Orokonui EcoSanctuary

Restoration Plan

February 2006

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1. Introduction

1.1 The ecosanctuary concept

The Otago Natural History Trust is a registered charitable trust, formed in 1983 with the intention of establishing an area of protected habitat where people could see New Zealand's threatened wildlife. The success of Wellington's Karori Wildlife Sanctuary gave the project new impetus and the hunt for a suitable site was restarted in 1999. The Trust chose the Orokonui Valley from a short-list of five sites, which included Fraser's Gully, Graham's Bush, Nicol's Creek and Sullivan's Dam. The Orokonui site, the majority of which is conservation land, was selected on a number of criteria including size, aspect, vegetation and tenure.

The ecosanctuary site is located at Waitati, 20 km to the north of central Dunedin (see Figure 1 location plan). Also shown on the plan is 18.5 hectares of land that the Trust has recently purchased at the south-eastern boundary of the Orokonui Conservation Area.

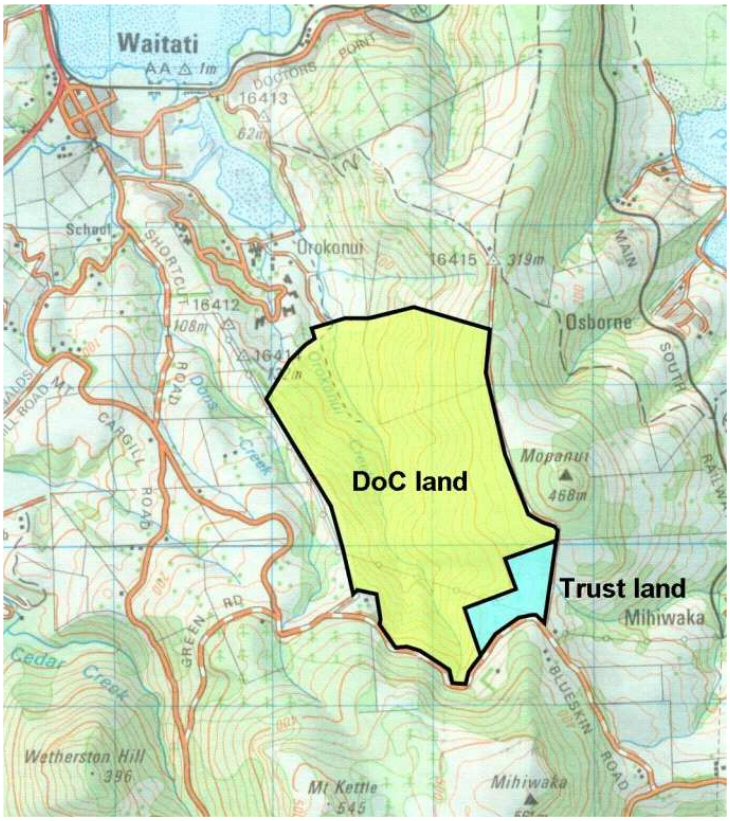

Figure 1: Location of proposed ecosanctuary

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At the Orokonui site the Trust intends to create a secure ecological sanctuary by enclosing the land with a mammal exclusion fence, approximately 7.5 km in length. This will exclude all introduced mammals, including possums, wild cats, rats, mice, stoats and hedgehogs. Once the fence is in place, all pest mammals within the fence will be eradicated, and ecological restoration will then begin.

The Trust has recently signed a Heads of Agreement document with the Department of Conservation. This sets out the conditions under which the Trust will be allowed to build the pest exclusion fence. It includes provision for the conservation land within the completed fence to be classified as Nature Reserve, and for the day-to-day control and management of this land to be passed to the Trust.

1.2 The Restoration Advisory Group

During the ecosanctuary feasibility study in 2003, the Trust assembled a Restoration Working Group to look at questions of pest eradication, habitat restoration, and the appropriate species for reintroduction to the sanctuary. Their report, which was published within the overall feasibility report, provides the foundation for this plan.[1] The working group has continued to meet in order to advance the restoration strategy for the ecosanctuary and to coordinate the baseline flora and fauna surveys in the valley prior to fencing.

Membership of this restoration advisory group is evolutionary and currently the group comprises:

Ralph Allen	Plant ecologist and Trust chairman
Alison Cree	Reptile biologist, Zoology Dept, Otago University
Anne Besson	PhD student, Zoology Dept, Otago University.
Diane Campbell-Hunt	Project manager
Murray Efford	Population ecologist, Landcare Research
Ruth Goldsmith	Aquatic biologist, Ryder Consulting
Grant Harper	Ornithologist and mammal ecologist, Zoology Dept, Otago University
Kelvin Lloyd	Plant ecologist, Wildland Consultants, and trustee
Ken Mason	Ecological restorer and conservationist
Derek Onley	Ornithologist and bird artist
Justine Ragg	Mustelid ecologist
Marc Schallenberg	Freshwater biologist, Zoology Dept, Otago University
Elton Smith	Conservation manager, DoC
Mandy Tocher	Reptile and frog biologist, Department of Conservation
Claudine Tyrrell	Reptile biologist with skills in the invasion/restoration ecology of islands

[1] *Orokonui Sanctuary: "A Once and Future World" Feasibility Report*. Diane Campbell-Hunt and Ralph Allen Otago Natural History Trust September 2004

2. The Restoration Vision

2.1 Conservation outcomes

Conservation Outcomes	Explanation
A self-sustaining ecosystem representative of eastern Otago coastal lowland forest	The goal of restoration is to recreate – as far as possible – the kind of coastal forest that would have been present at Orokonui in pre-human times. This will be done through: pest mammal exclusion and eradication, weed control, replanting where appropriate, and translocation of species that have become locally extinct. The revitalisation of the forest will, to a large extent, occur unaided once pests are excluded. Some planting of nectar and fruit sources may be necessary to allow early re-introductions of some bird species. Active management of areas at the forest edges may be used to create habitat, such as wetlands and grassland, which may not have originally been in the Valley, but which are nonetheless representative of coastal Otago and allow for the reintroduction of species that belong here, such as takahe and wetland birds. This maximises the potential of the site. The ecosanctuary will not be home to threatened native species that were not originally part of the coastal Otago biota, with the possible exceptions of surrogates for extinct species. The Trust may also consider a role for the ecosanctuary as a transit point for other threatened species when suitable breeding facilities are in place.
Key ecological processes functioning in the valley.	The goal of restoration is not simply to return and conserve native plants and animals at the site, but rather to restore a fully functioning, healthy ecosystem where natural processes such as regeneration, succession, nutrient cycling, breeding and dispersal can take place with minimal human intervention.
A haven for threatened & taoka species, such as SI brown kiwi, saddleback, burrow-nesting seabirds, tuatara, jewelled gecko, galaxiids, mistletoe.	The ecosanctuary will provide a new 250 hectare pest-free environment which will supplement New Zealand's pest-free islands and other mainland sites. By providing an additional haven for our threatened species, it will contribute to the New Zealand's Biodiversity Strategy, including national species recovery programmes.

Conservation Outcomes	Explanation
Species dispersal and gene flow into the wider Otago ecosystem.	For mobile species the Orokonui ecosanctuary could become an important source of emigration to the wider Otago ecosystem. An almost continuous corridor of native vegetation links the ecosanctuary with central Dunedin. The Trust will urge surrounding landowners, the local community, and the city and regional authorities to run predator control programmes in order to decrease the threats to migrating species. Saddleback, for example, with not survive where there are mustelids. With adequate predator control, the repopulation of Dunedin suburbs by forest birds may be possible. For ground-dwelling species (e.g. kiwi and tuatara), the Orokonui populations will contribute to the genetic diversity of meta-populations, and will be potentially available for human-assisted dispersal to other sites.
A valued site for high quality ecological research, including studies by tertiary students.	At each step of the way, the restoration programme will be informed by sound ecological research, for example research into the suitability of habitat and food supplies at Orokonui for species to be translocated. Research will also be a key part of tracking the ecological changes in the sanctuary, and thus assessing progress towards conservation outcomes. The University of Otago, the Otago Museum, Landcare Research and other research agencies are sources of expertise for the Trust and are already active in research programmes at Orokonui.
New knowledge informing ecological advocacy and conservation elsewhere in New Zealand	The lessons learned through the restoration programme at Orokonui can be communicated to similar initiatives around New Zealand. The Otago Natural History Trust has taken the lead on establishing a network of similar community initiatives around New Zealand.

In addition the ecosanctuary will:

Provide opportunities for every visitor to understand and appreciate N.Z's ecology.	Through the restoration programme, the Orokonui ecosanctuary will offer a richness of flora and fauna no longer present in the pest-ravaged forests of the New Zealand mainland. Visitors will gain an understanding of how New Zealand's forests functioned before the arrival of mammalian predators. This understanding will enhance community support for conservation of New Zealand's indigenous biodiversity.

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2.2 A timeline of past, present and future

Past (pre-human, within the last 10,000 years)	Native vegetation remnants at other eastern Otago coastal sites, along with evidence from the vegetation maps generated by computer modelling, suggest that in pre-human times the Orokonui Reserve would have been clad in forest characterised by the podocarp trees kahikatea, matai, miro, rimu and totara, emergent from a canopy dominated by a wide range of other broadleaved tree and shrub species. Canopy composition would have changed with moisture gradients. Kowhai and narrow-leaved lacebark would have been present on the steep, dry slopes. Kahikatea would have featured where soils were deep and fertile, with matai and totara on the drier fertile lands. Rimu, miro and pokaka would have grown where soil moisture was sufficient. Fossil records, from the south-eastern South Island, together with studies of nearby and similar habitats for reptile distribution, indicate that a wide variety of native vertebrate species were in and/or around the Orokonui Valley in pre-human times. These include 2 species of native bat, the tuatara, around 10 species of skinks and geckos, 5 species of moa, 2 species of kiwi, 11 species of burrow-nesting seabirds (prions, shearwaters and petrels), takahe, kakapo, kaka, saddleback, SI kokako and many others (a further 40 bird species over and above the current avifauna).
Present (2005 AD)	The 250 ha of regenerating forest is in a patchwork of successional stages. Kanuka forest dominates in much of the valley, with broadleaved tree and shrub species present throughout. In some areas, broadleaved trees dominate the forest in the absence of kanuka. In general the forest is about 100 years old but it retains small groups of podocarp trees (mainly Hall's totara, rimu and miro) that are much older (200 to 500 years). At the northern end of the reserve there is a substantial stand of the Australian mountain ash (*Eucalyptus regnans*), which includes New Zealand's tallest tree. In most places this is accompanied by native understorey species. There are some small patches and windbreaks of radiata pine (*Pinus radiata*) at the western and northern edges of the reserve and a broad swathe of gorse along the eastern boundary. Gorse also occupies a small area of the valley floor immediately inside the northern boundary. Over 100 species of birds use the valley in different ways, some living within the reserve, others visiting occasionally, some foraging there regularly and others nesting around the margins. Almost two-thirds of the bird species in the area are indigenous. These include the common widely distributed native species (shining cuckoo, silvereye, grey warbler, SI fantail and bellbird), a couple that require larger patches of forest (brown creeper and SI rifleman), and several with rather limited distributions on the east coast of the South Island (NZ falcon, NZ pigeon, morepork and tui). Also present are the two introduced species that have adapted well to native and exotic forest throughout New Zealand (blackbird and chaffinch) as well as two more localised species (little owl and eastern rosella).Ten wetland and farmland birds commonly occur close to the reserve.

	The stream is very rich in native fish, with 11 different species recorded there. Koura (freshwater crayfish) are also present in the stream, as is a freshwater isopod that is endemic to coastal Otago and is thought to be a threatened species. Of the species that could have been in the area in pre-human times, 22 birds, one bat and one frog are now globally extinct. Many others are locally extinct, including kiwi, takahe, kakapo, kaka, weka, kakariki, mohua and saddleback.
10 years time (2015)	The overall forest structure will be little changed, although broadleaved species will be at greater heights within the kanuka forest and *E. regnans* stand. Weed species will be under control and the western windbreak of pines will have been removed. Browse-susceptible species such as broadleaf and three-finger will be strongly represented in the understorey, following the eradication of goats and possums, while seedling densities of many species will have increased due to freedom from rat and mouse predation. Litter depths will be increasing steadily and invertebrate abundance will be greatly improved. All exotic mammals will be absent and other exotic fauna will be a diminishing component of the total biota. Pre-existing bird populations will be experiencing greater breeding success and will have increased in numbers as a result. The ecosanctuary will now be home also to breeding populations of little spotted kiwi, SI robin, southern tokoeka, buff weka, tuatara, kakariki, kaka, saddleback, fairy prion, takahe, jewelled gecko, Duvaucel's gecko, morepork and short-tailed bats. Wetlands will have been developed at the top of the catchment and these will be frequented by pukeko, spur-winged plover, kingfisher, fernbirds, paradise shelduck and several species of duck.
100 years time (2105)	In the absence of fire, the *Eucalyptus regnans* stand will now comprise widely-spaced giant trees over a dense subcanopy of native forest. Kanuka forest will no longer predominate in the valley, but will have been substantially replaced by broadleaved species. Native mistletoe will be widespread and flowering in abundance. Young podocarps will be beginning to show a significant presence in the canopy. The natural diversity of the fauna will have been restored. Previously rare species will have been successfully reintroduced, including kakapo, mohua and orange-fronted parakeet. Most populations will be self-sustaining and mobile species will be dispersing throughout the surrounding forests. Ecosystem processes, such as soil building, nutrient cycling and plant dispersal, will be fully functional. Burrow-nesting seabirds will be a major source of nutrient input to the ecosystem. Healthy populations of fairy prion, sooty shearwater and mottled petrel will be a feature of the sanctuary.
500 years time (2505)	The valley will resemble the forest of pre-human times, although globally extinct flora and fauna will be absent and there may be small numbers of exotic species.

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3. Management of Exotic Plants and Animals

3.1 The role of exotic trees in the reserve

Two key exotic trees in the reserve have a part to play in the restoration of the native ecosystem: the Australian *Eucalyptus regnans* and the Californian *Pinus radiata*.

Eucalyptus regnans is a pioneer species, and will eventually be replaced by native trees because it cannot regenerate under a forest canopy. However, at present the eucalypts offer a significant area of tall tree habitat in the reserve, and may provide nest sites for birds and, potentially, roosting holes for bats. The eucalypt forest also has public appeal, and includes the popular tallest tree in New Zealand. For these reasons, as well as the destructive effect of tree felling, most of the eucalypt forest will not be removed.

However, in parts of the reserve the heavy load of eucalypt leaves and bark on the forest floor impedes the establishment of native plant species and represents a significant fire hazard. For these reasons there will need to be targeted removal of some trees (see Table 1). Some eucalypts on the northern boundary of the site may also have to be removed to enable fence construction.

Pinus radiata stands in the reserve provide deep leaf litter that may have a role to play in the shorter term as a source of invertebrate food for ground-feeding birds such as kiwi. Kakapo are known to eat pine foliage and immature cones, and although it is unlikely that kakapo will be available for reintroduction to the ecosanctuary in the near future, this may also argue for retaining some areas in pine, possibly on the Trust land. Pine trees near the boundary will be felled and removed for timber where practicable, but many isolated trees may be felled and left to decay *in situ*, providing further opportunities for the development of a rich invertebrate fauna (see Table1).

3.2 Weed management

Plant pests identified as having ecological impact at Orokonui are gorse, broom, Himalayan honeysuckle, Darwin's barberry**,** rangiora and sycamore. Several exotic tree species may also have adverse impacts on the vegetation. Table 1 lists strategies and costs for managing these pest and tree species.

Table 1. Weed and exotic tree management

Species	*Distribution*	*Impact*	*Strategy*	*Method of management*	*Costs*	*Effectiveness*
Gorse	Dense stands along the Mopanui Track boundary; scattered at tracksides in eucalypt forest; scattered elsewhere. Encroaching on "picnic clearing" Dense stands on Trust land	Dense stands retard regeneration of native forest and inhibit access; seeds remain viable in soil for up to 70 years and germinate on exposure to light.	Except where gorse impedes access, and where control is required by local authorities at boundaries, allow natural succession to native forest; or control, and establish grassland	1. Use herbicide spray application to prevent establishment of gorse within 10 m of boundaries. 2. Cut by hand and treat stumps with herbicide gel where access is required.	1. Herbicide spray e.g. Tordon Brushkiller, 10 l/ha @ c. $90/l, 700 m boundary total c. $1000; volunteer labour. 2. Herbicide gel e.g. Vigilant @ c. $50/ 250ml applicator bottle; total c. $500; volunteer labour.	Needs to be repeated as soil-stored seeds germinate over many years.
Broom	Scattered around boundaries. Locally dense on Trust land	Dense stands retard regeneration of native forest and inhibit access; seeds remain viable in soil for up to 70 years and germinate on exposure to light. However, broom is an important food source for Kereru in the early spring when fruit supplies are at their lowest.	Except where broom impedes access, and where control is required by local authorities at boundaries, allow natural succession to native forest; or control and convert to grassland	1. Use herbicide application to prevent establishment of broom within 10 m of boundaries. 2. Cut by hand and treat stumps with herbicide gel where access is required.	1. Herbicide spray e.g. Tordon Brushkiller, 10 l/ha @ c. $90/l, cost covered by gorse management. 2. Herbicide gel e.g. Vigilant @ c. $50/ 250ml applicator bottle, cost covered by gorse management.	Needs to be repeated as soil-stored seeds germinate over many years.
Himalayan honeysuckle	Scattered throughout; relatively extensive stand near upper north-west boundary.	Dense stands inhibit regeneration of native forest; inhibits access; provides food source for frugivorous birds. Source of dispersal to other sites	Targeted removal as access and restoration goals require.	Grubbing and cutting by volunteer labour.	Hand tools.	Grubbed plants die.

Species	*Distribution*	*Impact*	*Strategy*	*Method of management*	*Costs*	*Effectiveness*
Darwin's barberry	Scattered along riverside in conservation covenant; denser stands on north-eastern boundary; rare elsewhere.	Dense stands inhibit regeneration of native forest; inhibits access; provides food source for frugivorous birds. Source of dispersal to other areas.	Targeted removal of dense stands; continual monitoring and removal of regeneration.	Cut and apply herbicide gel to stumps; hand pull small seedlings.	Herbicide gel e.g. Vigilant @ c. $50/ 250ml applicator bottle; total c. $500.	Gel-treated plants die; some risk of resprouting if root or stem material is missed when hand pulling small plants. Continual re-establishment from bird-carried seeds.
Eucalyptus regnans	Dense stands in lower valley; scattered mature trees elsewhere.	Dense stands inhibit regeneration of native forest in some areas; provide a little nectar and possibly nest sites for birds; considerable fuel load from dropped bark and foliage.	Targeted removal of outlier trees; natural attrition of main stands.	Ringbark trees using volunteer labour.	Very low – chainsaw fuel and maintenance.	Quick death of ringbarked trees; several centuries until mature stands are succeeded by shade-tolerant native species.
Radiata pine	Small plantations at southern, south-western and north-western boundaries; scattered mature trees elsewhere.	Inhibit regeneration of native forest; decaying wood may provide food for insectivorous birds; may provide nest sites for birds.	Removal of most trees. Some left as kiwi habitat	Clear-fell plantations and replant with appropriate native species; ringbark and leave standing isolated trees.	Tender/contract basis	Death or removal of most pines within a few years. Will need monitoring and removal of wildlings on open ground until native canopy closes.
Other exotic trees: hawthorn, sycamore, ash, etc	None recorded, but occasional establishment is likely.	Hawthorn berries provide food for frugivorous and seed eating birds but otherwise there are few or no ecological benefits; detract from naturalness. Invasive and persistent	Complete removal.	Fell and treat stumps with gel herbicide; hand pull seedlings as necessary.	Very low – chainsaw fuel and maintenance; Herbicide gel e.g. Vigilant @ c. $50/ 250ml applicator bottle.	Removal of all mature trees. Continual re-establishment from incoming seed will need periodic attention.

3.3 Animal pest management

Mammalian species known, or likely, to be present and identified as having ecological significance at Orokonui, are goats, cats, possums, ship rats, Norway rats, mice, stoats, ferrets, and hedgehogs. Cattle, sheep, pigs, and dogs are likely to be present occasionally. It is not known whether weasels are present, but it is likely given their presence in nearby Silverpeaks. Potential avian pests are magpies, starlings, and eastern rosellas. Magpie control is readily achieved by cage trapping using call birds, but only on a large scale. Apart from competition for nest sites, the ecological effects of starlings and rosellas are not known, and no control is proposed until any adverse effects are quantified. Invertebrate pests, such as wasps, can be satisfactorily controlled as the need arises.

Eradication is the goal for all exotic mammals present in the sanctuary. Most work will take place after the fence is completed so there is no risk of reinvasion. The methodologies investigated by the Trust are outlined in Appendix 1. When using toxins, the Trust will take into account the use of water from Orokonui Stream for domestic and other purposes, and the potential effect on non-target biota.

The most appropriate method for getting rid of the goats is hunting, and mustering for any other larger mammals that may be there when the fence is closed (e.g. cattle, sheep and dogs). For the smaller mammals the best methods are ground application of 1080 gel blocks or bags (possums and rodents), and aerial or ground application of brodifacoum (rodents and carnivore by-kill). The Karori experience was that poisoning possums and rodents with Talon (brodificoum) resulted in a 100% by-kill of mustelids and almost 100% of hedgehogs. An estimate of $150,000 spread over four years has been provided by a commercial operator for mammalian pest eradication at Orokonui. Table 2 below summarises the cost estimates for an eradication programme that will use volunteers under the supervision of licensed operators.

Table 2: Methods and costs (materials only) for mammal eradication

Mammals	Method	Estimates of quantity and cost
Possum and rats	Option 1. Feratox Philproof bait stations @ 100 m intervals	Feratox pellets @ 12/ha ($0.35 each) **$1050**
Possum and rats	Option 2. 1080 block baits (Bait stations as for Option 1)	Need 6 x 40 units of 250 g **$7080 + GST and freight**
Rodents and mustelid bykill	Option 1. Aerial application of brodificoum (requires ACVM and ERMA permission)	brodificoum ($3/kg) @ 8 kg/ha (250 ha) **$6000** 21 days repeat @ 7 kg/ha **$5250** flying @ 70% of poison cost 1st appln **$4200** 2nd appln **$3675** Total **$19,125**
	Option 2. Ground based Assumes bait stations @ 25 m intervals = 8/ha = 2000 in total	2000 Philproof bait stations @ $8.50 **$17,000** Brodificoum **$12,000** **Total $29,000**
Stoat and ferret control	Fenn traps @ 1 per hectare	Traps @ $24 each, two per tunnel, 250 sets of two for 250 ha **$12,000**

The initial knockdown of mammals will be followed by a period of monitoring, with any remaining pests trapped or poisoned. The Trust will consider the use of trained dogs.

4. Restoring Orokonui's vegetation

4.1 The Orokonui Conservation Area

The current patchwork of vegetation in the Orokonui Conservation area is shown in Map 1. The stand of Australian mountain ash (*Eucalyptus regnans)* includes New Zealand's tallest tree and currently provides an extensive tall forest habitat. In most places it is accompanied by native understorey species. Mountain ash is a pioneer species that will not establish where there is continuous ground vegetation, including grass and herbaceous weeds. In the absence of fire it will eventually be replaced by native species.

A species list of vascular plants known to be present at Orokonui is given in Table 1 of Appendix 2.The range of plants present indicates that the reserve contains a wide range of microclimates, particularly with respect to humidity, and thus a substantial diversity of habitat for fauna. Detailed vegetation surveys are currently underway to provide baseline data with which future changes in the vegetation can be compared.

Table 2 of Appendix 2 gives detail on the feasibility of reintroducing some of the plant species that should be in the Orokonui reserve, but are presently absent or under-represented. The following is a summary.

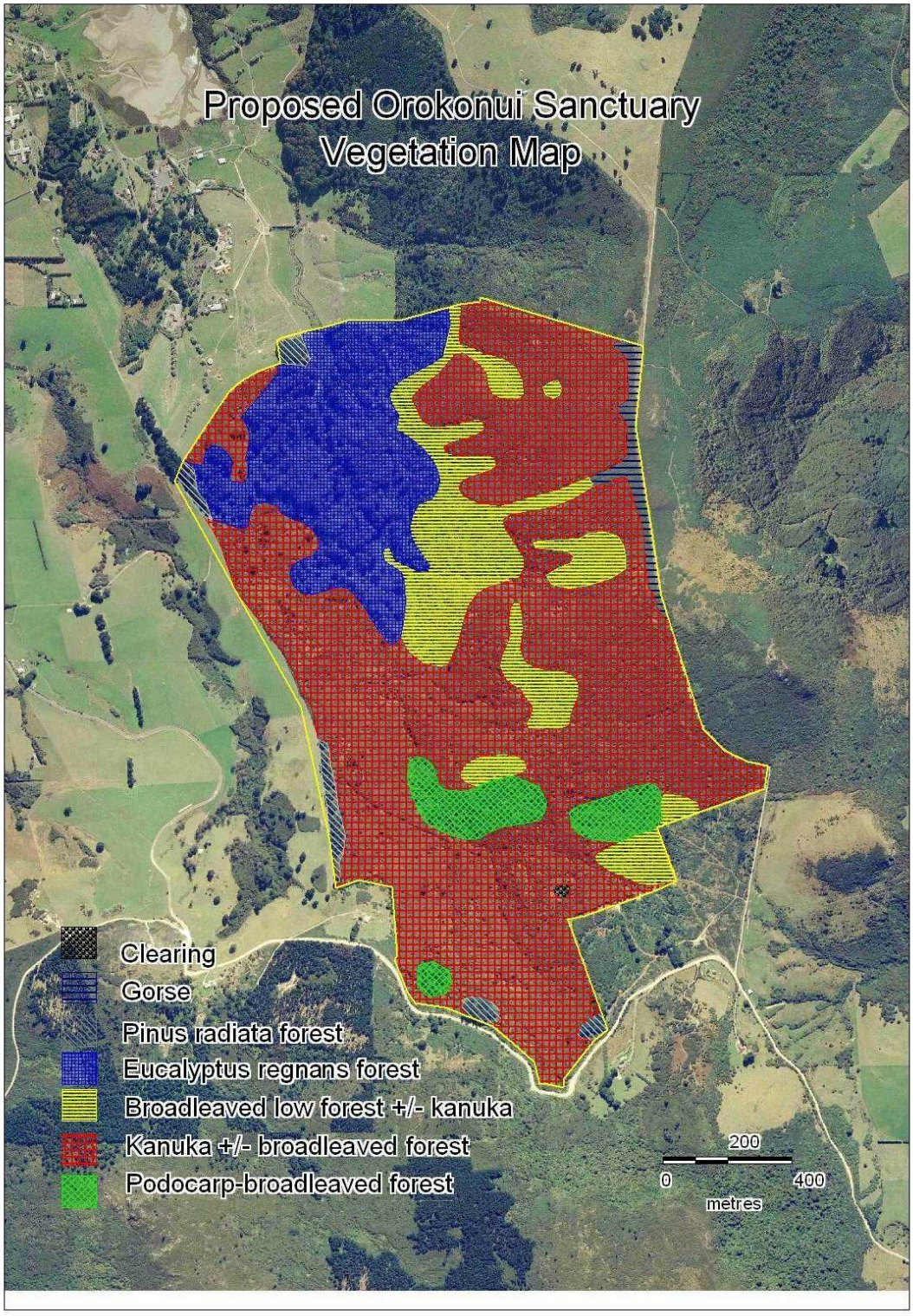
Existing remnants of rimu-Hall's totara-miro-pokaka/broadleaved forest in the upper half of the valley indicate that this would have been the dominant forest type at higher elevations, with some *Libocedrus* in the saddle between Mopanui and Mihiwaka. None of the original emergent trees remain in the lower valley, but rimu was almost certainly present here, along with kahikatea, matai and possible true totara. Steep, dry sites may have provided local habitat for kowhai, narrow-leaved lacebark and lowland ribbonwood. Only rare vestiges of dry forest vegetation, such as the fern *Pellaea rotundifolia,* are present in the current vegetation.

Other broadleaved tree species that are likely to have been present, and may still be there in low numbers, include the threatened species fierce lancewood and *Olearia fragrantissima*. These will be reintroduced in appropriate habitats, along with other rare or uncommon small tree, shrub and climber species, such as tree nettle, *Scandia geniculata,* and *Brachyglottis sciadophila*.

The dominance of kanuka over much of the valley has delayed the re-establishment of most of the species listed in Appendix 2. Although kanuka forest is now opening out sufficiently to allow natural establishment of many, there are few seed sources in the vicinity and re-establishment will be facilitated by planting, especially under canopy gaps. The removal of pine stands will provide good opportunities for planting in the absence of competition from existing vegetation.

Section 6 of this report indicates which species could be planted to encourage invertebrates, particularly Lepidoptera.

Map 1: Vegetation types of the Orokonui Conservation Area



4.2 Management and Restoration of the Trust's Land

The Trust land at the top of the valley is considerably modified, having been used until recently for growing *Pinus radiata.* The management regime for this area is still under discussion as it has been recently purchased by the Trust. The land provides opportunities for the development of managed grassland in a mosaic with shrubland and forest. Extensive planting and development will take place, a high priority being the re-establishment of *Libocedrus* forest. The Trust has decided to locate the visitor centre on this land and sees the potential for a range of "mini-environments" that would have high public appeal. These could include wetlands, cloud forest, a takahe/kiwi and/or weka glade, and reptile areas. The land is also a promising site for the translocation of burrow-nesting seabirds (see section 5.4)

Wetlands: There are seepages on this land, and thus it would be an excellent site for the development of wetlands. The establishment of dense beds of reeds, rushes, and raupo on the margins of wetlands would provide habitat for spotless crake and marsh crake, and possibly bittern. Fernbirds have been recorded in the general area, and could be reintroduced to the shrubland surrounding the wetlands.

Fire ponds: At least 10,000 litres of stored water is needed to prepare for the scenario of a fire in the sanctuary. Fire ponds entail the natural collection of seepage water in an excavated and unlined cavity. The northwestern part of this land is ideal for the creation of fire ponds because of its comparatively flat location and poor drainage.

Shrublands and grasslands: The existing shrublands are excellent habitat for reptiles that were formerly much more common in eastern Otago, including jewelled gecko and green skink. The Trust intends to reintroduce these reptiles once predators are absent from the sanctuary. Some parts of the property that are in open grassland also show promise as tuatara habitat. To prevent reinvasion of woody species, open areas and tracks will be vegetated with grass swards.

A mosaic of shrubland and grassland will offer good habitat also for birds such as takahe, pukeko, kiwi and weka. Grass will provide food for takahe and waterfowl, and these birds will in turn keep the grass a manageable length. Translocations of birds (such as weka) that prey on reptiles and on other birds will need to be carefully timed and managed.

Cloud forest: The gentle south facing slopes at around 300m in elevation might have once supported montane podocarp forest featuring the NZ mountain cedar, *Libocedrus bidwillii.* The fog that frequently cloaks the land simulates the higher rainfall requirements of *Libocedrus*. Another indicator that this is probable *Libocedrus* habitat is the presence of damp-tolerant manuka. The restoration of montane podocarp-*Libocedrus* forest in parts of this zone will require active planting of young trees, but provides an excellent opportunity to protect the unusual NZ mountain cedar and restore the original forest cover.

5. Restoring Orokonui's Birdlife

5.1 Current birdlife

Over 100 species of birds have been recorded in the Orokonui, Waitati and Blueskin Bay areas in the last seven years. Of these, the 35 listed below (Table 3) have been recorded in, or near (e.g. flying over) the Orokonui Reserve and will be considered in relation to reserve design and management.

Not all these species use the reserve in the same way, or to the same extent: a territorial bush bird like the brown creeper may spend most of its life within the reserve; black shags may occasionally fish the stream or roost in the tall trees; some, like redpolls, nest around the margins and feed elsewhere, while others, such as native pigeons, may nest in and obtain some food from the reserve but also forage widely outside it.

Table 3: Bird species that regularly visit the Orokonui Reserve (1998-2005).
* denotes exotic species

	Native	*Introduced*	*Feeding*	*Breeding*		*Native*	*Introduced*	*Feeding*	*Breeding*
Sooty shearwater *(flying over)*	✓				SI fantail	✓		✓	✓
Black shag	✓				Brown creeper	✓		✓	✓
Little shag	✓				SI tomtit	✓		✓	✓
White-faced heron	✓			✓	Tui	✓		✓	**?**
Paradise shelduck	✓			✓	Bellbird	✓		✓	✓
Mallard*/grey duck		✓		✓	Blackbird*		✓	✓	✓
Australasian harrier	✓			✓	Song thrush*		✓		✓
NZ falcon	✓		✓	**?**	Starling*		✓		✓
NZ pigeon	✓		✓	✓	Dunnock*		✓		✓
Feral pigeon*		✓		**?**	House sparrow*		✓		✓
Eastern rosella*		✓	✓	✓	Chaffinch*		✓	✓	✓
Shining cuckoo	✓		✓	✓	Redpoll*		✓		✓
Little owl*		✓	✓	✓	Goldfinch*		✓		✓
Morepork	✓		✓	**?**	Greenfinch*		✓		✓
NZ kingfisher	✓			**?**	Yellowhammer*		✓		✓
Welcome swallow	✓				Australian magpie*		✓		✓
SI rifleman	✓		✓	✓					
Silvereye	✓		✓	✓					
Grey warbler	✓		✓	✓	**Total**	**20**	**15**	**16**	**26**

This is a reasonably typical species list for a moderate-sized remnant of bush on the east coast of the South Island. It includes the common widely distributed native species (silvereye, grey warbler, fantail and bellbird), a couple that require larger patches of forest (brown creeper and

rifleman), and small numbers of several others with rather limited distributions on the east coast of the South Island (NZ falcon, NZ pigeon, morepork and tui). Also present are the two introduced species that have adapted well to native and exotic forest throughout New Zealand (blackbird and chaffinch) as well as two more local species (little owl and eastern rosella).

A further 10 wetland and farmland birds commonly occur close to the reserve (Table 4).

Table 4: Wetland and pasture species adjacent to Orokonui reserve (1998-2004)
* denotes exotic species

	Native	*Introduced*	*Feeding*	*Breeding*		*Native*	*Introduced*	*Feeding*	*Breeding*
Black swan*	✓		✓	✓	Spur-winged plover	✓			✓
Feral goose*		✓	✓	✓	Pied stilt	✓		✓	✓
Grey teal	✓		✓	**?**	Skylark*		✓		✓
Australasian shoveler	✓		✓	**?**	New Zealand pipit	✓			✓
Pukeko	✓		✓	✓					
NZ pied oystercatcher	✓		✓	✓	**Total**	**8**	**2**	**7**	**8**

Detailed bird surveys are currently underway to provide baseline data with which future changes in the avifauna can be assessed.

5.2 Past Birdlife

Fossil records from the south-eastern South Island indicate that the following bird species could have been in the Orokonui reserve in pre-human times. The Trust's feasibility report gives more detail about where fossils were found for each species, and the ages of these fossils, most of which date from the Holocene, i.e. within the last 10,000 years.[2]

[2] *Orokonui Sanctuary: "A Once and Future World" Feasibility Report. Part B Reports of the Feasibility Study Working Groups.* Diane Campbell-Hunt and Ralph Allen Otago Natural History Trust September 2004

Table 5: Birds that were probably at Orokonui

Still at or near Orokonui	*No longer in Orokonui*	*Globally extinct*
Sooty shearwater	Southern Tokoeka (SI brown kiwi)	*Little bush moa*
Pied shag	Little spotted kiwi	*Heavy-footed moa*
NZ falcon	Shearwater sp.	*Stout-legged moa*
New Zealand pigeon	Long-tailed cuckoo	*Eastern moa*
Shining cuckoo	Sooty shearwater	*Giant moa*
Morepork	Common diving petrel	*Eastern South Island kiwi*
New Zealand kingfisher	Fairy prion	*Scarlett's shearwater*
SI Rifleman	Broad-billed prion	*New Zealand storm petrel*
Brown creeper	Cook's petrel	*Eyles's harrier*
Grey warbler	Mottled petrel	*Haast's eagle*
SI fantail	New Zealand storm petrel	*New Zealand quail*
SI tit	Grey-backed storm petrel	*Hodgen's rail*
Bellbird	White-faced storm petrel	*New Zealand coot*
Tui	King shag	*SI adzebill*
Black shag	Spotted shag	*Laughing owl*
Little shag	Banded rail	*New Zealand owlet-nightjar*
New Zealand pipit	Buff weka	*Bush Wren*
SI fernbird	Spotless crake	*SI Stout-legged wren*
	Marsh crake	*SI thrush/piopio*
	Takahe	*SI kokako*
	Kakapo	*New Zealand crow*
	SI kaka	
	Parakeets spp.	
	Yellowhead/mohua	
	SI robin	
	SI saddleback	

Note that the orders Ciconiiformes (herons & allies), Anseriformes (waterfowl) and Charadriiformes (gulls & shorebirds)) plus the marine shags (Leucocarbo & Stictocarbo) were excluded from this list because, at present, the ecosanctuary does not extend down to the sea, nor does it include any ponds)

5.3 Feasibility of bird translocation

The feasibility templates for bird species are presented in full in the feasibility report.[3] For many of the species, particularly those endangered ones whose distribution is currently very limited, there are many unknowns. For example, there is considerable uncertainty about the diversity of habitats in which takahe might be able to live, and about the requirements for successful breeding of kakapo. The key issues associated with translocations are included in the feasibility report[4], and are summarised in the Trust translocation timetable (see section 8 on page 31 of this report). A key element in assessing the feasibility of translocation has been the specifications of DoC's

[3] Ibid

[4] Ibid

species recovery plans. For several species the recovery plan talks of translocations to predator-free islands. The Orokonui ecosanctuary will be the mainland equivalent of such an island.

Table 6: Feasibility assessment for bird species

South Island bird species	*Is a breeding population currently present?*	*Is the species likely to find its own way back to the Reserve?*	*Is it feasible to translocate it?*
Southern tokoeka (SI brown kiwi)	No	No	Yes
Little spotted kiwi	No	No	Yes
Mottled petrel	No	No	Yes
Sooty shearwater	No	possibly	Maybe
Common diving petrel	No	No	No, due to lack of cliff tops
Fairy prion	No	No	Yes
Broad-billed prion	No	No?	No?
Cook's petrel	No	No	Yes
New Zealand falcon	Maybe	Yes	Not necessary
Buff weka	No	No	Yes, but may need to be restricted because of predatory behaviours
Takahe	No	No	Yes
Kakapo	No	No	Not at present
South Island kaka	No	Not entirely impossible	Maybe – may require supplementary feeding
Red-crowned parakeet	No	No	Yes, may require supplementary feeding
Yellow-crowned parakeet	No	No	Yes, may require supplementary feeding
Orange-fronted parakeet	No	No	No, but aviary birds may become available in future.
Long-tailed cuckoo	No	Maybe	No
Morepork	Nearby	Yes	Not necessary
New Zealand kingfisher	Nearby	Yes	Not necessary
Yellowhead/mohua	No	No	Uncertain
South Island fernbird	No	Probably	Yes
South Island robin	No	Possibly	Yes
Tui	No	Yes	Not necessary
South Island saddleback	No	No	Yes

5.4 Seabirds

Burrow-nesting seabirds would once have bred in the Orokonui Valley and would have played an important role in the forest ecosystem by transferring nutrients from the oceanic ecosystem. Sooty Shearwaters already fly around the reserve at night and could possibly recolonise of their own accord. The Restoration Working Group has looked in detail at suitable seabirds for

reintroduction and at the associated issues.[5] These issues include the suppression of forest seedlings at dense nesting sites, weed invasion and the potential predation of seabird eggs and chicks by tuatara and buff weka.

The mottled petrel and the fairy prion are suitable species for trial reintroduction, and if successful the Trust may move on to rarer species such as Cook's petrel. The Trust land at the top of the Valley is considered an excellent site for the location of artificial burrows. Seabirds represent a major opportunity for night-time ecotourism, their dramatic return to their burrows.

5.5 Habitat suitability for reintroducing missing birds

The Orokonui reserve is of similar habitat quality to many regenerating areas of native forest of similar age around Dunedin, but has the advantages of low elevation and northerly aspect. The ground litter layer varies from very deep under eucalypt forest to shallow on bouldery ground, and its suitability as a source of invertebrates for ground feeding birds varies accordingly. Soils are similarly variable.

Removal of mammalian predators will immediately increase breeding success for many birds as their eggs and chicks and young will no longer be eaten. There also will be a decrease in competition from mammals for available food. Once possums and rats are removed, the birds will benefit from greater availability of fruit from *Coprosma* shrubs and broadleaved trees such as fuchsia, mahoe, broadleaf, putaputaweta and wineberry. The exotic eucalypts provide a brief and somewhat unreliable source of nectar source that is used by bellbirds, but at present there are few native sources of nectar . This will be overcome in the shorter term by planting suitable species, such as kowhai and flax but most fruit and nectar eating species, such as kereru and tui, will continue to rely on outside sources of food until planted sources of nectar and fruit mature. Several re-introduced bird species such as kaka and parakeets will require supplementary feeding. In the immediate future, insectivorous birds are likely to benefit the most as competition from rats and mice for invertebrate food sources ceases.

The presence of thousands of hectares of predominantly native vegetation within flying distance of the reserve boundary is an additional advantage, providing additional habitat and food sources for flighted birds, and allowing the possibility of outward migration and survival of surplus progeny. However, the continued presence of predators outside of the ecosanctuary represents an ongoing threat and the Trust will encourage predator-control programmes in the wider landscape.

The reserve has a limited number of appropriate nesting sites for hole-nesting birds (such as kaka, mohua) in, for example, the many large and partially decayed broadleaf trees. However the supply will not be adequate to meet all needs, and it will be necessary to provide artificial next boxes for a number of species, including kakariki and saddleback. Artificial burrows will be created for nesting seabirds such as mottled petrel and fairy prion as part of the standard translocation process.

[5] Ibid

Multiple introductions may be needed to get some species established, and the Trust will introduce birds from different places at different times to build up genetic diversity although there is also merit, where possible, in sourcing reintroductions from local populations so as to ensure any local genetic adaptations are maintained. Some species will need "soft release" and the Trust will build aviaries for this purpose. These will probably be sited lower down in the valley where there is light canopy cover and favourable climate.

5.6 A managed step by step approach to the restoration of avifauna

Care must be taken in the reintroduction of essentially forest dwelling birds into young regenerating bush lacking many of the elements of mature forest. A year round supply of food may well be a problem for many birds until more mature forest develops. For example the vegetation survey has identified a lack of nectar bearing plants in the reserve and much of the available fruit comes from the smaller understory coprosmas and pioneer species like wineberry. Results from the first season's bird survey indicate that bird numbers are relatively low in the valley and this is especially true of fruit and nectar eating species, with both tui and kereru occurring in lower numbers than in the Dunedin town belt. Removal of browsing animals will undoubtedly improve the food supply but until the situation after fence construction has been thoroughly assessed, cautious optimism coupled with consideration of supplementary feeding is the best policy.

The order in which birds are reintroduced is important. One would not want to reintroduce a top predator such as weka early on (unless in an enclosure) when it would jeopardise the establishment of geckos, small seabirds and the larger invertebrates. However, there are also less well known interactions that could be problematic, for example kaka and parakeet feeding on nectar bearing flowers in a way that prevents seeding, extensive predation by saddleback of large invertebrates in dead wood. Monitoring of reintroductions and the way they interact with the ecology of the ecosanctuary is essential at all stages. The success or otherwise of one step will dictate the next move.

Bearing this in mind and remembering that monitoring may require changes to the plan, below is a tentative restoration program for the first few years.

Stage one:

- Introduce the two small insectivorous birds that still occur locally: robin to the lower valley and fernbird to the upper saddle.
- Try and attract sooty shearwaters, titi, that already over fly the valley to land and prospect for nest sites by playing calls from nesting colony at night – loudly.
- Introduce "advocacy birds" such as takahe in a managed environment with supplementary feeding.

Stage two:

- Once the small passerines, especially the robins prove successful, introduce birds that have been absent from the area for many years; SI saddleback which has a good success rate elsewhere, Little Spotted Kiwi which has shown itself to be adaptable to small island areas and regenerating bush, and possibly mohua.

- As part of DoC management of kiwi, the ecosanctuary could be a nursery Southern tokoeka for a year or so before their reintroduction into the wild.
- Introduce parakeets using an aviary and supplementary feeding with the intention of allowing offspring to fly free.
- Assess the success of titi and consider introducing fairy prion by transferring chicks using techniques developed elsewhere.

Stage three:

- As the habitat improves, translocate species that require large territories such as Southern tokoeka and kaka.
- Introduce mottled petrel by transferring chicks.

Stage four:

- Introduce other more critically endangered species such as kakapo as sanctuary proves viable and expertise of staff increases.

- Introduce weka in fenced off part of sanctuary once all other populations of reptiles, amphibians, invertebrates and birds have become established. Monitor closely and consider "liberation" only when impact on other organisms is known.

6. Restoring Orokonui's Other Fauna

6.1 Reptiles

The following reptile species could have been in the Orokonui reserve in pre-human times. Evidence is taken from the fossil record, together with information about which reptile species are present in the vicinity or in habitat similar to that at Orokonui.[6]

- Common gecko
- Forest gecko
- Duvaucel's gecko
- Jewelled gecko
- Common skink
- Green/spotted skink
- Other *Oligosoma* skinks

Reptiles that would have been in the general vicinity of the reserve in pre-human times include the tuatara, Duvaucel's gecko and the jewelled gecko. Species that may be in the reserve (or in the immediate vicinity) at present include the jewelled gecko, the common skink, the green skink, the cryptic skink, the southern forest gecko and the Otago/Southland large gecko. Populations of these species may build up to noticeable levels once mammals are removed. If not, translocation of these species would be appropriate as food resources and habitat requirements are likely to be sufficient within the reserve. Tuatara and Duvaucel's gecko are also suitable species for translocation. They have been translocated elsewhere in New Zealand to mammal-free islands with very positive results to date, and all available evidence suggests that removal of introduced mammals is the major step that will allow these species to thrive. Issues associated with reptile reintroduction include the danger of poaching the visible and attractive species such as tuatara, jewelled gecko, green skink and Duvaucel's gecko.

Artificial cover objects have been placed throughout the Orokonui Valley to ascertain which species of reptile are currently in the area. A research programme is underway to ascertain the thermal suitability of the Orokonui site for the reintroduction of tuatara.

Tuatara and some geckos offer opportunities for dusk and night-time ecotourism. The Department of Conservation's Grand and Otago Skink recovery programme would support the development of facilities to display giant skinks at Orokonui. These facilities could become part of the captive breeding programme for these threatened lizards. This Trust will also consider the possibility of creating some rock habitat for an experimental giant skink transfer as there are some good rock patches in the reserve.

[6] Ibid

Table 7: Feasibility assessment for reptile species[7]

Reptile species	*Is a breeding population currently present?*	*Is the species likely to find its on way back to the Reserve?*	*Is it feasible to translocate it?*
Tuatara	No	No	Yes
Duvaucel's gecko	No	No	Yes
Jewelled gecko	Maybe	Unlikely	Yes
Common skink	Maybe	Maybe	Not necessary
Green skink	Maybe	Maybe	Yes
Cryptic skink	Not likely	Not likely	Yes
Southern forest gecko	Maybe	Maybe	Not likely
Otago/Southland large gecko	Maybe	Maybe	Yes

6.2 Bats

Fossil records show that the lesser and greater short-tailed bat could have been in the Orokonui reserve in pre-human times. The greater short-tailed bat is now extinct. Even though it has not been confirmed in the fossil record, the long-tailed bat is also likely to have been in the Orokonui Valley in pre-human times. The long-tailed bat exists in remnant populations in the lower South Island and may find its own way back to the sanctuary. If it does not, then translocation is feasible. The long-tailed bat is known to use artificial day roost structures and would benefit from supplementary feeding and soft release (temporary captivity)[8]. It is also considered feasible to reintroduce the short-tailed bat, which was once widespread throughout New Zealand and is now endangered. For this species soft release and supplementary feeding would also be wise. Bats represent an opportunity for dusk/night ecotourism. Long-tailed bats emerge from their day roosts before dark and hence are more readily seen than short-tailed bats.

6.3 Fish

The stream is very rich in native fish species, with 11 different species recorded there in 1999 (Table 8). This richness is due, in large measure, to the absence of introduced fish. An introduced species, brown trout (*Salmo trutta*), has been present in the stream, but a barrier (gabion basket) was placed in the lower stream in *c.*1999 about 500 m below the forest boundary, with the intention of preventing the entry of trout upstream but allowing native fish to pass through. Most of the native fish present in the stream are migratory and the proposed predator-proof fence will allow for downstream and upstream passage of these species. Koura (freshwater crayfish, *Paranephrops zelandicus*) are also present in the stream and might benefit from removal of

[7] See the feasibility report for full feasibility templates
[8] Shirley McQueen (DoC) pers comm.

mustelids and rats. Also present is a freshwater isopod that is endemic to coastal Otago and is thought to be a threatened species.

Translocation of fish into the stream is not recommended because the fish community is already so diverse.

Table 8: Native fish species present in the Orokonui Stream[9]

Common name	*Scientific name*
Short-finned eel	*Anguilla australis*
Long-finned eel	*Anguilla dieffenbachii*
Lamprey	*Geotria australis*
Common bully	*Gobiomorphus cotidianus*
Giant bully	*Gobiomorphus gobioides*
Red-finned bully	*Gobiomorphus huttoni*
Blue-gilled bully	*Gobiomorphus hubbsi*
Inanga	*Galaxias maculatus*
Koaro	*Galaxias brevipinnis*
Banded kokopu	*Galaxias fasciatus*
Giant kokopu	*Galaxias argenteus*
Common smelt (lower stream only)	*Retropinna retropinna*

6.4 Amphibians

There are almost certainly no native frogs in the reserve at present. Species of *Leiopelma* could be considered for translocation; at least one species of *Leiopelma* has been successfully translocated elsewhere. Frogs have moderate public appeal, but their introduction would need to be carefully planned to ensure adequate food, shelter and climate protection. Issues to consider with the reintroduction of *Leiopelma* into the reserve include predation by native birds (weka, kiwi and morepork) and possibly by *Litoria raniformis*, an Australian frog that may be present in the reserve. The Australian whistling tree frog, *Litoria ewingii*, is also present although probably in low numbers. *L. ewingii* can be found around streams in native bush, although this habitat is sub-optimal and they only reach sizeable populations when they have access to ponds. The effect of *L. ewingii* on native frogs is uncertain but may include disease transmission. Control of *Litoria spp* is difficult. Recognised control methods (e.g. rotenone) are severe and damaging to many other aspects of the environment. Frogs are very good at climbing over barriers and would not be excluded by the proposed fence (Phil Bishop, pers.comm.). Tadpoles from these species can provide a seasonal food source for native birds like kingfisher.

9 Allibone, R. 2000. Fish population and fish passage monitoring for Orokonui Creek, Otago. *Conservation Advisory Science Notes No. 304*. Department of Conservation, Wellington.

Table 9: Feasibility assessment for amphibian species in the Orokonui Sanctuary[10]

Species	*Is a breeding population currently present?*	*Is the species likely to find its on way back to the Reserve?*	*Is it feasible to translocate it?*
Markham's/Aurora frog	This is now extinct		
Hochstetter's frog	No	No	Maybe in the longer-term
Maud Island & Stephen's Island frog	No	No	Maybe in the longer-term

6.5 Invertebrates

Some initial invertebrate survey work has been undertaken and further survey work is planned:

1. Pitfall trapping

In December 2004 the following study was completed (Mara Nydegger)
Aim: What is the difference in invertebrate diversity between eucalypt and native broadleaved habitat?
Method: Two study sites 150m x 150m
5x5 metre quadrats established
20 pitfall traps in each study site
Traps set at start of December and left for a week.
Early results: 616 individuals found across both sites
Amphipods more numerous in native broadleaved habitat
Large carabid beetles more numerous in eucalypt habitat
No significant difference between sites in terms of spp in the litter or soil characteristics.
No darkling beetles (tuatara food) found
No frogs, lizards, stones flies, damselflies or mayflies found

This study is still being written up.

A subsequent programme of pitfall trapping was begin in December 2005 and is on-going. Results are not yet available.

2. An evening of light trapping in September 2005 (Brian Patrick *et al*)

240 Volt powered 160 watt UV light was used, except in the stream where a 12 Volt 8 watt light was used. Twenty-seven moth species were identified and insect fauna of the stream showed promising diversity.

[10] See the feasibility report for full feasibility templates

Noctuidae	Geometridae	Tortricidae	Crambidae
Feredayia graminosa 3 Meterana stipata 3 Meterana merope 2 Rhapsa scotoscialis 2 Graphania mutans 2 Graphania insignis 1 Graphania gallaria 1 Graphania fenwicki 2 Graphania ustistriga 1	Pseudocoremia suavis 5 Chalastra pelurgata 2 Sarisa muriferata 1 Sestra humeraria1 Ischalis fortinata 4 Asaphodes beata 1 Poecilasthena schistaria 3 Poecilasthena pulchraria 2 Homodotis falcata 1 Cleora scriptaria 5 Declana egregia 1 Declana floccosa 6	Planotortrix excessana 3 Planotortrix notophaea 1 Pyrgotis plagiatana11 Strepsicrates zopherana 1 Ctenopseustis obliquana 12	Deana hybreasalis 2 chafer Odontria striata 13 several flies several caddis species stonefly Austroperla cyrene on rock in stream

Of the 27 moth species trapped the following species are of some significance:

- *Graphania fenwicki* is a local Dunedin endemic species
- The zebra moth *Declana egregia* – featured on the $100 note – is a spectacular large species
- *Meterana merope* with larvae on *Schefflera, Ischalis gallaria, Planotortrix notophaea, Chalastra perlurgata* & *Poecilasthena pulchraria* are widespread but generally uncommon species

3. Freshwater invertebrates (Ruth Goldsmith)

An initial study of freshwater invertebrates in summer 2004/05 surveyed 6 sites, of which 2 were outside and 4 inside the reserve. Two surber samples were taken from each, and the macroinvertebrates were identified. The number of taxa and the number of invertebrates were counted. Macroinvertebrate community index (MCI) & quantitative MCI were calculated.

The general results were:

- MCIs were high at all sites, indicating a healthy stream
- Quantitative MCI showed that there were more of the sensitive species inside the reserve
- There were no invasive macrophytes or algae in the stream
- There was some evidence of siltation, almost certainly from the recent tree felling in the upper catchment and runoff from the unsealed Blueskin Road.

More detailed results are given in appendix 4.

Not a great deal is known about the invertebrate species that should be in the reserve. Weta specialist George Gibbs (pers. comm.) has confirmed that there appear to have been no tree weta (*Hemideina* species) or giant weta (*Deinacrida* species) around Dunedin. This gap in their distribution seems to be a quirk of biogeography. Some ground and cave weta species are probably present in the reserve, and their abundance will be enhanced by the eradication of mammalian predators. Snail specialist Hamish Spencer (pers. comm.) reports that there is no

evidence for the past presence of large land snails (e.g. *Placostylus, Powelliphanta*) in the Dunedin region. The largest local endemic species, which might even be endemic to Dunedin, is a species of *Rhytida*. Broadleaved forest litter generally provides suitable habitat for snails, but kanuka litter tends to be too dry. Beetle specialist John Nunn (pers. comm.) notes that there are over 1,000 known species of beetles in the Dunedin area and that habitats like Orokonui would have supported a rich proportion of the forest fauna. Flighted beetle species are likely to find their own way back once the Valley is restored, and other species could be reintroduced by bringing leaf litter from healthy areas with comparable vegetation. The Trust will consider reintroducing the iconic *Peripatus,* which has a healthy and protected population in the Caversham area of Dunedin.

In other nature sanctuaries, such the Chetwode Islands in the Marlborough Sounds and Matiu-Somes Island in Wellington Harbour, there has been a build up in invertebrate numbers following the eradication of rodents.[11,12] Regular invertebrate monitoring at Karori ecosanctuary has also detected a strong increase in ground-dwelling population density (Denise Fastier, pers. comm.). Expert advice indicates that we should wait and see what builds up after the pests have been eradicated, rather than immediately beginning translocations of invertebrates. Because tree weta and giant weta do not appear to have been present in Dunedin, it may not be appropriate to introduce them to the sanctuary, although this position could be reviewed, were more food sources needed for tuatara, for example. A small population of the Wellington tree weta *(Hemideina crassidens)* has established in a Dunedin garden after being accidentally introduced from the West Coast. This provides an indication that tree weta would survive in the Valley if introduced.

For butterflies and moths**,** local expert Brian Patrick has indicated the plant species that are important hosts for Dunedin's rich lepidopteran fauna. About 860 species are known from Dunedin city, representing 48% of all New Zealand species. Butterflies and moths are highly specific to certain plant species or genera, or ecological associations at certain stages of their life cycle. Key plant species for Dunedin Lepidoptera include kanuka and other species that are already present in the reserve. Table 10 below indicates how Lepidopteran richness can be enhanced in the reserve. Enhancing Lepidopteran populations through native plantings will have a companion-effect of also enhancing many other plant-dwelling invertebrate species, such as beetles, spiders and bugs.

[11] Rufaut, C.G. and Clearwater, S.G. 1998. Chetwode Islands Recovery: The response of lizards and invertebrates following eradication of kiore and weka from the Chetwode Islands. Department of Conservation Occasional Publication No. 41, 25 pp.

[12] Watts, C.H. and Gibbs, G.W. 2000. Species richness of indigenous beetles in restored plant communities on Matiu-Somes Island, Wellington Harbour, New Zealand. *New Zealand Journal of Ecology* **24,** 195-200.

Table 10: Enhancement of Lepidopteran populations

Important local habitats that should be nurtured/ increased within the forested slopes

- Wet banks of *Gunnera*, *Epilobium* etc.
- Track-side herb-fields of *Acaena*, *Urtica*, *Stellaria*, *Cardamine*, *Hydrocotyle*
- Lianes over understorey shrubs such as *Parsonsia*, *Rubus*, *Helichrysum lanceolatus*, *Muehlenbeckia*, *Calystegia*, *Corokia*, *Clematis*, *Coprosma*, *Streblus*, *Urtica ferox* (well away from tracks)
- Stream-side ferns and shrubs
- Forest-edge lianes such as *Rubus* and *Muehlenbeckia* (sufficient of these are currently present and in balance with the canopy; *Muehlenbeckia* can cause canopy collapse so no further planting is recommended.)

Lepidoptera species that are apparently locally extinct that could be considered for re-introduction

- *Asaphodes stinaria* (Geometridae) on *Ranunculus*
- *Asaphodes imperfecta* (Geometridae) on *Ranunculus*?
- *Asaphodes adonis* (Geometridae) on *Ranunculus*?
- *Hydriomena hemizona* (Geometridae) on wet bank herbs?

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7. Risk Management

Table 12: Restoration risks and strategies

Risk	***Strategy***
Fire	Prevention will be the first line of defence against fire, underpinned by visitor education on the risks and effects of fire. Smoking and lighting of fires will be prohibited. A fire plan will be drawn up in cooperation with DoC and the local rural fire officer, and implemented as soon as fire is detected in the sanctuary. Visitor evacuation is the first priority.
Storms and floods	Rapid detection of damage to fence and rapid repair.
Mammal reinvasions	Once the fence is up, the risk of mammal reinvasions should be very low. There have been no such reinvasions to date at 'Warrenheip', where the Xcluder fence has been in place since 1999. Regular surveillance of the entire fence perimeter is vital to detect any early signs of breaching. Detection will be achieved by constant monitoring using diverse methods, including bait stations and tracking tunnels. Detection will be followed by rapid eradication. Bag searches will be conducted at entry.
Ant invasion	There will be a very small risk of invasive ants being introduced to the ecosanctuary area. Most invasive ant species are from warmer climates and will not survive in the Orokonui Valley (Warwick Don, Otago Museum, pers. comm.).
Fence breaches (by humans)	Adequate surveillance is vital. Management will include the following: • ensuring that adjacent ecosanctuary neighbours are supportive. • regular checking of the fenceline • an electronic surveillance system along the top of the fence
Poaching	The Trust should consider the following strategies: • disperse desirable populations (especially reptiles, which are prone to poaching) through the sanctuary. • encourage ecosanctuary visitors to report suspicious behaviour. • mark desirable species with PIT (passive integrated transponder) tags.

8. Measuring conservation outcomes - initial ideas

(Note that Landcare Research is developing a set of indicators to measure the success of community-based conservation initiatives)

Conservation Outcomes for Orokonui Ecosanctuary	**Goals**	**Measure**	**Example Methods**
A self-sustaining ecosystem representative of eastern Otago coastal lowland forest	Phase 1) For first 50/100/300 (?) years: A general upwards trend (discernible despite annual fluctuations) in: • Flowering and fruiting of native plants (not being measured at present) • Seedling density • Plant species diversity • Faunal species diversity and • breeding success • Abundance of invertebrates	Steady improvement in the following indicators when data compared for start and end of 5/ 10 (?) year periods: Population and breeding rates of the following indicator species: • Tuatara • SI robin • Mistletoe • Native land snail • Plus? • Number of indigenous species recorded as present	Flora and fauna surveys Monitoring of sample plots Observation of marked individuals Nest counts Nest box occupancy rate Annual?
	Phase 2) Beyond 50 years: Sustained population numbers of key species above despite seasonal fluctuations. All species returned to the valley that would have been there in the past, with the exception of extinct species. Notes: A storm, fire or flood could return all or part of the ecosanctuary back to phase 1.	The percentage of species likely to have been originally present at Orokonui that are now present/returned	As above
Key ecological processes functioning in the valley.		The percentage of species, particularly indicator species, maintaining or improving status. Regeneration of once	Flora and fauna surveys Monitoring of sample plots Observation of marked individuals

Conservation Outcomes for Orokonui Ecosanctuary	Goals	Measure	Example Methods
		absent species occurring naturally. Vegetation succession proceeding in secondary vegetation.	Five-yearly
A haven for threatened & taoka species, such as SI brown kiwi, saddleback, burrow-nesting seabirds, tuatara, jewelled gecko, galaxiids, mistletoe.		Number of threatened/taoka species breeding in the sanctuary	Flora and fauna surveys Monitoring of sample plots Observation of marked individuals Five-yearly
Species dispersal and gene flow into the wider Otago ecosystem.		Number of species present in the ecosanctuary that have established beyond the enclosed area	Surveys at selected sites at increasing distance from Orokonui e.g. Mihiwaka, Mt Cargill, Sullivans Dam, Town Belt Bird banding
A valued site for high quality ecological research, including studies by tertiary students.		Number of research projects underway/completed	Maintain database
New knowledge informing ecological advocacy and conservation elsewhere in New Zealand		Number reports published. Number talks, conferences.	Database Library

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9. Restoration Policies

These policies will guide all restoration activities and all species management programmes.

Policy Area	**Policy**
Translocation	Translocation of missing species will be undertaken in accordance with DoC translocation guidelines, and will be contingent on the presence of suitable habitat and food sources (including appropriate supplementary feeding).
Sourcing	Species for translocation will be sourced from the nearest geographical and/or genetic population that is able to support the loss of individuals, and from which sourcing is culturally acceptable. Sourcing from captive populations will be considered where possible as it may offer advantages in some cases.
Cultural issues	Te reo, kawa and tikanga of mana whenua will be an inherent part of the ecosanctuary and its operations, including all restoration activities. All materials from dead birds and other fauna will go to cultural materials bank for the appropriate rohe, and will be administered by DoC and the runaka.
Protection	There will be no exploitative use of native species from the ecosanctuary for purposes other than restoration
Analogues	Where a formerly representative species (or subspecies) is extinct, replacement with an analogue species may be considered. This may be necessary to ensure ecological processes function well
Self-introductions	Species that are confirmed as self-introduced to New Zealand since human arrival will be treated as native species and representative if found in coastal Otago. (Examples: Spur-winged plover, silvereye, welcome swallow)
Management techniques	All management techniques available to conservation management may be used, if considered appropriate, including: • Supplementary feeding • Captive rearing and breeding (in Botanic Garden aviary) • Temporary holding in on-site enclosures (“soft release”) • Enclosures/exclosures within the sanctuary • Rehabilitation of injured fauna • Artificial nest and/or roost sites • Possible planting of exotic species as food sources

Policy Area	Policy
Faunal health and welfare	Surveillance, prevention and treatment programmes will be used to maintain the health of native animals, according to best practice. All work with fauna will be conducted in accordance with the Animal Welfare Act. The trust will seek to involve the appropriate ethics committee.
Flagship species	Where desirable for public support, priority for translocation may be given to selected "flagship" species, either flora or fauna, provided it does not impede the achievement of the restoration outcomes.
Public feeding of birds	Feeding of birds by the public will not be allowed due to health risks and potential over-socialisation of species.
Habitat manipulation	Manipulation of existing habitats (e.g. controlling regeneration) or the development of new habitats (e.g. wetlands) will be permitted for purposes of: • Fire safety • Fence security • Managing forest succession • Providing suitable habitat for translocated species (e.g. maintaining grasslands) • Providing appropriate food sources for translocated species. • Providing opportunities for visitors to see rare species
Research	The Trust is keen to encourage research within the Orokonui Valley/Ecosanctuary and to ensure that research is coordinated and documented. A separate policy is being developed for research

10. Faunal Translocation Timetable

Following fence construction and the eradication of pest mammals the general strategy will be as follows:

Sequencing of species translocation	Potential source populations	What is known about food and habitat requirements	Notes on introduction of this species to the sanctuary.	Time after valley confirmed as mammal-free
Stage One				
South Island Robin	Whare flat Silverpeaks	Like open, sparse forest with a good canopy but not much understorey. Thus they will probably occupy different parts of the Orokonui forest from the tomtits that are already there Robins nest in trees. There are no habitat restrictions at Orokonui	Translocate as matter of urgency to ensure survival of local genetic stock. May be a challenge to get them to stay in the valley since they are strongly territorial? Juveniles will disperse – territory holders are not likely to.	First 6 months
Fernbird	Local populations			First 6 months
Takahe	Murchison mountains, Maud Island, Tiritiri matangi.	**Habitat**: alpine-tussock habitat - generally to be found at 3300 to 3800 feet, where the forest has given way to scrub and snow . Takahe from the present Fiordland population are adapted to living and breeding in an alpine environment. Takahe also do well on lowland pasture grasses – pasture is maintained on Maud Island for this reason. Mated pairs or family groups of takahe are attached	Establishment of suitable tussock areas (for nest building) and plenty of mown grass. Address the issues of need for supplementary feeding, and potential chick predation by harrier hawk and falcon. More likely to get one pair of non-breeding birds for advocacy purposes than for establishment of breeding population (which needs 5 pairs and a larger area of	First year as advocacy birds

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Sequencing of species translocation	Potential source populations	What is known about food and habitat requirements	Notes on introduction of this species to the sanctuary.	Time after valley confirmed as mammal-free
		at least semi-permanently to an area (5 to 20 acres). Young birds must move over considerable distances to establish new territory; up to 1.9 km **Diet:** vegetarian diet: mostly grass (*Chionochloa rigida, C. flavescens*, but also *Poa colensoi, Festuca novae-zelandiae, F. mathewsii, Hierochloe alpina*). Food species in Fiordland: *Chinonochloa pallens, C. crassiuscula, C. rigida* and *Celmisia petriei.* Also seeds and flowers of these species; rarely insects. Success of supplementary feeding suggests that the present diet is inadequate and alpine tussock is not their favoured habitat. Birds on Maud live in low scrub and regenerating bush. Not much is known about takahe diet when takahe occurred throughout NZ. During winter takahe are forced to feed in the forest: stalks of *Hypolepis* sp., seed-heads of *Anthoxanthum odoratum* and *Dactilis glomerata.* Dependent on water. Tussock needed for nest building.	grassland habitat). Dave Crouchley: Takahe like a mosaic habitat and wetland areas too, and are territorial, so space for territories needs to be sufficient. He also doesn't think takahe are important predators of tuatara, and thinks that kingfishers and starlings would take more than takahe do. Would therefore probably do well on Trust land in shrubland/open grassland/forest mosaic.	
Sooty shearwater	Local		Try and attract sooty shearwaters, titi, that already over fly the valley to land and prospect for nest sites by playing calls from nesting colony at night – loudly.	First year

Sequencing of species translocation	Potential source populations	What is known about food and habitat requirements	Notes on introduction of this species to the sanctuary.	Time after valley confirmed as mammal-free
Stage Two				
SI saddleback	Muttonbird Islands	**Habitat**: Dense native forests. 2-9 ha required for territory**,** roosts in cavities. Nests in holes in trees and in rock crevices surrounded by vines and shrub. Uses kiekie long-leaved vine leaves as nesting material. **Diet:** Insectivorous but partly frugivorous. Chisels and probes in rotting wood and bark, gleaning off leaves like mahoe., *Coprosma* spp, and pate *(Schefflera digitata)* fruits were eaten by birds Feed on fruit and nectar, they hunt weta and other insects on the forest floor. Reintroduced SIS spent most time on the ground and in five-finger *Pseudopanax arboreus* Saddleback happy in shrub/kanuka	Establish nest boxes.	Second year
Little spotted kiwi	Kapiti Island	**Habitat**: occupies all vegetation types on Kapiti Island, including flax, mixed scrub, seral and older forest and rough grassland. Lower population density in scrub and grassland. **Diet:** feeds mostly on small invertebrates such as earthworms, insect larvae, spiders and beetles, but also occasionally on fallen fruit.	Sufficient habitat and food present at Orokonui (may occupy pine forest areas due to depth of litter) .	Second year
Tuatara	Stephens Island, Captive stocks	Soil for burrowing. Dappled or open sunlight for basking. Tolerant of modified habitat: can survive in forest or open areas, but needs open, sunny areas	Establish that soil temperatures suitable and sufficient food sources present in the valley.	Second year

Sequencing of species translocation	Potential source populations	What is known about food and habitat requirements	Notes on introduction of this species to the sanctuary.	Time after valley confirmed as mammal-free
		for nesting. Will eat many species of invertebrates, also eggs and chicks of small seabirds and occasionally ground-dwelling lizards	Would probably do well on Trust land in shrubland/open grassland /forest mosaic.	
Green skink *Oligosoma chloronoton*	Catlins, Kakanui Mountains, Falls Dam (Central Otago)	This species inhabits a wide range of habitats which are generally well vegetated and open. They are known from pastureland, herb-fields rocky knobs and boulder banks	Would probably do well on Trust land in shrubland/open grassland/forest mosaic with rocky cover deep enough to protect them from extremes in temperature.	Second year
Jewelled gecko *Naultinus gemmeus*	Dunedin area	Inhabits forest and shrublands (including lowland broadleaved and montane beech). Also found in seral shrub land, subalpine shrub land and sub-shrub vegetation up to 1000m. Has been reported from exotic woody vegetation including gorse and pines.	Establish that it is not already present in the Valley If not, find a local population large enough to spare individuals. Likely to require soft release to ensure success. Would probably do well on Trust land in shrubland/open/forest mosaic.	Second year
Duvaucel's gecko	Brothers Island, Marlborough Sounds	Occupies a wide range of habitats including forest, scrub, coastal vegetation and cliffs, often close to the shoreline.	More information on success of other translocations and adequacy of food supplies at Orokonui. Would probably do well on Trust land in shrubland/open/forest mosaic.	Second year
Otago/ Southland large gecko	Otago Peninsula, Mt Cargill	Occupies a wide range of habitats throughout its range including beech forest. Commonly associated with rocky bluffs and tors in tussock grasslands.	Establish that it has not self-introduced	Second year
Yellow-crowned parakeet	Dunedin Botanic Garden	**Habitat:** Forest (canopy) bird, tree hole breeder. Commonly feeds on the ground in West Coast	Advice from Tony Pullar: "Establish breeding or at the very least release aviaries	Second/third year

Sequencing of species translocation	Potential source populations	What is known about food and habitat requirements	Notes on introduction of this species to the sanctuary.	Time after valley confirmed as mammal-free
Note: interbreeds readily with RC so advice from Tony Pullar is to introduce YCs only	South Island beech forests	beech forests in winter. Observed on rimu, silver beech, Hall's totara and southern rata They select very similar sites to sympatric OC YC are more arboreal than RC. Nests are 4.5-32m above ground, predominantly in large old trees. Do not nest in dead trees. **Diet:** invertebrate based diet, mainly feeding in the upper forest storeys ripping bark from branches and trunks exposing galleries of larval beetles. Invertebrates (homopterans, coleopterans and lepidopteran larvae) formed the basic diet. Feeds on 17 plant species: flowers were important; fruits, berries and seeds occasionally important Normally raise one brood but during a beech mast year up to 5 broods are possible Interbreed readily with RCs Males have large, not well-defined home ranges. Territory between 1–4 km	at the site, that way young birds can be released while the parents remain calling birds back to the release aviary for feeding. Once the release birds know to come back for their food you will retain what you release. Initially while setting up well-trained residents you will need an attractant, which is usually food and company of the same kind. Rosella will compete for food and nest sites with both kaka and kakariki but if we supply abundant artificial nesting sites and feeding opportunities this problem will be overcome. First generation release birds will be from a captive situation and should not be too wild at release time leading to easy training. The first generation release stock will then train their offspring to the feeders and breeding sites within the reserve at which point we should be away to a self sustaining population." Anecdotal evidence that rosella will evict parakeets from nesting boxes; can make holes smaller so that only parakeets can enter. Also parakeets found in narrower, deeper nesting holes – this may indicate different preferences from rosellas and could design nesting boxes appropriately if had the data. Another strategy is to out 2 nesting boxes at different heights on same tree. Rosellas may occupy the first and defend the second from other rosellas, thereby keeping it free for parakeets.	

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Sequencing of species translocation	Potential source populations	What is known about food and habitat requirements	Notes on introduction of this species to the sanctuary.	Time after valley confirmed as mammal-free
Some invertebrates?			Monitoring of changes once pests removed Identify species that are missing	Second/Third year?
Fairy prion	Otago Peninsula and islands	Soil for burrow-nesting. Can nest on flat ground or forested slopes. Good tree climbers – can climb out of taller vegetation. Eggs and chicks may be eaten by tuatara Dense seabird sites may limit forest seedlings	Establish suitable burrow sites away from the burrows of the mottled petrel Would probably do well on Trust land in shrubland/open grassland/forest mosaic.	Second/third year
Mohua	Eglinton Valley and Catlins	**Habitat:** forest passerine, hole-nester, feeds by gleaning. Historic data show that mohua were once abundant and conspicuous in most forest habitats of the South Island and Stewart Island (c. 6.5 million ha) Needs large, old trees for perching. Territory size held by groups of birds not clear but rather large. **Diet:** Insectivorous. Most feeding and nesting occurs on large, old beech trees.Not entirely insectivorous, also feeding on fruit of *Astelia fragrans*	Determine if Orokonui habitat suitable. Status of remaining populations improved, or alternatively if habitat is suitable, need to get mohua in asap before wild populations decline.	Third year?
Southern tokoeka	Stewart Island, Haast, Fiordland	**Habitat:** They occupy all vegetation types including flax, mixed scrub, seral and older forest and rough grassland. Lower population density in scrub and grassland. Birds have large home ranges. **Diet:** feeds mostly on small and large invertebrates such as earthworms, insect larvae, spiders and	Sufficient habitat and food present at Orokonui (may occupy pine forest areas due to depth of litter)	Second/third year as nursery species; full introduction later

Sequencing of species translocation	Potential source populations	What is known about food and habitat requirements	Notes on introduction of this species to the sanctuary.	Time after valley confirmed as mammal-free
		beetles, but also occasionally on fallen fruit Today, Kapiti Island is the only place left where little spotted kiwi and southern tokoeka live together. There is no obvious segregation between the two.		
Stage three				
Kaka	Dunedin Botanic Garden Stewart Island, Murchison Mountains, Codfish Island	**Habitat:** Native forest**;** 95% of birds were observed on rimu, southern rata, silver beech, Hall's totara, miro and kamahi also on parasitic mistletoes growing on silver beech and fuchsia (red and scarlet mistletoes provided up to 46% nectar) **Diet**: wood boring insects, seeds (esp. hinau, tawa, possibly pukatea and kiekie), nectar, fruit (esp. five finger for nestlings), sap (apparently confined to females), scale insects. Loranthaceae mistletoes and fuchsia also important. Move from one food source to another during their annual cycle. Sap is an important seasonal component. Needs trees capable of supporting sap feeding e.g. rimu, mountain totara Wood boring beetle larvae (e.g. kanuka longhorn beetles *Ochrocydus huttoni)* provide the majority of fat and protein	Will need to offer supplementary feeding and nest boxes. Kaka like to tear rotten wood to bits: ring-barking pines may offer this at Orokonui. The kanuka long-horned beetle is a good food source and likely to be in the valley. Decaying kanuka a good resource? Kaka more likely to stay in the valley if the birds come from the Botanic Gardens. There will be limits to how big the population will grow. They will be there primarily as a visitor attraction and to contribute to wild populations in the region rather than Orokonui supporting its own viable breeding population.	Third/fourth year

Sequencing of species translocation	Potential source populations	What is known about food and habitat requirements	Notes on introduction of this species to the sanctuary.	Time after valley confirmed as mammal-free
		Nectar most important in spring and summer – would feed on *Eucalyptus* spp. Kaka do very well in the absence of possums, which compete for food, and mustelids, which raid nests.		
Mottled petrel	Codfish Island, Big South Cape Is, Island in the middle of Lake ?	Do well in the kind of forest at Orokonui. Climb trees to take off. Do not need to be able to see the surf, do not need wind for take-off.	Establish artificial burrows. (Will be 4-5 years before they start returning) Would probably do well on Trust land in shrubland/open/forest mosaic.	Third year
Short-tailed bat	Fiordland or Codfish Island	Indigenous forest (e.g. kauri, *Nothofagus* beech, podocarp-hardwood). Roost sites in trees or caves. Revegetation could enhance habitat within reserve (for roosts, fruit, pollen and nectar).	Establish that it has not self-introduced Ensure adequate roosting sites and sources of fruit, pollen and nectar. Needs soft release	Fourth year?
Stage Four				
Buff weka	Chatham Islands, Banks Peninsula, Stevensons Island in Lake Wanaka	**Habitat:** wide range of habitats including forest, scrub and wetlands. Also use highly modified habitat, even semi-urban very adaptable to a wide range of conditions. Breeding is closely related to food supplies and can occur year-round in some situations of high food availability. Up to 14 young can be produced in a year (average 3.45 young/year). Birds can breed as young as 5 months of age under low population pressure.	Build an exclosure to limit weka predation on other birds and uprooting of restoration plantings	Later, or early on if kept separate

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Sequencing of species translocation	Potential source populations	What is known about food and habitat requirements	Notes on introduction of this species to the sanctuary.	Time after valley confirmed as mammal-free
		Density on islands can reach more than 1 bird per hectare. Adults maintain year-round territories while young birds are more mobile. **Diet**: feeds on soil and litter dwelling invertebrates (beetles and earthworms) and fruit, but also lizards, carrion and whatever else is available. Weka also take eggs and young of many ground-nesting birds; e.g. NZ Robins.		
Cook's petrel	Codfish Island	Soil for burrow-nesting. Can nest on flat ground or forested slopes. Good tree climbers – can climb out of taller vegetation. Eggs and chicks may be eaten by tuatara Dense seabird sites may limit forest seedlings	Successful establishment of less endangered seabirds at Orokonui needs to come first.	Later
Orange-fronted parakeet	Captive birds (e.g. Botanic Garden)	**Habitat:** Endemic, forest (canopy) bird, tree hole breeder. Uses similar nest sites to YC. Uses the lower levels of the forest strata more than YC. They select very similar sites to sympatric YC. Is most closely related to RC. **Diet:** Consume similar items and behave in similar manner, but they consume more invertebrates in spring and more flowers than YC. Not much is known about breeding biology.	Species needs to recover – currently too rare. As for RC and YC, predation while foraging outside of reserve is an issue. Hybridisation issues with YCs?	Later

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Sequencing of species translocation	Potential source populations	What is known about food and habitat requirements	Notes on introduction of this species to the sanctuary.	Time after valley confirmed as mammal-free
Native frogs	Maud Island, Marlborough Sounds for *Leiopelma pakeka/hamiltoni*	Suggestive evidence that they require mammalian predator-free habitat. They reside in rocks piles or under rocks on ground away from streams but often in the vicinity of terrestrial seepages, (which we have on the trust land) Occasionally found in tree-holes and under rotting logs. *L. hamiltoni* (Stephens Island) have survived when canopy cleared, but original habitat was forested. Therefore, canopy cover is preferable. Infrequent droughts tolerated. *Leiopelma hochstetteri* found in shaded creek edges in native forest, (which we have on the trust land) .	Changes in Recovery Plans needed Removal of Australian frogs. More knowledge of effect of predators such as morepork and kiwi.	Later
Kakapo	Codfish Island	**Habitat**: podocarp and beech (SI) forests. Nests mostly in thick vegetation, in short holes in banks or rotten trees at ground level. Individuals occupied home ranges of 15-50 ha on Stewart Island, 21-38 ha on Little Barrier Island **Diet:** Folivore and frugivore Feeds on berries pate (*Shefflera digitata*), five-finger, tutu (*Coriaria aborea*), mapou (*Myrsine australis*) and kotukutuku (*Fuschia excorticata*). Feeds on leaves of various shrubs, fern roots, some fungi, reeds, toetoe, flax and honey and also on bark of rata.	Population needs to grow to point where individuals can be spared for translocation. Could do well at Orokonui	Later

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Appendix 1: Options for mammal pest control

Species	*Distribution*	*Eradication method*	*Advantages*	*Disadvantages*	*Effectiveness*
Goat	Occasionally throughout	a. Muster with sheep dogs, ground shoot escapees	a. Reasonably straightforward; no toxins	a. Remote possibility of persistent escapees	a. 100% eradication
		b. Use radio-tracked Judas goat, ground shoot	b. Reasonably straightforward; no toxins	b. Remote possibility of persistent escapees	b. 100% eradication
Possum	Abundant throughout	a. Aerial application of 1080	a. Very quick and efficient; by-kill of carrion-eating mustelids, cats, hedgehogs and rodents	a. Bad PR; concern about water supplies from Orokonui Stream. Not permitted on conservation land.	a. 95%
		b. 1080 baits in bags on 50 m grid	b. Efficient; by-kill	b. Labour intensive and bad PR	b. 95%
		c. Feratox bait stations/bags	c. Good PR; very target specific	c. Labour intensive; bait unattractive when moist	c. 80%
		d. Kiwicare 1080 long-life blocks in bait stations on 1 ha grid	d. Efficient; low-maintenance; by-kill.	d. Labour intensive to set out; may be bad PR	d. 95%
		e. Aerial application of Talon baits	e. Very quick and efficient; by-kill	e. Bad PR, toxin persistent.	e. 95%
		f. Leg-hold/kill trapping on 50 m grid to remove most possums, followed by poisoning to kill remainder and achieve carrion by-kill	f. By-kill	f. Labour intensive; humaneness issues with traps	f. 95%

Species	*Distribution*	*Eradication method*	*Advantages*	*Disadvantages*	*Effectiveness*
Ship rat	Probably present throughout	a. Aerial application of Talon cereal baits	a. Very quick and efficient; by-kill of carrion-eating mustelids, cats, hedgehogs	a. Bad PR; toxin persistent	a. 99-100%
		b. Talon cereal baits in appropriate bait stations on 50 m grid	b. Efficient; by-kill	b. Labour intensive; toxin persistent	b. 100%
Norway rat	Probably present throughout	a. Aerial application of Talon cereal baits	a. Very quick and efficient; by-kill of carrion eating mustelids, cats, hedgehogs	a. Bad PR; toxin persistent	
		b. Talon cereal baits in appropriate bait stations on 50 m grid	b. Efficient; by-kill	b. Labour intensive; toxin persistent	
Mice	Probably present throughout	a. Aerial application of Talon cereal baits	a. Very quick and efficient; by-kill	a. Bad PR; toxin persistent	a. 99-100%
		b. Talon cereal baits in appropriate bait stations on 50 m grid	b. Efficient; by-kill	b. Labour intensive; toxin persistent	b. 100%
Cat	Probably present at low densities throughout	a. Live trap and return domestic cats to owners/SPCA	a. Good PR	a. Labour intensive; slow and inefficient	
		b. Trap feral cats – bait Timms traps with meat. (Note: most will be by-kill of poisoning operations for possums and rodents)	b. Not efficient	b. Bad PR; labour intensive	
Stoat	Probably present at low densities throughout	a. Fenn traps on 250 m grid (Note: most will be by-kill of poisoning operations for possums and rodents)	a. Efficient	a. Labour intensive	

Species	*Distribution*	*Eradication method*	*Advantages*	*Disadvantages*	*Effectiveness*
Ferret	Probably present at low densities throughout	a. Fenn traps on 250 m grid (Note: most will be by-kill of poisoning operations for possums and rodents)	a. Efficient	a. Labour intensive	
		b. Hunt with trained dogs	b. Has been used effectively elsewhere	b. Labour intensive	
Hedgehog	Probably present at low densities throughout	a. By-kill from poisoning for possums and rodents	a. Efficient	a. Bad PR from poisoning operations, especially aerial application	
		b. Bait stations with Talon	b. Efficient	b. Toxin persistent	
Cattle	Occasional strays	Muster with dogs	Efficient	none	100%
Sheep	Occasional strays	Muster with dogs	Efficient	none	100%
Dog	Occasional strays	Search with dogs	Efficient	none	100%
Weasel	unknown	As for stoat			

Appendix 2 Table 1: Vascular plants of the Orokonui Reserve

(* denotes exotic species)

Trees and shrubs	***Climbers***	***Dicot herbs***	***Grasses***	***Other monocots***	***Ferns and fern allies***
*Acer pseudoplatanus** sycamore	*Clematis paniculata*	*Acaena anserinifolia* bidibidi	*Agrostis capillaris** browntop	*Arthropodium candidum*	*Asplenium bulbiferum* hen and chicken fern
Aristotelia serrata wineberry	*Metrosideros diffusa* climbing rata	*Acaena novae-zelandiae* bidibidi	*Anthoxanthum odoratum** sweet vernal	*Astelia fragrans* bush flax	*Asplenium flabellifolium*
*Brachyglottis repanda** rangiora					*Asplenium placcidum*
*Berberis darwinii** Darwin's barberry	*Muehlenbeckia australis*	*Callitriche stagnalis*	*Dactylis glomerata** cocksfoot	*Carex forsteri*	*Asplenium hookerianum*
Carpodetus serrata putaputaweta	*Parsonsia heterophylla*	*Cardamine corymbosa*	*Microlaena avenacea* bush rice grass	*Luzula sp*	*Asplenium lyallii*
Coprosma areolata	*Ripogonum scandens* supplejack	*Cardamine sp*	*Rytidosperma unarede*	*Uncinia banksii*	*Asplenium richardii*
Coprosma ciliata	*Rubus cissoides* lawyer	*Cerastium fontanum** mouse-ear chickweed	*Vulpia megalura**	*Uncinia divaricata*	*Asplenium appendiculatum*
Coprosma foetidissima stinkwood		*Cirsium vulgare** Scotch thistle		*Uncinia scabra*	*Blechnum colensoi*
Coprosma linariifolia		*Galium aparine** cleavers		*Uncinia uncinata*	*Blechnum discolor* crown fern
Coprosma propinqua mikimiki		*Gonocarpus aggregatus*			*Blechnum novae-zelandiae*
Coprosma rhamnoides		*Hydrocotyle moschata*			*Blechnum penna-marina*
Coprosma rotundifolia		*Hydrocotyle sp*			*Blechnum procerum*
*Crataegus monogyna** hawthorn		*Hypochaeris radicata** catsear			*Ctenopteris heterophylla*
*Cytisus scoparium** scotch broom		*Lagenifera strangulata*			*Cyathea smithii*

Trees and shrubs	***Climbers***	***Dicot herbs***	***Grasses***	***Other monocots***	***Ferns and fern allies***
Eleocarpus hookerianus pokaka					*Cyathea dealbata* Soft tree fern
*Eucalyptus regnans** mountain ash		*Mycelis muralis** wall lettuce			*Dicksonia fibrosa* wheki ponga
Fuchsia excorticata tree fuchsia		*Nertera depressa*			*Dicksonia squarrosa* ponga
Griselinia littoralis broadleaf		*Nertera villosa*			*Dyropteris filix-mas** male fern
Hebe salicifolia koromiko		*Plantago lanceolatum** narrow-leaved plantain			*Grammitis billardieri*
Kunzea ericoides kanuka		*Prunella vulgaris** self heal			*Histiopteris incisa* water fern
*Leycesteria formosa** Himalayan honeysuckle		*Ranunculus acris**			*Hymenophyllum demissum*
Melicytis ramiflorus mahoe		*Senecio jacobaea** ragwort			*Hypolepis ambigua*
Myrsine australis mapou		*Senecio minimus* fireweed			*Hypolepis millefolium* thousand leaved fern
Neomyrtus pedunculata rohutu		*Stellaria parviflora*			*Leptopteris hymenophylloides*
Olearia arborescens		*Trifolium repens** white clover			*Lycopodium scariosum*
Pennantia corymbosa		*Verbascum virgatum** moth mullein			*Microsorum pustulatum* hound's tongue fern
*Pinus radiata** radiata pine					*Paesia scaberula* hard fern
Pittosporum eugenioides tarata					*Pellaea rotundifolia*
Pittosporum tenuifolium kohuhu					*Polystichum neozelandicum* shield fern
Dacrydium cupressinum rimu					*Polystichum vestitum* prickly shield fern

Trees and shrubs	***Climbers***	***Dicot herbs***	***Grasses***	***Other monocots***	***Ferns and fern allies***
Podocarpus hallii Hall's totara					*Pteridium esculentum* bracken
Prumnopitys ferruginea miro					*Rumohra adiantiformis*
Prumnopitys taxifolia matai					*Tmesipteris tannensis*
Pseudopanax colensoi three finger					*Trichomanes venosum*
Pseudopanax crassifolius lancewood					
Pseudowintera colorata pepper tree					
Pseudopanax simplex					
*Rubus fruticosus** blackberry					
*Sambucus nigra** elder					
Schefflera digitata pate					
Solanum laciniatum poroporo					
*Ulex europaeus** gorse					

Appendix 2 Table 2: Some of the many plant species that could be considered for reintroduction (Ralph Allen and Kelvin Lloyd)

Species	***Known habitat requirements***	***Certainty of information***	***Ecological appropriateness for OES***	***Biological feasibility***	***Other constraints***	***Additional benefits***	***Risks***
TREES							
Dacrycarpus dacrydioides	Relatively warm, fertile sites; swamp/riparian margins	high	High on valley floor and low elevation sunny aspects	high	Competition from established vegetation	Very high fruit production as bird food	None
Hoheria angustifolia	Relatively warm, fertile sites	High low?	High on valley floor and low elevation sunny, dry aspects	high	Competition from established vegetation		None
Plagianthus regius	Relatively warm, fertile sites	High low?	High on valley floor and low elevation sunny, dry aspects	high	Competition from established vegetation		None
Podocarpus totara	Relatively warm, fertile sites	High low?	High on valley floor and low elevation sunny aspects	high	Competition from established vegetation	Fruit source for NZ pigeon and other bird species	None
Prumnopitys taxifolia	All but least hospitable sites	high	High throughout	high	Competition from established vegetation	Fruit source for NZ pigeon	none
Prumnopitys ferruginea	All but least hospitable sites	high	High throughout	high	Competition from established vegetation	Fruit source for NZ pigeon	none
Dacrydium cupressinum	All but least hospitable sites	high	High throughout	high	Competition from established vegetation	Fruit source for NZ pigeon and other bird species; thought to be important for kakapo breeding	none
Sophora microphylla	Relatively warm, fertile, + droughty sites	High low?	High at valley floor streamsides and low-mid elevation sunny aspects	high	Competition from established vegetation		None
Podocarpus hallii	All mid to high elevation sites	high	High on mid-upper slopes	high	Competition from established vegetation	Fruit source for NZ pigeon and other bird species	none

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Species	*Known habitat requirements*	*Certainty of information*	*Ecological appropriateness for OES*	*Biological feasibility*	*Other constraints*	*Additional benefits*	*Risks*
Elaeocarpus hookerianus	Throughout	high	High throughout	high	Competition from established vegetation		none
Pseudopanax ferox	Open forest	medium	High in preferred habitat	med	Competition from established vegetation	Fruit source	none
Lophomyrtus obcordata	Open forest	High	High in preferred habitat	High	Competition from established vegetation		none
Melicope simplex	Open forest	High	High in preferred habitat	High	Competition from established vegetation	Host for *Korthalsella*	none
Olearia fragrantissima	Open forest	medium	High in preferred habitat	med	Competition from established vegetation		none
SHRUBS							
Coprosma virescens	Shrubland and light forest	High	High in preferred habitat	high	Competition from established vegetation	Fruit source	none
Streblus heterophyllus	Open forest	High	High in preferred habitat	High	Competition from established vegetation		none
Teucridium parvfolium	Streamsides in open forest	medium	High in preferred habitat	med	Competition from established vegetation		none
Urtica ferox	Moist, fertile sites with sufficient light	High	High in preferred habitat	High	Competition from established vegetation	Invertebrate friendly. Deter poachers.	Being stung!
HERBS							
Uncinia strictissima	Lowland pasture, scrub and forest margin/ fertile soils	Med	High in preferred habitat	High	Competition from established vegetation	Rare hookgrass	
Urtica incisa	Moist, fertile sites with sufficient light	high	High in preferred habitat	high	Competition from established vegetation	Invertebrate friendly	Being stung!
CLIMBERS							
Scandia geniculata	Open forest	medium	High in preferred habitat	med	Competition from established vegetation		
Brachyglottis sciadophila	Open forest	medium	High in preferred habitat	med	Competition from established vegetation		

Species	*Known habitat requirements*	*Certainty of information*	*Ecological appropriateness for OES*	*Biological feasibility*	*Other constraints*	*Additional benefits*	*Risks*
MISTLETOES							
Ileostylis micranthus	Shrubs and small trees, wide host range	High	High in preferred habitat Present on Trust land	med	How to establish	Declining mistletoe, fruit source	none
Korthalsella lindsayi	Shrubs and trees, esp. *Melicope*	High	High	med	How to establish	Interesting dwarf mistletoe	none
Tupeia Antarctica	Successional forest	High	High in preferred habitat	med	Difficult to cultivate	Rare mistletoe, fruit source	none
Drymenathus	Broadleaved forest						
FERNS							
Botrychium biforme	Damp, shady forest	Medium	High in preferred habitat	med	How to establish	Primitive fern	none

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Appendix 4 Freshwater invertebrate survey results (Ruth Goldsmith)

Site number		1		2		3		4		5		6	
Site location		Outside reserve		Outside reserve		Inside reserve		Inside reserve		Inside reserve		Inside reserve	
Sample number		a	b	a	b	a	b	a	b	a	b	a	b
TAXON	**MCI score**												
COLEOPTERA													
Elmidae	6			1	2	34	3	1	6	4	2	5	13
CRUSTACEA													
Paracalliope fluviatilis	5		6									2	
Paranephrops zealandicus	5									1			
DIPTERA													
Austrosimulium species	3			1		2		3	4	1	1	17	1
Chironomidae	2	1	4	100	51	9	17	2	5	7	5	7	
EPHEMEROPTERA													
Deleatidium species	8	7	5	39	13	43	20	41	33	21	11	14	26
MOLLUSCA													
Potamopyrgus antipodarum	4	33	22	3	1	3	2	2			1	2	
OLIGOCHAETA	1	43	38	29	12		4		8	10	19	8	
PLECOPTERA													
Austroperla cyrene	9					1		3	1	6		2	1
Megaleptoperla grandis	9				1					1			
Stenoperla prasina	10						1		1	2		1	
Zelandobius species	5	1	2	3	5	1	3	1	1				1
TRICHOPTERA													
Aoteapsyche species	4			1									
Helicopsyche species	10		1	12	2	6							
Hudsonema amabile	6		1	2	1	1	1						
Hydrobiosidae early instar	5			3		2	1					2	
Olinga species	9	1	1	1									
Pollicheremia species	8	1	1		1	2	1		2				1
Pycnocentrodes species	5	22	17		1								
Number of taxa		8	11	12	11	11	10	7	9	9	6	10	6
Number of EPT taxa		5	7	7	7	7	6	3	5	4	1	4	4
Number of invertebrates		109	98	195	90	104	53	53	61	53	39	60	43
MCI score		105	115	105	116	120	110	106	116	118	80	106	130
QMCI score		3.3	3.4	3.8	3.4	6.6	5.1	7.3	6.1	5.8	3.5	4.5	7.2