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

Mainland weed and pest control

Management of weeds

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

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

Site-led weed control

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

Weed threats

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

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

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

Heather in flower. *Photo: Susan Timmins.*

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

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

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

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

The exotic sea spurge. *Photo: DOC.*

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

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

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

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

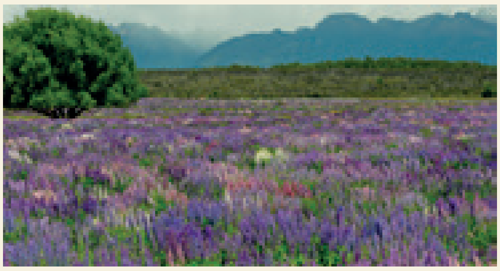
[3] Environmental weeds are those that can invade native ecosystems and adversely affect the survival of native flora and fauna.

Gorse at Big Bay

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

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

Colourful curse in the Eglinton Valley



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

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

Tutsan. *Photo: John Barkla.*

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

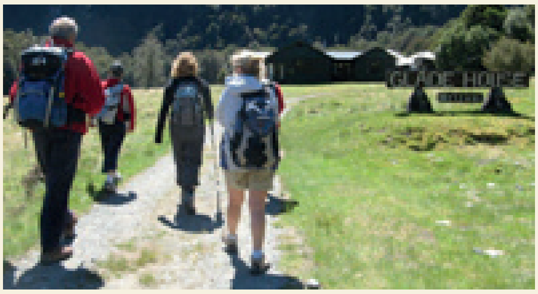
Tordon™ herbicide. Until recently this programme had significantly reduced the amount of blackberry present, and greatly reduced or eliminated many known infestations. However, its ongoing control has been hampered by bad weather, difficult conditions, the availability of skilled staff at the right time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

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

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

Movement of unwanted seeds

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



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

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

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

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

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

Species-led weed control

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

Stonecrop

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

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

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

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

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

Pine trees

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

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

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

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

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

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

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

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

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

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

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

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

Douglas firs

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

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

Biological control

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

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

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

Ragwort. *Photo: Jeremy Rolfe.*

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

Management of deer, chamois and goats

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

Red deer control

Red deer control in the Murchison Mountains

Red deer colonised the Murchison Mountains in Fiordland National Park during the 1930s and 40s. In 1948, takahē were rediscovered in the area. They have similar food preferences to deer, particularly when feeding on alpine tussock grasses, so efforts began to control the number and dispersal of deer to protect the takahe and their habitat.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The effect of fluctuating venison prices on deer control efforts

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

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

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

Fiordland Wapiti Area

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

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

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

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

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

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

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

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

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

Map 6. Fiordland Wapiti Area.

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

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

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

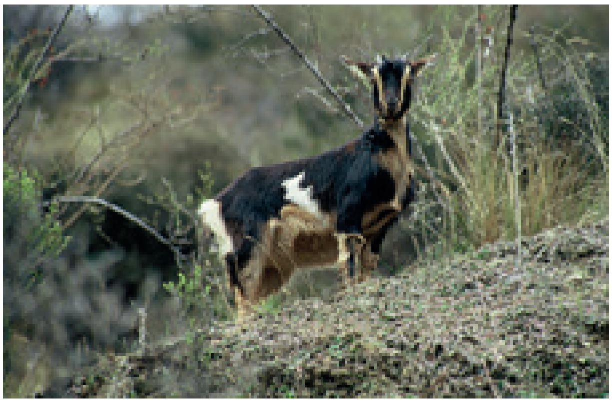
DOC is responsible for managing the vegetation monitoring programme in the Wapiti Area, which includes alpine browse transects and forest Seedling Ratio Index (SRI) plots. However, the planning of this work in the Wapiti Area is carried out in consultation with FWF and opportunities for FWF member involvement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

Goat eradication – Clinton and Arthur Valleys

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

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

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



Feral goat. *Photo: DOC.*

Chamois control

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

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

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

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

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

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

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

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

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

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

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

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

Richard's review made four recommendations:

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

Management of possums, stoats and rats

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

Possums

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

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

Possum control in the Eglinton Valley

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

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

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

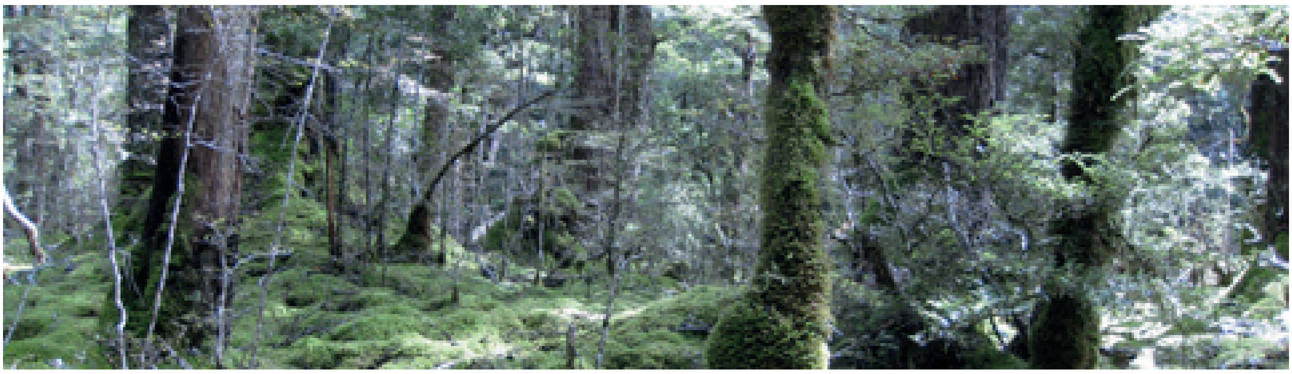
Brushtail possum. *Photo: Alan Cressler.*

Birds' beech mast response programme (See 'Battle for our Birds' box). This successfully controlled rats and possums to very low levels.

Possum control in the Pembroke Wilderness Area

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

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



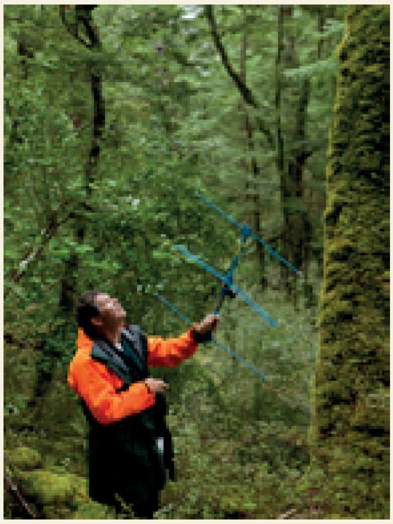
Eglinton Valley forest. *Photo: James Mortimer.*

Why is the Eglinton Valley so important?

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

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

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

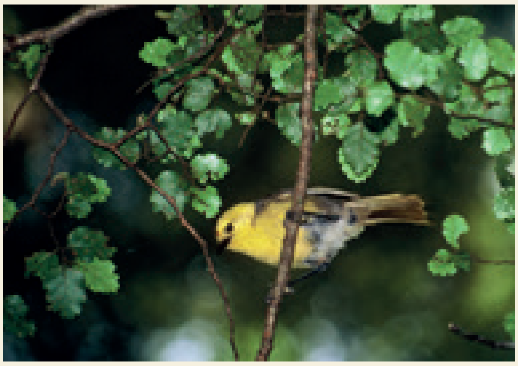


Colin O'Donnell radio tracking bats at Knobs Flat, Eglinton Valley, 2012. *Photo: Sabine Bernert*.

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

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

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


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

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

Battle for our Birds (and Bats)

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


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

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

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

Possum control in the Clinton, Arthur and Cleddau Valleys

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

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

Possum control on the Mount Forbes Peninsula

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

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

Possum control in the Murchison and Kepler Mountains

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

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

Possum control in the Eglinton Valley

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

A love affair with mistletoe

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

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

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

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

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

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

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

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

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

Possum control in the Pembroke Wilderness Area

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

Possum control in the Clinton, Arthur and Cleddau Valleys

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

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

Stoats

Stoat control in Northern Fiordland

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

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

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

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

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

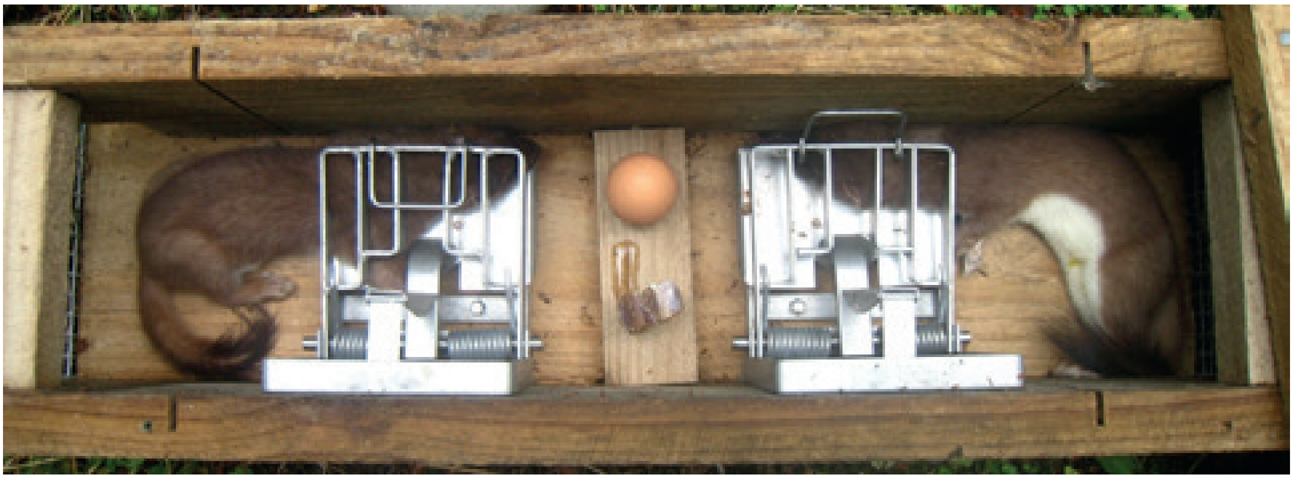
In 2006, stoat control was initiated along the Hollyford Road. This work was initially carried out by Downer, but the lower Hollyford Road traps are now serviced by members of the Gunns Camp Trust. In 2013, stoat trapping was established by the New Zealand Alpine Club in the alpine area of the the upper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

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

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

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

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



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

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

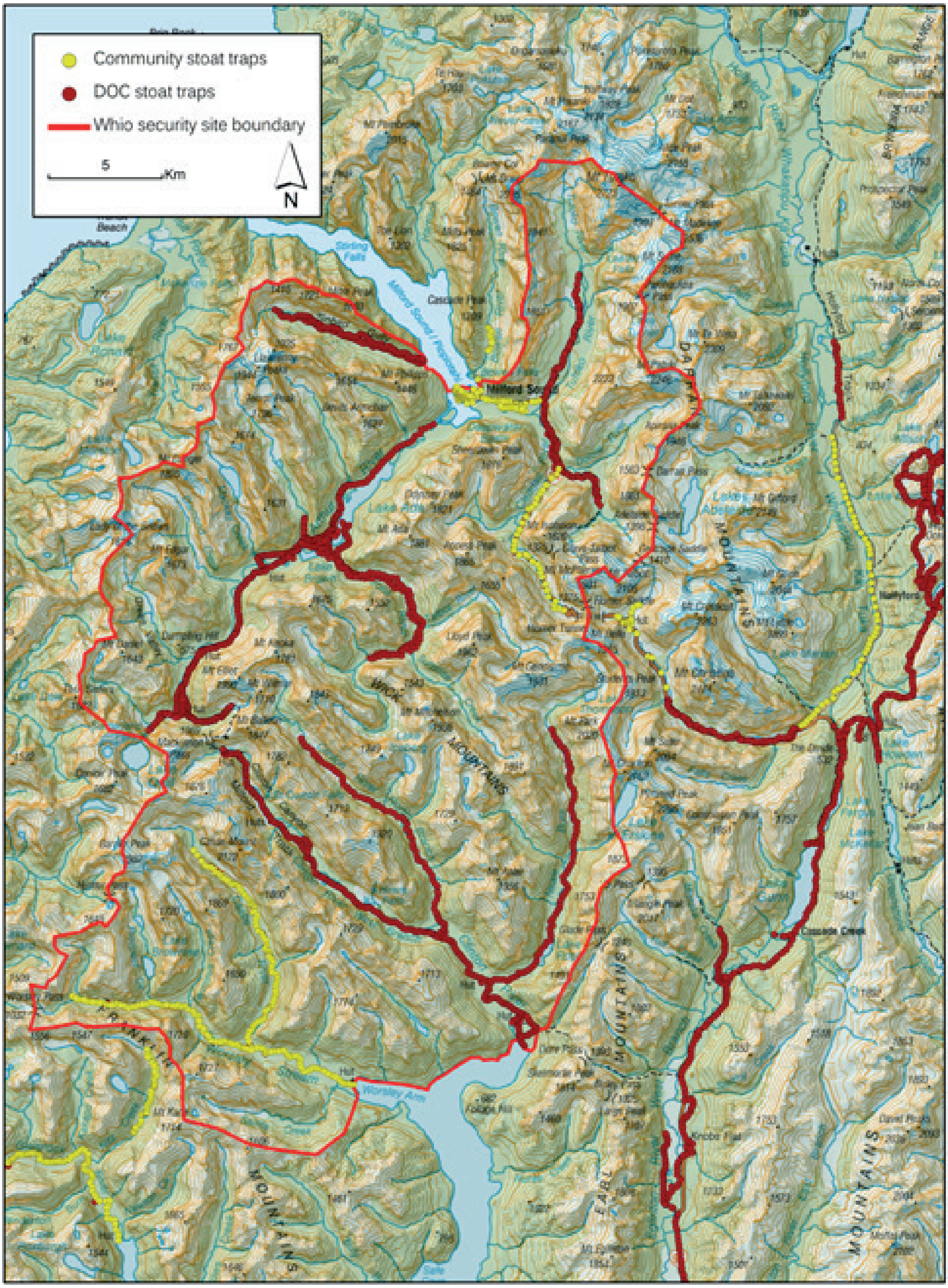
Stoat control in the Murchison and Kepler Mountains

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

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

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

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



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

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

Stoats in high places

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

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

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

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

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

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

Rats

Rat control in the Eglinton Valley

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

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

The ongoing challenge of controlling stoats

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

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

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

The important role of DOC's partners in pest control

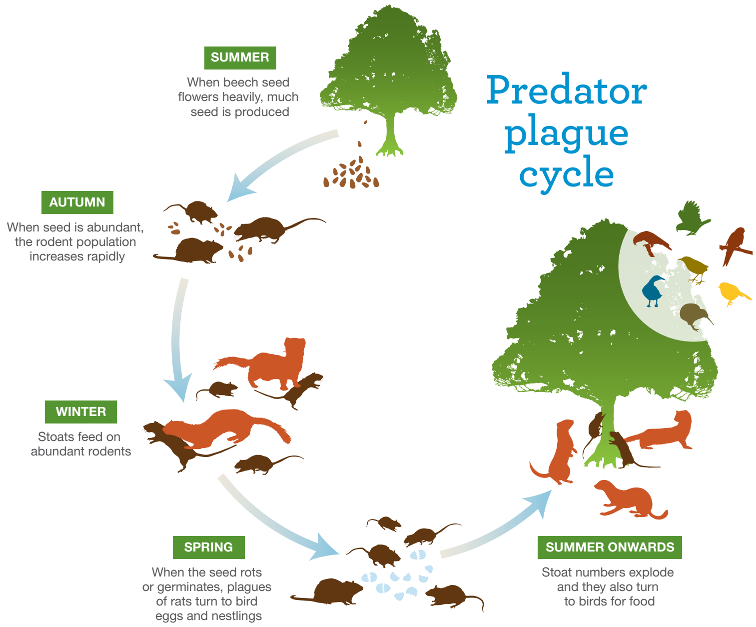
Mainland pest control in Fiordland, particularly for stoats, has wide support from corporate sponsorship, local businesses and community groups, including:

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

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

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

What is a mast event?



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

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

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

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

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

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

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

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

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

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

Rat control in the Murchison and Kepler Mountains

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

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

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

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

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

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

Rat control in the Cleddau Valley

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

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

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