once, but some are visited yearly and a few (Clinton River, Arthur River and Grebe River) are visited more than once during the survey season.

Unfortunately, the battle to protect the main rivers of the Southland Plains from didymo was lost very quickly after its arrival in New Zealand, as they were quickly infected. In Fiordland, didymo has established in 16 waterways, most of which are either tributaries of waterways already known to be infested (Hollyford River/Whakatipu Kā Tuka, Ettrick Burn, Eglinton River), or located within 200 m of the edge of Lake Te Anau or Lake Manapouri (which are known to be infested). The waterways west of the Main Divide remained free of didymo for many years, mainly due to their isolation. However, in 2013 there was a positive find in the Large Burn Valley.

The didymo advocacy and surveillance role for DOC is based in Te Anau. Initially, biodiversity staff oversaw the whole of the former Southland Conservancy; however,

Didymo smothering aquatic plants. Kayak tour company guides direct white-water kayakers to Fiordland Lobster Company who oversee compliance with clean-gear certificates for the Arthur River. *Photo: DOC.*

with the rapid initial expansion of didymo into the major Southland rivers, the primary focus shifted to Fiordland and Stewart Island/Rakiura (where didymo had not yet reached). In the current Te Anau District, DOC monitors Fiordland's waterways, provides clean gear certification to anglers and advocates to all user-groups about the risks that didymo poses. Clean gear certification is an attempt to limit the potential spread of didymo by anglers who travel into the more remote parts of Fiordland to fish. The whole of Fiordland National Park is a controlled area (with the exception of the major lakes and rivers), and every angler who wants to travel into the controlled area must have their gear inspected and cleaned to gain the certificate that allows them to fish there.

Aquatic weed surveillance

A number of freshwater pest species that are listed on the unwanted organisms list are either known to exist in New Zealand or are thought to pose a threat to waterways. The main target weed species for the Southland lakes area is lagarosiphon, which is a significant threat because there are existing incursions in areas close to Fiordland.

Lagarosiphon major (lagarosiphon). *Photo: DOC.*

Lagarosiphon was first noted as a problem in the 1950s, when it was recorded in lakes in the Rotorua District. It arrived in Lake Wanaka in the 1970s, where eradication attempts have been unsuccessful. Lagarosiphon spread downstream from Lake Wanaka in 1992 with the creation of Lake Dunstan, and in 2007 it was detected in the Frankton Arm of Lake Wakatipu.

Annual surveys of the Southland lakes are carried out by DOC to provide early detection in the event of the introduction of any invasive aquatic weed species to region's lakes and waterways. These surveys have been conducted since 1998, and involve staff and contractors visiting 15 lake sites and five river sites.

A group of longfin eels (tuna). *Photo: James Reardon.*

Elvers on the spillway of a dam. *Photo: Theo Stevens.*

Longfin eel monitoring

As part of their resource consent conditions for operating the power station on Lake Manapouri, Meridian Energy has been responsible for a number of additional monitoring programmes. Lake Manapouri provides 73% of New Zealand's longfin eel (tuna) lake habitat that is protected from commercial fishing. However, the number of longfin eels in the lake has declined due to the construction of a control structure, which blocks and regulates outflow from the lake. This acts as a barrier to eel migration (both upstream and downstream) and has led to eels moving into the hydro intake at West Arm as they try to migrate downstream and being killed as they pass through the turbines of the power station. A vertical slot fish pass was installed at the structure in 1999, and trap and transfer of elvers (young eels) was started in summer 1998/99. Since then, more than 407,000 elvers have been transferred upstream of the Mararoa Control structure.

The trap and transfer technique was successful in improving the distribution of longfin eels, but unfortunately operations had to be stopped in 2004 due to concerns that transferring elvers to upstream habitats would spread didymo. Therefore, the operation now transfers elvers just past the control structure. Concern remains about whether the trap and transfer operation traps enough silvers (eels of breeding age), with an average of only 200–400 being transferred annually – which is much lower than the recommended standards in other countries. More research is needed to understand whether trap and transfer is the best option for longfin eels in Lake Manapouri.

Future monitoring

DOC is likely to have greater involvement in freshwater issues in the near future as more high-profile programmes are developed. Many wetlands around the Te Anau Basin and throughout Fiordland now form a number of high-ranking ecological management units within DOC's ecosystem prioritisation programme. Therefore, more effort and resources will be required to manage these priority sites.

Many other ecological management units (such as Kā-Tū-Waewae-o Tū/Secretary and Mauikatau/Resolution Islands) contain wetland and freshwater ecosystems that will now be afforded greater protection by the ongoing management of vertebrate pests. The restoration of these islands will soon provide a picture of what a fully functional and intact freshwater ecosystem looks like, and will be very useful for future baseline monitoring.

DOC is also preparing an application for Ramsar status for a number of wetlands throughout Southland. The Ramsar Convention is an international treaty for the conservation and sustainable utilisation of wetlands, which embodies the commitments of its member countries to maintain the ecological character of their wetlands of international importance and to plan for the 'wise use' (i.e. sustainable use) of all the wetlands in their territories. Should the application for these wetlands be successful, there will be a number of ecologically significant wetlands within the Te Anau basin that will be protected by the Ramsar convention.

Appendix 1

Glossary of the plant and animal species mentioned in the text

Note: Only those species mentioned in this book are listed – Fiordland contains a wealth of additional species.

Mammals

Native

Bat (pekapeka)
- Southern lesser short-tailed bat *Mystacina tuberculata tuberculata*
- Long-tailed bat 'South Island' *Chalinolobus tuberculatus*

Dolphin
- Bottlenose dolphin *Tursiops truncatus*
- Common dolphin *Delphinus delphis*
- Dusky dolphin *Lagenorhynchus obscurus*
- Hector's (New Zealand) dolphin *Cephalorhynchus hectori*

Seal
- Leopard seal *Hydrurga leptonyx*
- New Zealand fur seal (kekeno) *Arctocephalus forsteri*
- Southern elephant seal (ihupuku) *Mirounga leonina*

Whale
- Arnoux's beaked whale *Berardius arnuxii*
- Humpback whale/paikea *Megaptera novaeangliae*
- Long-finned pilot whale *Globicephala melas*
- Minke whale *Balaenoptera acutorostrata*
- Orca (killer whale) *Orcinus orca*
- Southern right whale (tohorā) *Eubalaena australis*
- Sperm whale (parāoa) *Physeter macrocephalus*
- Strap toothed whale *Mesoplodon layardii*

Introduced/pest

- Brushtail possum *Trichosurus vulpecula*
- Cat *Felis catus*
- Chamois *Rupicapra rupicapra*
- Ferret *Mustela putorius furo*
- Goat *Capra hircus*
- Mouse *Mus musculus*
- Rabbit *Oryctolagus cuniculus*
- Rat *Rattus* spp.
  - Norway rat *Rattus norwegicus*
  - Ship rat *Rattus rattus*
- Deer
  - Red deer *Cervus elaphus scoticus*
  - Wapiti *Cervus canadensis*
- Stoat *Mustela erminea*

Birds

- Banded dotterel (pohowera) *Charadrius bicinctus*
- Bellbird (korimako) *Anthornis melanura melanura*
- Black-billed gull *Larus bulleri*
- Black-fronted tern (tara) *Chlidonius albostriatus*
- Bush wren (mātuhituhi) *Xenicus longipes*
- Kākā *Nestor meridionalis meridionalis*
- Kākāpō *Strigops habroptilus*
- Kakaruai (South Island robin) *Petroica australis australis*
- Kea *Nestor notabilis*
- Kiwi
  - Fiordland tokoeka (northern/southern) *Apertyx australis australis*
  - Haast tokoeka *Apteryx australis* 'Haast'
  - Little spotted kiwi *Apteryx owenii*

Kōkako
- North Island kōkako *Callaeas cinerea wilsoni*
- South Island kōkako *Callaeas cinerea*

Mohua (yellowhead) *Mohoua ochrocephala*

New Zealand falcon/kārearea *Falco novaeseelandiae*

New Zealand snipe/tutukiwi *Coenocorypha* sp.

New Zealand thrush/piopio *Turnagra capensis*

Parakeet (kākāriki)
- Orange-fronted parakeet *Cyanoramphus malherbi*
- Red-crowned parakeet/kākāriki *Cyanoramphus novaezelandiae*
- Yellow-crowned parakeet/kākāriki *Cyanoramphus auriceps*

Pāteke (brown teal – North/South Island) *Anas chlorotis*

Rifleman (tītipounamu) *Acanthisitta chloris*

Rock wren (tuke) *Xenicus gilviventris*

Ruru (koukou, Morepork) *Ninox novaeseelandiae*

Takahē *Porphyrio hochstetteri*

Tawaki (Fiordland crested penguin) *Eudyptes pachyrhynchus*

Tīeke (South Island saddleback) *Philesturnus carunculatus carunculatus*

Tomtit (miromiro) *Petroica macrocephala*

Tūī *Prosthemadera novaeseelandiae*

Weka *Gallirallus australis australis*

Whio (blue duck) *Hymenolaimus malacorhynchos*

Lizards

Gecko
- Cascade gecko *Mokopirirakau* sp. 'Cascades'
- Large Otago gecko *Woodworthia* 'Otago large'
- Takitimu gecko *Mokopirirakau cryptozoicus*

Skink
- Barrier skink *Oligosoma judgei*
- Common skink *Oligosoma polychrome*
- Cryptic skink *Oligosoma inconspicuum*
- Eyre Mountains skink *Oligosoma repens*
- Fiordland skink *Oligosoma acrinasum*
- Green skink *Oligosoma chloronoton*
- Sinbad skink *Oligosoma pikitanga*
- Te Kakahu skink *Oligosoma tekakahu*

Fish

- Blue cod (rāwaru) *Parapercis colias*
- Butterfly perch *Caesioperca lepidoptera*
- Hagfish *Eptatretus cirrhatus*
- Groper (hāpuku) *Polyprion oxygeneios*
- Hoki *Macruronus novaezelandiae*
- Longfin eel (tuna) *Anguilla dieffenbachii*
- Rough skate *Zearaja nasuta*
- Sea perch *Helicolenus percoides*

Shark
- Broadsnouted seven gill shark *Notorynchus cepedianus*
- School shark *Galeorhinus galeus*
- Six gill shark *Hexanchus griseus*
- Spiny dogfish *Squalus acanthias*

Trout

Brown trout *Salmo trutta*

Rainbow trout *Oncorhynchus mykiss*

Invertebrates

Native

Arrow squid *Nototodarus sloanii*

Coral

Black *Errina novaezelandiae*

Red *Antipathies fiordensis*

Glowworm *Arachnocampa luminosa*

Gorgonian (sea fan) *Acanthogorgia* sp.

Grasshopper

Sigaus homerensis

Sigaus takahe

Kina (sea urchin) *Evechinus chloroticus*

Leafroller *Epichorista emphanes*

Rock lobster (crayfish)

Green or packhorse rock lobster *Jasus verreauxi*

Red/spiny rock lobster *Jasus edwardsii*

Snake star *Astrobranchion constrictum*

Snail Giant land snail *Powelliphanta fiordlandica*

Spider Tunnel web (*Hexathele* or *Porrhothele* sp.)

Weevil

Flax weevil *Anagotis fairburni*

Knobbled weevil *Hadramphus stilbocarpae*

Wētā

Cave wētā *Talitropsis sedilloti*

Unidentified Raphidophoridae sp.

Ground wētā *Hemiandrus maculifrons*

Hemiandrus spp.

Introduced/pest

Broom psyllid *Arytainilla spartiophila*

Mediterranean fan worm *Sabella spallanzanii*

Ragwort flea beetle *Longitarsus jacobaeae*

Wasp

Common wasp *Vespula vulgaris*

German wasp *Vespula germanica*

Other

Native

Ascidian spp. (sea squirts)

Introduced/pest

Sea squirt *Styela clava*

Plants

Native

Beech (tawai)

Mountain beech *Fuscospora cliffortioides*

Red beech *Fuscospora fusca*

Silver beech *Lophozonia menziesii*

Bog pine *Halocarpus bidwillii*

Broadleaf (kāpuka) *Griselinia littoralis*

Buttercup

Ranunculus lyalli (Mt Cook buttercup)

Ranunculus ranceorum

Ranunculus ternatifolius

Celmisia verbascifolia

Common kelp *Ecklonia radiata*

Coprosma pedicellata

Five-finger *Pseudopanax arboreous*

Haumakoroa *Raukaua simplex*

Heart-leaved kōhūhū *Pittosporum obcordatum*

Hebe arganthera

Hen and chickens fern *Asplenium bulbiferum*

Kahikatea *Dacrycarpus dacrydioides*

Kāmahi *Weinmannia racemosa*

Lakeshore dwarf daisy *Brachyscombe linearis*

Māhoe *Melicytus ramiflorus*

Melicytus flexuosus

Mistletoe

Red mistletoe *Peraxilla tetrapetala*

Scarlet mistletoe *Peraxilla colensoi*

Yellow-flowered mistletoe *Alepis flavida*

Patē *Schefflera digitata*

Pīngao *Ficinia spiralis*

Red sedge *Carex tenuiculmis*

Rimu *Dacrydium cupressinum*

Small-leaved coprosma *Coprosma pedicellata*

Southern rātā *Metrosideros umbellata*

Tetrachondra hamiltonii

Tree daisy *Olearia lineata*

Tree fuchsia *Fuchsia excorticata*

Tōtara *Podocarpus totara*

Trithuria inconspicua

Tufted hair grass *Deschampsia caespitosa*

Tussock

Mid-ribbed snow tussock *Chionochloa pallens*

Red tussock *Chionochloa rubra*

Umbrella fern *Sticherus tener*

Wineberry *Aristotelia serrata*

Introduced/weed

Asian kelp (undaria) *Undaria pinnatifida*

Blackberry *Rubus* spp.

Broom *Cytisus scoparius*

Buddleia *Buddleja* spp.

Californian thistle *Cyrsium arvense*

Common heather *Calluna vulgaris*

Cotoneaster *Cotoneaster* spp.

Crack willow *Salix fragilis*

Darwin's barberry *Berberis darwinii*

Didymo *Didymosphenia geminata*

Douglas fir *Pseudotsuga menziesii*

Foxglove *Digitalis purpurea*

Gorse *Ulex europaeus*

Heather *Erica* sp.

Himalayan honeysuckle *Leycesteria formosa*

Lagarosiphon *Lagarosiphon major*

Lupin *Lupinus* spp.

Russell lupin *Lupinus polyphyllus*

Marram grass *Ammophila arenaria*

Montbretia *Crocosmia × crocosmiiflora*

Montpellier broom *Teline monspessulana*

North Island five-finger* *Pseudopanax laetus*

Pine

Pinus spp.

Pinus contorta

Pinus mugo

Ragwort *Jacobaea vulgaris*

Red sedge *Carex tenuiculmis*

Sea spurge *Euphorbia paralias*

Spanish heath *Erica lusitanica*

Stonecrop *Sedum acre*

Tutsan *Hypericum androsaemum*

* Although this species is a New Zealand native, it is a pest species in Fiordland and so has been listed in this category.


New Zealand Government