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.

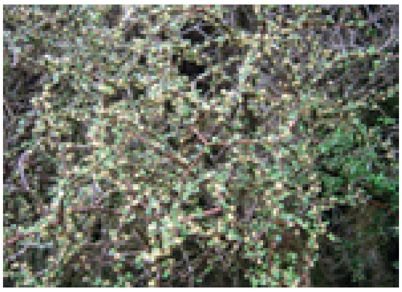
***Sticherus tener* (umbrella fern)** – Important population occurs on Taumoana/Five Fingers Peninsula, Mauikatau/Resolution Island.

***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 lyallii*) 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.

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

- 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.

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.

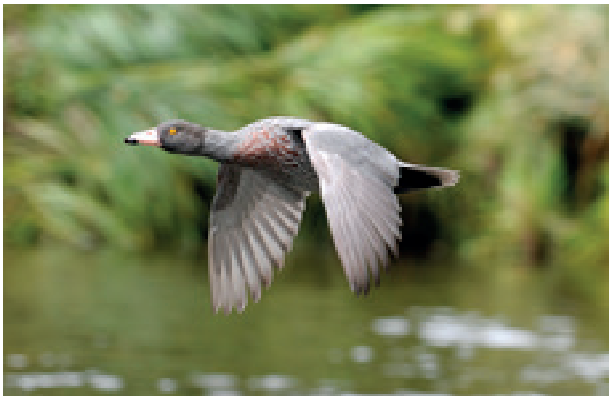
* Monks, A.; Lee, W.G.; Burrows, L.; McNutt, K.; Edge, K-A. 2005. Assessment of forest changes on Secretary Island, Fiordland National Park, from 1975 to 2003, based on long-term plot measurements, in relation to the presence of deer. Unpublished Landcare Research Contract Report LC0506/007.

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

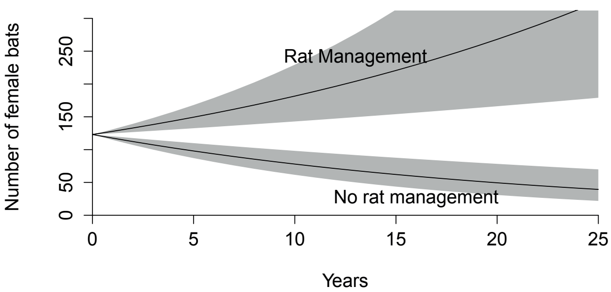
The long-tailed bat study in the Eglinton Valley is the longest-running research project on New Zealand bats, encompassing an intensive mark-recapture study that began in 1993. During that time, researchers have caught

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,



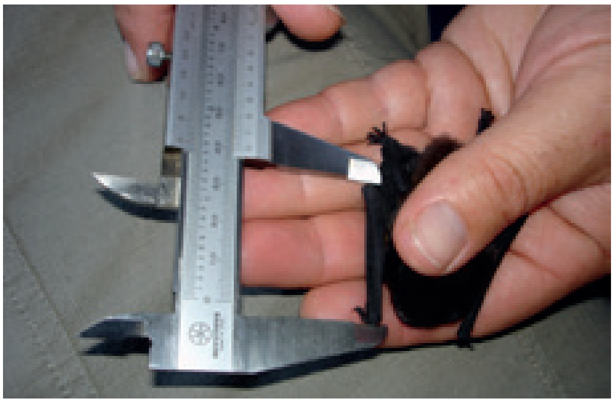
Predicted population trends in the number of female long-tailed bats in the Eglinton Valley over 25 years in the presence and absence of rat control. Shaded areas represent 95% confidence intervals.

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.*

Lesser short-tailed bats

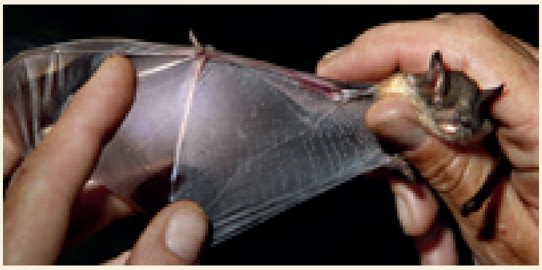
Lesser short-tailed bats were re-discovered in Fiordland in February 1997 – the first record of these bats in the region since 1871. A juvenile male was captured in a harp trap in beech forest at Mackay Creek during routine live capturing of long-tailed bats for marking. This bat was fitted with a transmitter 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.

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.

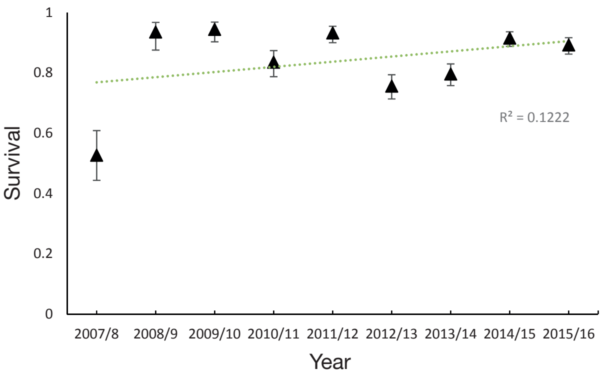
Long-tailed bat. *Photo: Colin O'Donnell.*



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

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.*

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

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 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.

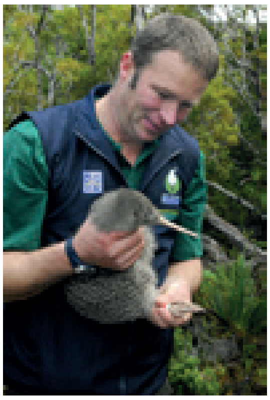
A Fiordland tokoeka retreating after having had a transmitter fitted, Fiordland, 2010. *Photo: James Reardon.*

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.

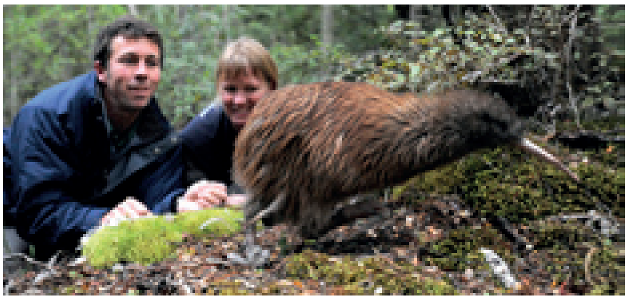
Fiordland tokoeka

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.

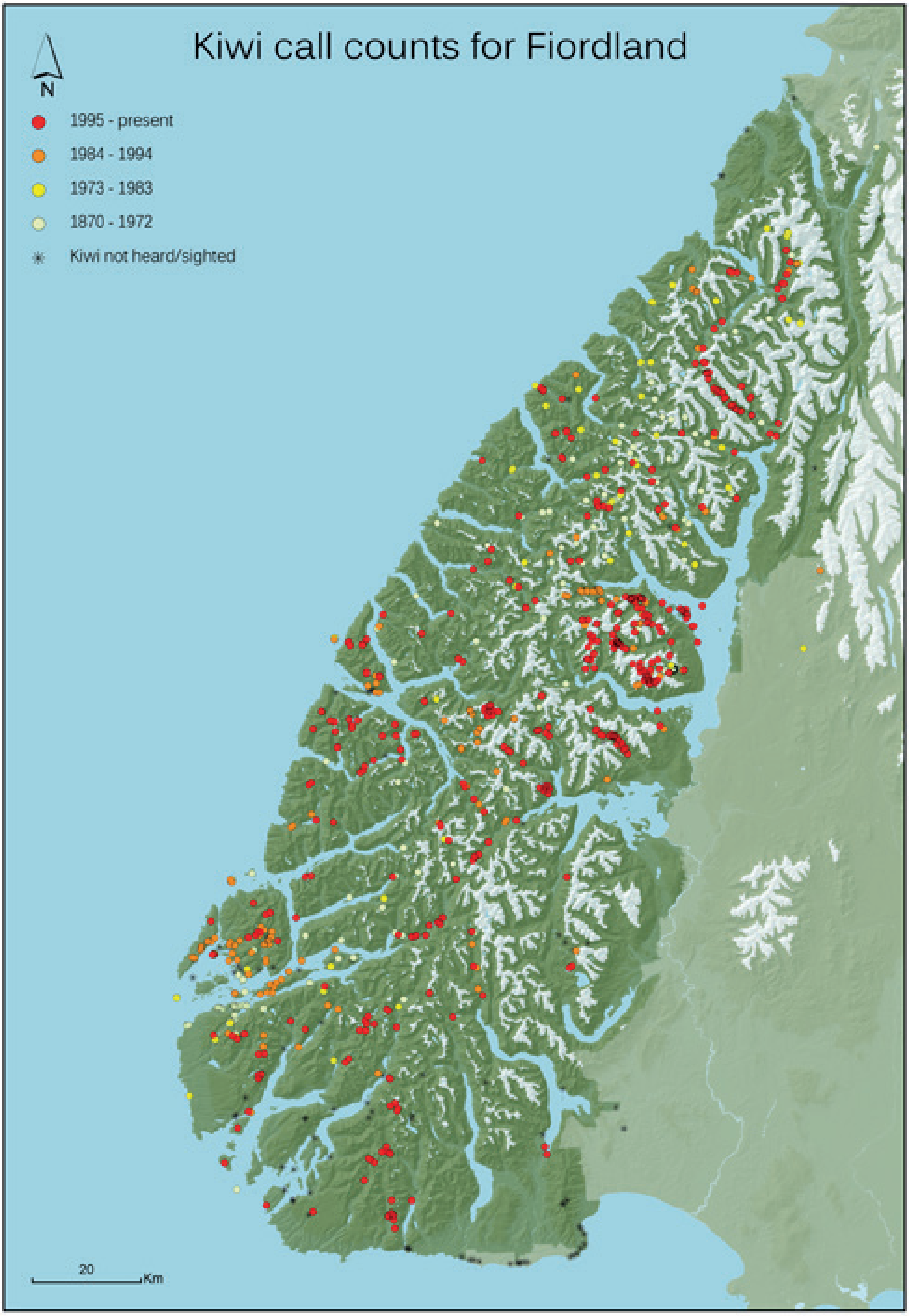
Kiwi partnerships

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

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

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.

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

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

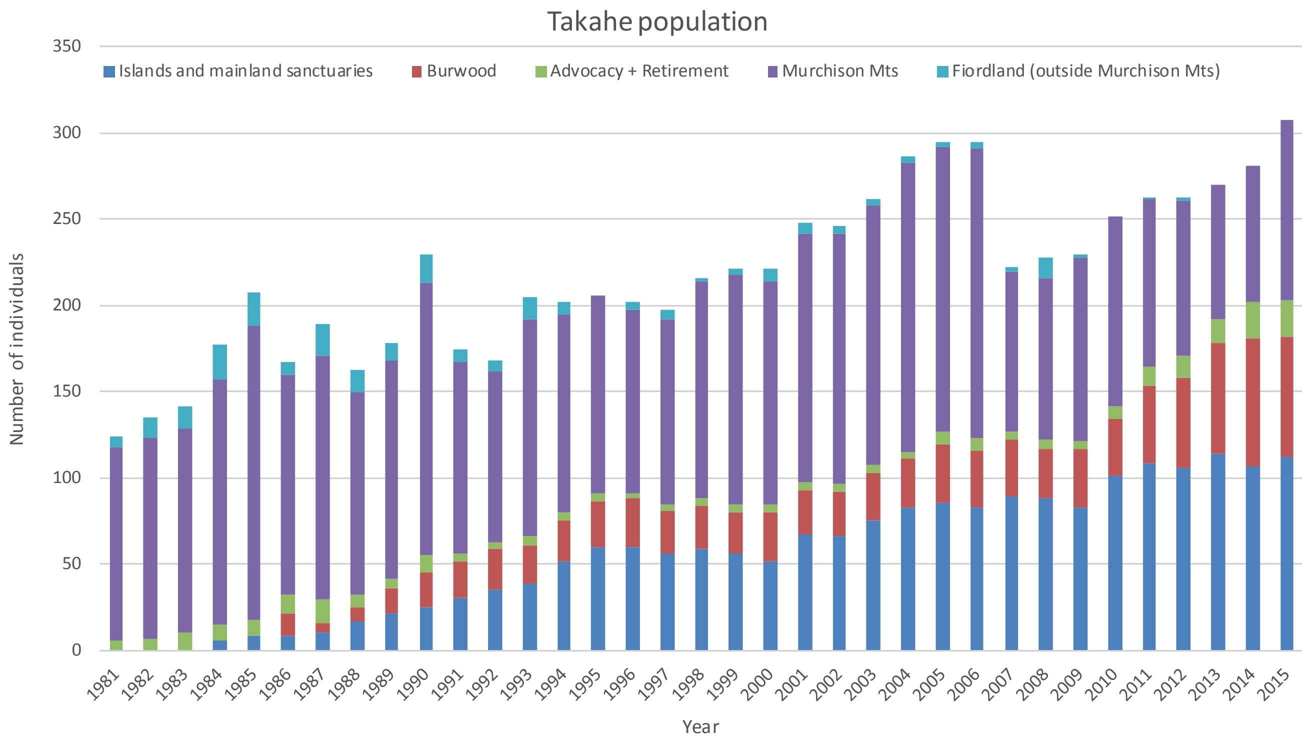
Takahē, Tiritiri Matangi Island, Hauraki Gulf, 2000. *Photo: Paul Schilov.*

the 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.)

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.*

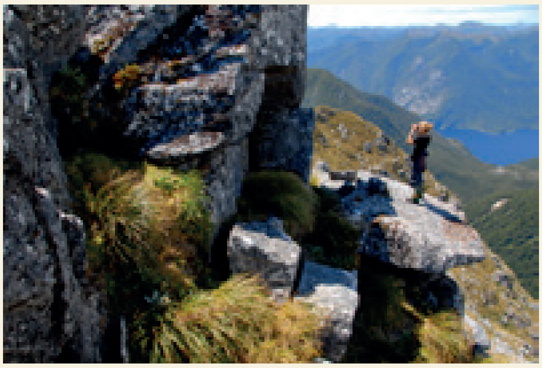
What's hidden in rock wren genes?

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.

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.*

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.*

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.

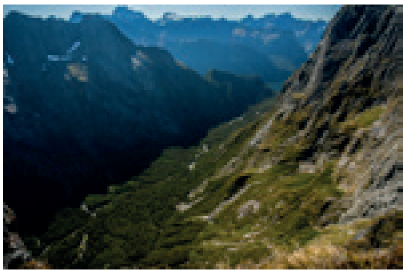
Te Kākāhu skinks were found on Te Kākāhu/Chalky Island in 2003. *Photo: Hannah Edmonds.*

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.



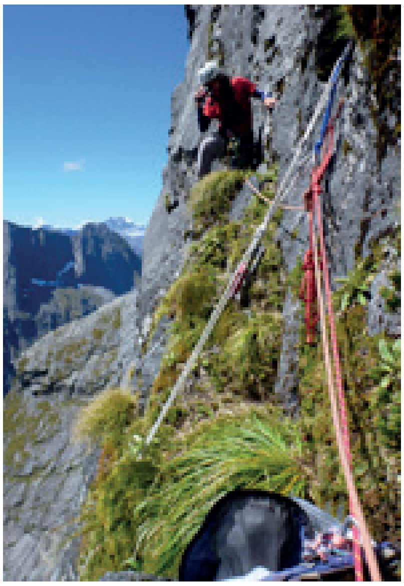
Sinbad Gully, with Milford Sound/Piopiotahi in the far distance. *Photo: James Reardon.*

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.

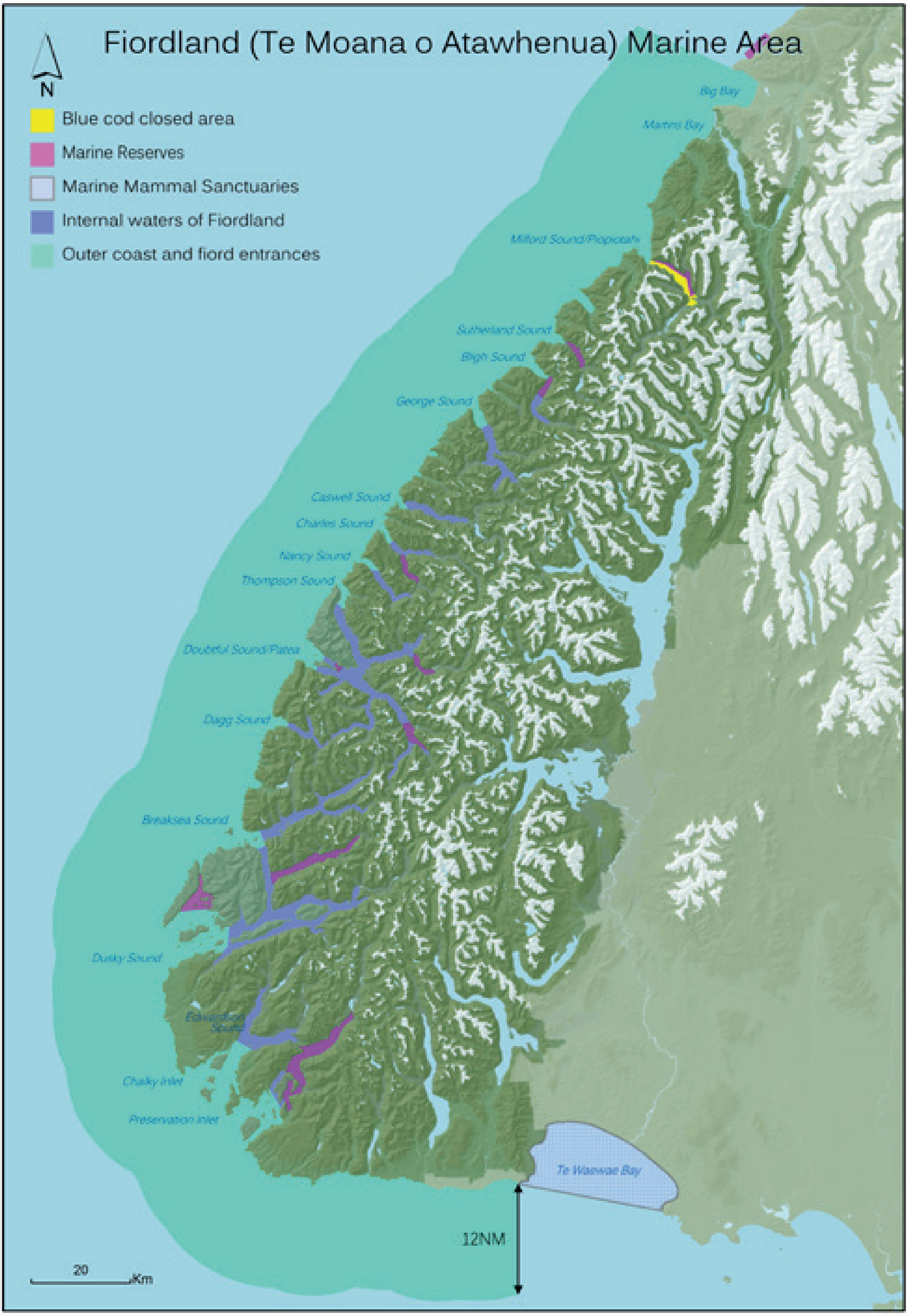
Juvenile cave weta, *Talitropsis sedilloti,* Eglinton Valley, Fiordland National Park. *Photo: Eric Edwards.*

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.

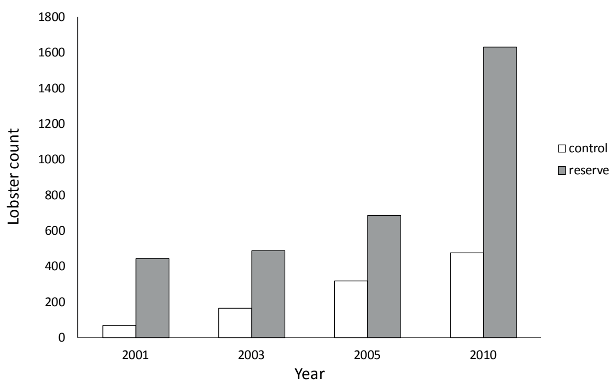
Marine ecosystem monitoring

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].

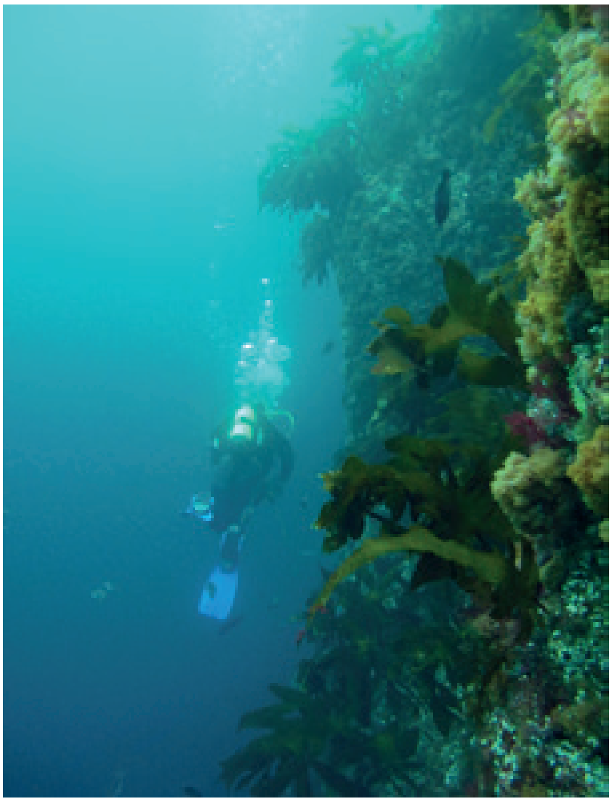
[20] This temporary closure for recreational blue cod fishing in Doubtful Sound/Patea was lifted in December 2015. Recreational fishers are now permitted to catch one blue cod per person per day in the internal waters of the Doubtful/Patea, Bradshaw and Thompson Sound complex with no accumulation.

[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).

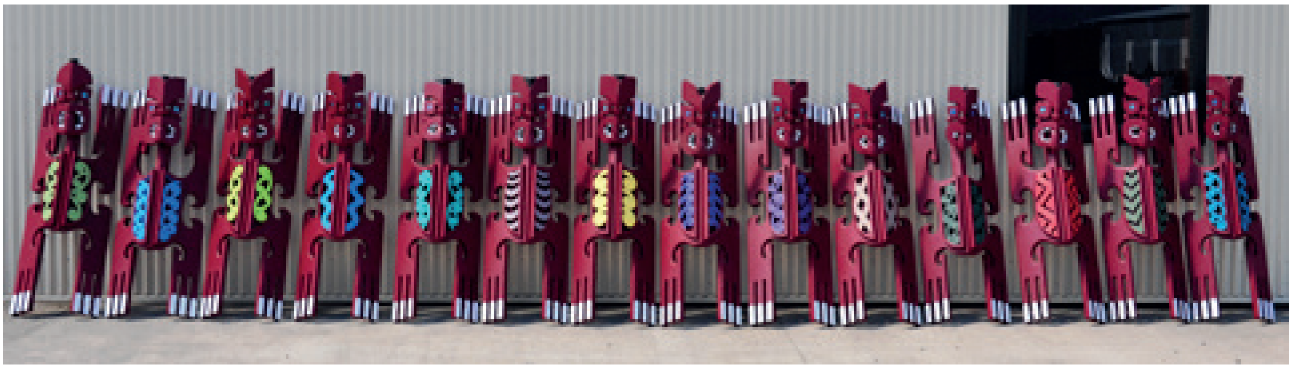
Marine reserves

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.

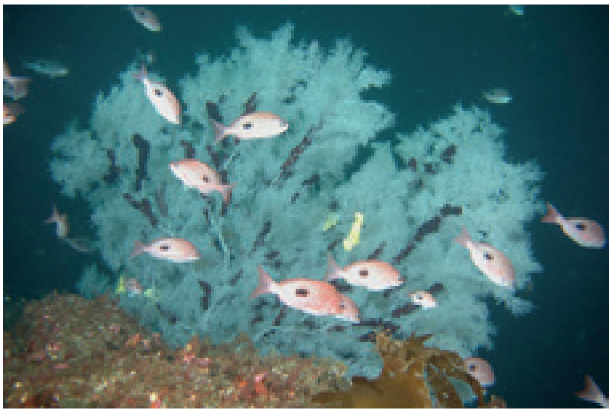
The new marine reserves outside of Doubtful Sound/Patea were marked with individually carved wooden Te Poupou o Rua o Te Moko (poupou) marine reserve markers. Poupou are carved figures that represent significant Māori ancestors from the area and they provide kaitiaki or guardianship over the reserves. 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.

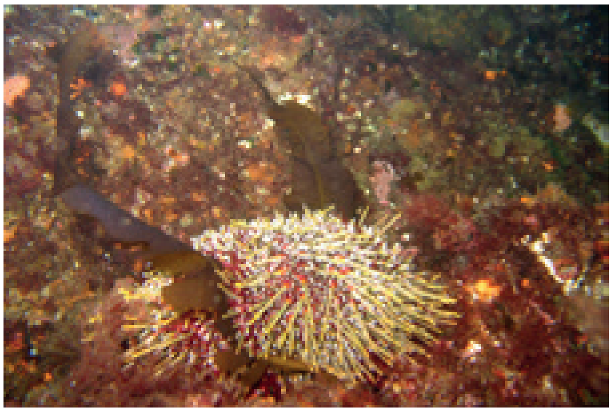
Biosecurity

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.

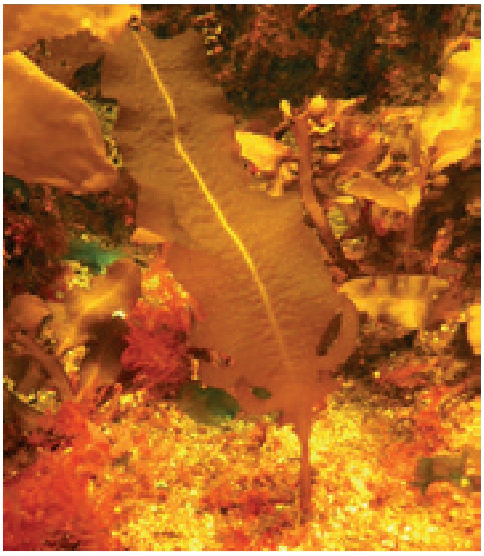
By September 2016, the eradication attempt had removed a total of 1906 individual undaria specimens from Sunday Cove. Monthly dive surveys to search for undaria will continue until there has been a continuous 18-month period of no undaria detections, prior to moving to a 3-year monitoring programme. 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



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

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.

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.

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.

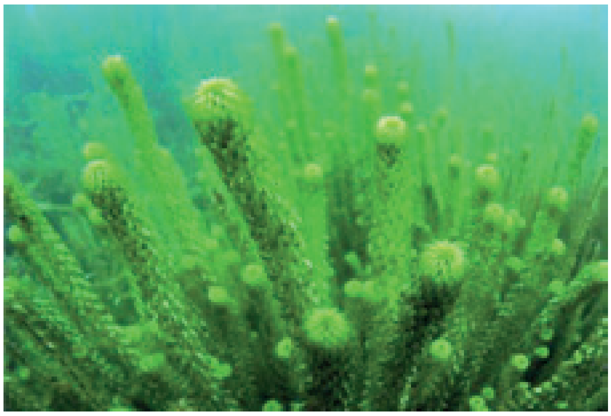
Unfortunately, the battle to protect the main rivers of the Southland Plains from didymo was lost very quickly after its arrival in New Zealand, as they were quickly infected. In Fiordland, didymo has established in 16 waterways, most of which are either tributaries of waterways already known to be infested (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, 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.

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.*

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*

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