Grand and Otago Skink Recovery Plan

2006-2016

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The draft Grand and Otago Skink Recovery plan was circulated for formal consultation in September 2006. Received Submission were analysed and reviewed by the Recovery Group in 2007. The agreed changes were included in this version of the plan.

Final approval of the Recovery pan was deferred pending a peer review of the programme in June-Aug 2008.

Grand and Otago Skink Recovery Plan

Recovery Plans

This is one of a series of recovery plans produced by the Department of Conservation. Recovery plans are statements of the department's intentions for the conservation of a particular species of plant or animal, or group of species, plant or animal community for a defined period. They focus on the goals and objectives of recovery management, guide the department in its allocation of resources and are used to raise public awareness of the recovery process.

Each plan has a term of 5- or 10-years.

The purpose of recovery plans is to achieve recovery of that species or group of species by empowering people to understand issues, make sound decisions and minimise uncertainties in the future.

Recovery of a species can be defined as 'establishing/enhancing multiple populations within the historic range, or at suitable sites, which may or may not require ongoing management' (Jansen 2001).

Recovery plans:

- Are proactive and operational in nature, focusing on specific key issues, providing direction and identifying roles to managers and technical workers.
- Set objectives for the recovery of species and outline measurable actions needed to achieve those objectives.
- Are primarily used by department staff to guide their annual work programmes. However, they also provide a forum for planned initiatives with tangata whenua, community interest groups, landowners, researchers and members of the public.
- Stimulate the development of best practise techniques and create documents which can be transferable across similar species recovery programmes.

The recovery group for grand and Otago skinks consists of people with knowledge of the ecology and management needs of the species. The recovery group's role is to achieve recovery of the species they represent through the generation and provision of high quality technical advice. The recovery group prepared this plan in conjunction with people interested in or affected by this plan or with an expert knowledge of the species. Drafts have been sent to relevant conservation boards for comment and to people or organisations with an interest in conservation management of grand and Otago skinks. Changes to the plan were made as a result of that consultation.

The recovery group will review progress in implementation of this plan and will recommend to department managers any changes that may be required in management. Comments and suggestions regarding conservation of grand and Otago skinks are welcome and should be directed to the Grand and Otago Skink Recovery Group via any office of the department or to The Manager, Biodiversity Recovery Unit, PO Box 10-420, Wellington.

The recovery planning process provides opportunities for further consultation between the department, tangata whenua and others regarding management of these species. Those

interested in being more involved in management of grand and Otago skinks or in receiving information, should also contact the recovery group.

The Otago Conservator of the Department of Conservation formally approved this plan on … (date). A review of the plan is due after (5 or 10 years) in (date) or sooner if new information or technology leads to a significant change in management direction. This plan will remain operative until a new plan has been prepared and approved. It will become redundant if recovery is achieved and management effort enters a maintenance phase.

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ABSTRACT

The grand skink (*Oligosoma grande*) and the Otago skink (*O. otagense*) are two of New Zealand's largest and rarest lizards, and are classified as nationally critical. They occur only in Otago where they inhabit schist rock outcrops in montane tussock grassland in two separate populations; east and west of their former range. Population modelling suggests a high probability of functional extinction for both species by 2010. Mammalian predation and habitat loss are considered to be the main causes, though the relative influences of the specific mammals involved have not been clearly identified. Eastern populations failed to recover from 1997 to 2002, following control of cats. Unreplicated experimental management has again been imposed on these skink populations in 2005 to determine if populations will recover if *all* mammalian pests are eradicated within a mammal-proof fence or whether controlling *all* mammalian pests (except rodents) with conventional trap technology without a fence will enable recovery. It is anticipated that no treatment effects will be detected until the 2009 season due to population sizes and the life-history traits of grand and Otago skinks. Depending on the trial's outcomes, the next phase of recovery will either involve securing viable populations of both species in captivity, if neither treatment succeeds: building more mammal-proof fences, if only the fence treatment succeeds, or controlling all pest species more widely, if pest control is as successful, or more successful than the fence. The latter options will require improved understanding of meta-population dynamics to take account of movements between subpopulations. Once these outcomes are known Grand and Otago skink conservation will then move into recovery.

Actions that can be implemented now are:

Secure the species: Secure representative populations in captivity. The protection of the eastern and western genome of grand and Otago skinks will require research and management in captivity.

Monitoring: Ensure high-quality monitoring of experimental populations at least until 2009, and implement a regular monitoring programme for the western populations.

Community Awareness: Build better relationships with landholders, especially in the western range; provide support for community-led skink conservation initiatives; increase awareness by the general public about the conservation problem; explore sponsorship options to raise the profile of skink conservation.

Research: Undertake research on other potential agents of decline besides pests – avian predation, food quality, habitat quality, and mice. Develop understanding of meta-population dynamics of skinks, determine the minimum number required to secure the genotype in captivity, and develop techniques that improve the efficacy of pest control.

INTRODUCTION

The grand skink (*Oligosoma grande*) and the Otago skink (*O. otagense*) are two of New Zealand's largest and rarest lizards. They occur only in Otago where they inhabit schist rock outcrops in montane tussock grassland. Both species now occupy a greatly reduced range in two separate population groups in the east and west of their former range. Their populations are in decline and at risk of extinction by 2010 (Tocher & Norbury 2006). Total population estimates range from <5,000 to as few as 1,400–1,800 (Patterson 1992, Whitaker & Loh 1995, Whitaker 1996, Coddington & Cree 1997).

The first recovery plan for grand and Otago skinks was published 11 years ago (Whitaker & Loh 1995). A draft second plan was put on hold in 2002 while the recovery programme was reviewed and restructured (Hitchmough et al. 2003) and a new management team and recovery group put in place. The current plan combines parts of the draft plan with the new information, management methods and strategic thinking that has arisen since then.

The survival of both species in the wild is more perilous than ever, and a sense of urgency must prevail.

Plan Term and Review Date

Term of the plan: 10 years from September 2006 – August 2016

Review date: 31 August 2009.

1. Context

Overview of Species

1.1. Species ecology and biology

Grand and Otago skinks are diurnal; active in sunshine and strongly associated with rocks. They inhabit deeply-creviced schist outcrops in montane tussock grassland. Although the species occur together at some sites, Otago skinks occur most frequently on extensive rock bluffs along steep-sided valleys and grand skinks are more commonly on ridge-top tors (Towns 1985, Whitaker 1996). Their usual activities are confined to rock surfaces, however, both species make occasional long movements between habitat patches—up to 400m for grand skinks and 2km for Otago skinks. These appear to be an integral part of metapopulation[1] dynamics (Whitaker 1996, Coddington & Cree 1997, Houghton 2000, Germano 2005, DOC, Otago Conservancy, unpublished data).

Both species are omnivorous, consuming a wide variety of invertebrates, soft fruit and vegetation. They occasionally eat small skinks, and flower petals. Seasonally, fruit is an important component of the diet (Tocher 2003). The optimum habitat quality for skinks is unknown. The seral nature of current vegetation in Central Otago provides challenges in understanding the direction vegetation recovery is taking. For grand and Otago skinks we presume the natural state to be some form of native woody-dominated climax vegetation.. However, we have limited data on the impact of such habitats on these skinks.

Otago skinks live up to 16 years in the wild and to their late 30s in captivity. They produce their first offspring at 4.8 years, have generally female-biased sex ratios and low annual survival (c. 54%) (Tocher 2006). In any given year an estimated 64% of females of reproductive size bear embryos, and on average each reproductive female has a clutch size of between 1.59-2.6 embryos (estimate by palpation during early pregnancy) (Cree 1994, Tocher unpublished data). Similarly, grand skinks live up to 17 years in the wild, produce their first clutch at 4.0 years of age, have a variable sex ratio, and up to 71% of reproductive females bear young every year. Each reproductive grand skink female produces an estimated average clutch size of 1.56-2.4 per year, and again only 59% survive from one year to the next.

[1] A metapopulation consists of a group of spatially separated populations that interact at some level. The development of metapopulation theory, in conjunction with the development of source-sink dynamics, emphasises the importance of connectivity between seemingly isolated populations. The theory assumes that although no single population may be able to guarantee the long-term survival of a species, the combined effect of *many* populations will increase the probability of persistence of a species.

1.2. Species status and recovery principles

In 2003, the threat classification of both species was elevated to 'Nationally Critical' (Molloy *et al.* 2002). Population modelling, based on demographic data collected from 1996-2002, suggests that for skink populations with initial numbers of 60 individuals the extinction probabilities by 2010 are 59% for grand skinks and 88% for Otago skinks (Tocher & Norbury 2006). The evidence we have is the more disjunct western populations have a greater urgency.

Comment [b1]: Suggested change in response to tech peer review

Projecting population recovery is most sensitive to changes in survival, especially sub-adult survival. Annual survival rates of sub-adults and adults are currently about 0.54 for both species (Tocher 2006). These would need to be increased to 0.8 to achieve greater than 90% probability that a given population of 60 will exceed 100 individuals in 20 years.

As all remaining known populations of grand and Otago skinks are small (<60 adults), small changes in survival rates (<0.1) may be undetectable. It will be necessary for survival to rates to climb to 0.75 for both species to be considered as a recovering population. Survival rates of below 0.6 will be considered as 'no alleviation of agents of decline'. Results falling between these two rates will be considered as neither success nor failure but justification to continue maintaining the experimental management and monitoring for definitive results.

The Recovery programme as a whole is in a phase of determining the agents of decline and securing the taxa in captivity. Significant progress on these issues must be made before substantive progress can be made on recovering grand and Otago skinks in the wild.

Most grand and Otago skink populations are widely scattered and isolated and, apart from those on land recently acquired by the department, are on freehold or leasehold land. These habitats can often be surrounded by pasture at a number of scales from individual rock tors to paddocks or runs

The Recovery Programme's emphasis on understanding the agents of decline means that some of the smaller skink populations will become extinct. The areas already acquired by the department, and those currently under consideration for purchase, are likely to be sufficiently large for successful management methods to lead to an increase in the total population size of both species. However, we do not know whether such an area is sufficient to maintain a viable metapopulation of either species in the longer term without ongoing management.

1.3. Past and present distribution

Sub-fossil remains, historical records, data with museum specimens, extrapolation from present habitat use, and the location of extant populations, show that grand and Otago skinks were widespread in Central Otago. This was over approximately 1.75 million hectares and extended from Lake Wakatipu to Lake Hawea and the Lindis Pass in the west to Macraes Flat and Sutton in the east. This distribution correlates closely with the broad band of metamorphic (quartzo-feldspathic schist) rock that crosses Otago. At the surface this schist weathers to form the deeply-creviced tors, outcrops and bluffs that are the habitat of these species. Another suitable correlate for the range of both species is climate – a rain shadow region with high sunshine hours and cold winters.

Grand and Otago skinks are now known from only two areas that in total cover just 8% of their estimated former range (Figure 1).

Figure 1. Estimated former range of grand and Otago skinks and their current range.

In eastern Otago, populations occur throughout the Macraes Flat/Middlemarch district, east of the Rock and Pillar Range. In the west, there are a few scattered populations between Lake Hawea and Lindis Pass. Within the latter areas the populations of both species appear to be small and isolated. The stronghold for both species is in the upper catchments of the Nenthorn Stream and the North Branch of the Waikouaiti River between Macraes Flat and Nenthorn.

In both regions, Otago skinks are widely distributed but are thought to be less numerous than grand skinks (Roughton 2005). In the Macraes Flat/Middlemarch district, the two species co-exist at some sites but in the Lindis district they have only been recorded sympatrically at sites on Morven Hills Station and at Breast Creek on Lake Hawea Station.

A disturbing trend is the localised extinction of several populations of both species in the last 30–35 years indicating that range reduction is an ongoing process. For example, Otago skinks were found in Alexandra as recently as the 1970s (Whitaker 1986). Less than half of the small populations of both species inspected in the late 1980s and early 1990s remained during revisits in the late 1990s to 2002 (Graeme Loh, unpublished data).

1.4. Agents of decline and threats

The agents of decline have not been clearly identified for either species.

Mammalian predators are considered a key threat based on their sheer numbers, the presence of grand and Otago skinks in cat diet (Baker 1989, Daugherty & Towns 1991, Middlemiss 1995), the numbers of common and McCann's skink remains found in ferret, stoat and hedgehog guts (van der Sluijs & Spitzen, 2000), and the fact that lizard populations respond dramatically to the removal of mice or rats on offshore islands (Lettink & Cree, 2006, Newman 1994, Towns *et al.* 2006). Identifying which of the predators are the *key* predator, and the positive and negative feedback loops that may exist between different species. For example, the impact of reduced predator impact on rats, because of the removal of cats by management, is work yet to be completed.

Habitat modification by conversion of shrub and tussock lands to pasture, and by grazing and burning, are also considered threats. They diminish native fruit and invertebrate resources for skinks, and expose them to predators as they disperse between tors (Whitaker 1996). Mining, quarrying, forestry and invasion by woody weeds also cause localised habitat depletion. Currently these threats are mostly in the eastern part of the species' range. Habitat restoration through removal of domestic stock is currently under way in that area at the Redbank Ridge/Emerald Stream Area at Macraes,.

Predation and habitat destruction are likely to interact. Satellite imagery of the Redbank Ridge/Emerald Stream Area in 1990 and 2003 shows how pastoral development is encroaching. This has coincided with an increase in rabbit numbers and possibly increasing predator trap rates (DOC unpublished data). Pastoral development generally leads to more rabbits in the system, which leads to more rabbit-specialist predators (Norbury 2001). Therefore, pastoral development may be exacerbating the predator problem. Other potential

agents of decline have been considered. Parasite infection, food resource limitation and structural degradation of habitat have also been identified. Increasing isolation of sub-populations or groups of skinks as a result of pasture development can lead to lower genetic diversity. This could be a major threat. (Berry & Gleeson, 2005; Berry *et al.* 2005).

Whilst parasite infection is clearly significant in the biology of both species and has been implicated in the cessation of breeding in captive Otago skinks, we do not have any data to suggest that high parasite loads in wild, grand or Otago skinks affect their fitness (Dennis Keall pers comm., Reardon & Norbury 2005). Conversely ectoparasite mites were implicated in the widespread failure of pregnancies in McCanns skinks when brought into captivity. Removal of mites lead to a markedly improved pregnancy success rate (Cree *pers. comm.*).

Under some circumstances, food quality may also influence growth rates, offspring quality and survival, yet wild grand and Otago skinks appear healthy and robust with no evidence of malnutrition or starvation. Mortality in Otago skinks is greater in winter than in summer Tocher (2003). If not due to predation, it may, as she suggests, indicate that animals are going into the winter with inadequate energy reserves. The condition of animals may affect their susceptibility to parasites and diseases.

1.5. Past and current management

Land reservation

Most of the skink populations in the eastern part of their range are legally protected in approximately 2400 ha of land managed by the Department of Conservation near the Macraes Flat Township. The design of the reserve is not optimal, the result of accumulation through a number of land deals. Fewer skink populations are legally protected in the west, where a tenure review outcome has resulted in 448 ha of habitat being reserved on Glenfoyle Station. A minimum of 34 Otago skinks are present in that reserve. A number of other pastoral leases are currently undergoing tenure review and there is a likelihood of protected areas for skinks being created from these.

Surveys and monitoring

Distribution surveys were undertaken throughout the presumed former range of both skinks in the 1980s and 1990s (e.g. Whitaker 1986). A database of grand and Otago skinks' records exists for Macraes Flat populations, with individual records dating from the late 1980s. This monitoring programme was reviewed in 2004, and now occurs once a year to minimise disturbance. Skinks are now identified remotely by digital photography and skin pattern recognition.

In the mid 1990s rock-count surveys focussed on the occurrence of grand skinks over approximately 300 rocks on Redbank Ridge (Whitaker 1996). Rock count surveys were also reviewed in 2004 and integrated with more accurate methods for assessing 'rock occupancy',

based on standardised methodologies and analytical procedures. These account for relative detectability of skinks (MacKenzie & Bailey 2004, Roughton 2005). Rock patch occupancy is also recorded at all experimental populations (see later) and with the Otago skink population on Glenfoyle. When necessary, this approach can be integrated with population viability analyses.

While base line data has now been generated for the Otago skink population at Glenfoyle in 2005/6, and repeat surveys have been completed at Morven Hills (McFarlane 1999), there is little meaningful data on the size, range or status of other populations of both species in the west of their range.

Small mammal exclosures

Three mammal-proof exclosures (approx. 20×20 m) were constructed in 1999 to measure the effect of complete cat and ferret removal on grand skinks. The fences were designed to test the effect of removing only cats and ferrets. Therefore, they allowed entry to stoats, weasels, rats and mice. In 2002 one of the exclosures was modified to exclude all mammals. The same modification was applied to the other two exclosures in 2003. The exclosures are monitored once or twice a year shows that they are neither mouse- nor stoat-proof. The grand skink populations contained within have continued to decline. There is an ongoing effort to rid the exclosures of mammals.

Research

The life history of grand and Otago skinks is well documented. With research on capture, handling, marking and monitoring protocols, there is a good understanding of the species' ecology and biology. This includes aspects of reproductive biology, genetics, social behaviour, population dynamics, habitat use, movements and comparative morphology and behaviour between captive and wild. (Patterson 1992, Cree 1994, Elliott 1994, Murphy 1994, Middlemiss 1995, Freeman *et al* 1996, Whitaker 1996, Coddington & Cree 1997, Stanley 1998, Eifler & Eifler 1999a & b, Houghton 2000, Marshall 2000, Germano 2005, Berry & Gleeson 2005, Berry et al. 2005).

A mark-recapture study was initiated at Macraes Flat from 1996-2002 to determine population trends and collect demographic data from multiple populations. A predator control operation that targeted cats, and also caught ferrets, was undertaken over five study populations within the reserve from May 1999 to May 2002, testing whether predator control could recover populations. Four of the five grand skink populations, and both Otago skink populations, declined during this period. With the possible exception of a single population of each species, the predator control did not avert downward trends (Tocher 2006).

Parasitism was investigated in grand skinks, Otago skinks and other lizard species in the Macraes Flat area. This revealed that both grand and Otago skinks carry significantly greater ectoparasite loads of the mites *Odontacarus lygosomae* and *Ophionyssus scincorum* than other species in the community. It also showed that both species carry infections of the hemogregarine protozoa, *Hepatozoon lygosomarum* (Reardon & Norbury 2004).

Eastern and western populations

In the medium and long term, decisions will need to be made about which of the eastern and western populations provide the best opportunities for securing the species in the wild. Some eastern populations are protected from further land development by land reservation and management, and knowledge of the skink populations there is very good. But because the reserve is surrounded by highly modified freehold agricultural land there is relatively little scope for expansion. The habitat in the west is more extensive and less modified and may provide better opportunities for future in situ management. There is real potential through the land tenure review process, currently underway in the west, to ensure large, intact areas are set aside for skink conservation

Captive management programme

The captive management programme was reviewed in March 2006 and it was agreed to secure the genetic diversity of both the eastern and western populations, and provide captive animals for reintroductions and future research. The existing captive management plan will be updated as part of the recovery plan, and include recent research results, into the differences between captive and wild Otago skinks (Connolly 2005). At June 2006 there were 95 Otago skinks, and at February 2007, 7 grand skinks in captivity. Otago skinks have been bred in captivity successfully for more than one generation. Currently, no grand skinks have bred successfully in captivity.

1.6. Preferred option for recovery

The vital experiments have not been undertaken to identify the agent(s) of decline. Therefore, the recovery programme is not at the recovery stage but still identifying threats and securing the taxa by captive management.

Strategic directives

This Recovery Plan supports the outcomes and outputs for the following three strategic documents:

New Zealand Biodiversity Strategy

The mandate for the conservation of these species is given in Goal 3 of the New Zealand Biodiversity Strategy, 'maintain and restore viable populations of all indigenous species and sub-species across their natural range, and maintain their genetic diversity'.

Department of Conservation strategic direction

The department's overall strategic direction was announced by the Director General in March 2006: the department's overarching purpose is to increase the value of conservation to New Zealanders.

To do this:

- The department will seek to entrench conservation as an essential part of the sustainable social and economic future of New Zealand.
- The department will be recognised as an effective manager of the lands, waters, species, historic places and roles entrusted to it.

- The department will lead, guide and facilitate conservation gains throughout New Zealand where ever conservation is most needed.
- The department will weigh society's values, nature's inherent qualities, and scientific criteria in its decision-making

Statement of intent

An intermediate outcome of the department's Statement of Intent (2005-2008) is that managed threatened species have a lower risk of extinction.

Cultural Importance

Grand and Otago skinks are not included in the Ngai Tahu Deed of Settlement as a Taonga species. However, in terms of Section 4 of the Conservation Act, to give effect to the principles of the Treaty of Waitangi, the Department of Conservation will recognise the manawhenua of Otakou, Makawhio, and Murihiku Runanga, when dealing with western skink populations, and the manawhenua of Puketeraki Runanga when dealing with eastern skink populations.

Public Awareness

Advocacy

Advocacy in the past has been low key and ad hoc. In recent years the skink recovery programme has gained higher public and community profile and increasing public awareness. This has been achieved by articles in popular publications and talks to the public, scientists and community groups.

Community trusts

The Central Otago Ecological Trust (COET) was established in 2005 with the primary goal of re-establishing a free-living population of Otago skinks in a fenced sanctuary in the Alexandra area. The trust will be a key partner in the recovery programme.

2. Goal(s)

A. long-term recovery goal

The long-term recovery goal is to maintain and restore viable populations of grand and Otago skinks across their natural range, and to maintain their genetic diversity.

B. Goals for the recovery plan period 2006-2016

Given the perilous state of grand and Otago skink populations, the immediate and urgent goals for the recovery programme are to:

a. Identify the agents of decline

b. Secure both species in captivity

Medium term goals are:

c. Secure both species in the wild

d. Raise community awareness and support for skink conservation

Comment [b2]: Suggested change in response to tech peer review

3. Implementation

Research

Topic 1: Agents of decline

Background

Predation is considered to be the most likely agent of decline for both skinks. There are nine species of potential mammalian predators (pig, cat, ferret, stoat, weasel, ship rat, Norway rat, hedgehog, and mouse), and several species of potential avian predators – including magpie, falcon, harrier and starling – within the current distribution range. The most pragmatic, safest and supposedly most guaranteed method to investigate the impact of such a wide range of predators is to remove all the mammalian predators, consumers of skinks. Previous experimental research (Tocher 2006), which focused on cats as predators did not prevent an ongoing decline in skink populations. Consumers of skink habitat, such as livestock, possum, goats, rabbits, hare and pig are also excluded within a mammal-proof fence.

The risk of focusing on predation means that other agents, such as parasites, avian predation, poor habitat structure and food resources may not have been investigated at the same time. Therefore, it may be too late to implement appropriate mitigation measures. This is especially true if habitat restoration is the key to skink survival, because of the time required for habitat restoration. The mammal-proof fence treatment should facilitate habitat recovery by removing herbivores as well as carnivorous mammals.

To investigate the impact of the full range of predators three mammal control trials have been implemented at the Redbank Ridge/Emerald Stream Area.

1. Eradication of all mammals inside a mammal proof fence.

2. Suppression of mammalian predators by intensive trapping.

3. No mammal control.

To date, these treatments consist of:

1. Xcluder© mammal proof fence, 1718m long, encompassing 18ha of skink habitat, erected in winter 2005. Mammal poisoning and trapping commenced in July 2005. Since completion, mouse sign was detected in March 2006 and in April 2006 rabbits were still present.

The mammal-proof fence represents only 0.001% of the skinks' former range and about 1% of their remaining numbers. The experimental fence, therefore, is by not at a scale that will significantly contribute to saving the species in the long term.

2. Trap lines (56km) of soft-jaw Victor, modified Timms, modified Conibear, Fenn Mark VI, DOC250 and DOC150 traps. Multiple bait types are used to target cats, ferrets, stoats, weasels, hedgehogs and rats. Approximately 1200ha are covered to minimise mammal numbers in a 59ha central area. Trapping is supplemented with spotlight hunting, dogs, and lures. Intensive rodent control using toxins as well as traps has not been attempted to date because of the technical constraints of controlling rodents on the mainland.

3. Uncontrolled mammal populations outside the conservation management area.

Grand and Otago skink populations are monitored at all experimental sites. Survival and population growth rates are estimated using photo-mark-recapture methods. Habitat use, rock tor colonisation, movement and extinction are monitored by occupancy surveys.

Issues

Mammalian predation is considered to be the most likely cause of decline.

Other causes of decline such as parasites, avian predation, poor habitat structure need investigation as well.

Comment [b3]: Suggested change in response to tech peer review

Objective 1.1: Demonstrate that skink populations are recoverable *in situ* by removing mammals

Objective 1.2: Determine other agents of decline

Actions	Accountability	Responsibility	Priority
1.1 Eradicate mammalian pests inside two experimental mammal-proof fences, one containing Otago skink habitat (18ha already installed at the wildlife site) and the other containing mostly grand skink habitat (c.12ha to be installed on Redbank Ridge – construction began late 2006).	Area Manager (Coastal Otago)	Programme Manager (Grand & Otago Skinks), Coastal Otago Area.	Essential
1.2 Impose mammalian pest control that targets all mammal species to maximum practical effort with current tools (already installed at the Redbank Ridge/Emerald Stream and beyond, covering 1200 ha).	Area Manager (Coastal Otago)	Programme Manager (Grand & Otago Skinks), Coastal Otago Area.	Essential
1.3 Establish a "no mammal management" area to allow stronger inference about effects of Actions 1.1 and 1.2 (already installed at Alistair's Gully and Mandy's Rock).	Area Manager (Coastal Otago)	Programme Manager (Grand & Otago Skinks), Coastal Otago Area.	Essential
1.4 Use statistically robust techniques to monitor population responses in all treatments, (of both skinks and predators) at least until treatment effects are sufficiently revealed (already underway).	Area Manager (Coastal Otago)	Programme Manager (Grand & Otago Skinks), Coastal Otago Area.	Essential
1.5 Initiate research to determine impacts of two of the following potential agents of decline by 2009: habitat quality, food quality, mouse predation, and avian predation.	Area Manager (Coastal Otago)	Science coordinator	High

Most likely outcomes of these experimental actions and their management implications:

Based on population viability analysis we will interpret annual survival rates of 0.7 for grand skinks and 0.8 for Otago skinks as indicating recovering populations. Survival rates below 0.5 for either species will be interpreted as declining populations and hence 'no alleviation of agents of decline'. Results falling between these rates will be considered as neither success nor failure but justification to continue maintaining the experimental management and monitoring for definitive results.

Outcome A:

Fence and pest eradication treatment - no increase in skink survival rate

Predator control treatment - no increase in skink survival rate

No treatment - no increase in skink survival rate

Management implication:

- Salvage the species by moving a pre-determined number into captivity (see below)
- Begin captive rearing programme.
- Investigate other (non-predator) agents of decline

Outcome B:

Fence and pest eradication treatment - increase in skink survival rate

Predator control treatment - no increase in skink survival rate

No treatment - no increase in skink survival rate

Management implication:

- Implement fencing and pest eradication at a sufficient scale to ensure survival of both species in the medium term
- Abandon further investment in conventional trapping control until species are secure or key predator agent identified.

Outcome C:

Fence and pest eradication treatment - increase in skink survival rate

Predator control treatment - increase in skink survival rate

No treatment - no increase in skink survival rate

Management implication:

- Implement either fencing/pest eradication or predator control more widely depending on cost-benefit analysis.
- Continue refining predator control techniques

Outcome D:

Fence and pest eradication treatment – increase in skink survival rate

Predator control treatment – increase in skink survival rate

No treatment – increase in skink survival rate

Management implication:

•Re-evaluate data used to define decline and investigate potential negative effects of historic monitoring technologies.

• Revise Threat Classification status

Outcome E:

There is a risk of ambiguous results over all treatments due to low precision of survival estimates

Management implication:

•Continue treatments to ensure this is not a statistical artefact

•Review experimental design

Topic 2: Genetics

Issues

The now isolated east and west populations of both grand and Otago skinks have distinctive genotypes (Berry & Gleeson 2005, Berry et al. 2005). As captive management skills are well developed for Otago skinks, and being developed for grand skinks, conserving this diversity should not present a serious technical challenge. However, captive security for the species still relies on developing knowledge of the number of individuals required to secure that diversity, understanding the impacts of maintaining the species outside of their range, and developing basic management skills and techniques for grand skinks.

Objective 2.1: Determine the minimum number of skinks required to secure each genetically distinct population in captivity

Actions	Accountability	Responsibility	Priority
2.1 Utilise existing genotypic data on grand and Otago skinks to model and identify the minimum number required to adequately represent the species in captivity, and avoid genetic	Area Manager, Coastal Otago	Science Coordinator	Medium

bottlenecking, by the end of 2007.			

Topic 3: Metapopulation dynamics

Issues

The successful long-term management of grand and Otago skinks relies on an understanding the dynamics of viable meta-populations. Minimum numbers of individuals and the habitat they require must be understood in relation to the probability of extinction through known impacts (return of predator pressure) as well as unpredictable, stochastic events such as weather, fire and disease. Improved knowledge of meta-population dynamics and management requirements can be gleaned from both monitoring extant populations and their behaviour, and predictive modelling developed from field data. By understanding the meta-population dynamics for these skinks we will be able to identify the required minimum management areas and judge any recovery in the species.

Objective 3.1: Determine minimum metapopulation required in the wild to ensure population persistence

Actions	Accountability	Responsibility	Priority
3.1 Undertake metapopulation modelling using colonisation and extinction rates of rock outcrops and population size, genetic and demographic data by 2009.	Area Manager, Coastal Otago	Science Coordinator	Medium

Topic 4: Experimental management techniques

Issues

A combination of large-scale pest control and/or fencing and pest eradication will be implemented if outcome B or C results from the experimental treatments. A key part of the decision will be the costs and benefits of different management techniques. The completion of a cost benefit-analysis for both the eastern and western ranges will be required by 2009. Included in this is more detailed understanding of the pre-human habitat for both species. Collaborative research will be required to investigate, describe and develop techniques to improve the habitat of the skinks.

Objective 4.1: Support and advocate for research towards techniques that potentially improve the conservation status of skinks

Actions	Accountability	Responsibility	Priority
4.1 Develop control techniques for rodent	Technical Support	TSO	Medium

populations in tussock habitat on the mainland by 2009 if Outcome B occurs.	Manager, Otago,	(Terrestrial Ecosystems)	(subject to funding)
4.2 Develop habitat improvement techniques in collaboration with Landcare Research by 2009.	Principal DOC contact Dryland Restoration IO, Sustaining & Restoring Biodiversity OBI	Science Coordinator	Medium
4.3 Complete a cost benefit analysis of different fencing/pest control strategies before 2009.	Technical Support Manager, Otago		High (subject to funding)
4.4 Look for opportunities to promote research initiatives.	GAOS RG, Community Relations unit Otago Conservancy	Science Coordinator.	High

Topic 5: Ecosystems

Issues

Species other than grand and Otago skinks are likely to benefit from the experimental management and it is important that these collateral benefits are recorded. They signify potential side-benefits of threatened species management that will ultimately inform on improved management design for future phases of species recovery programmes..

Objective 5.1: Understand the effects of experimental treatments on the wider ecosystem

Actions	Accountability	Responsibility	Priority
5.1 Continue ecosystem monitoring in collaboration with Landcare Research.	Principal DOC contact Dryland Restoration IO, Sustaining & Restoring Biodiversity OBI.	Science Coordinator	Medium

Management

Topic 6: Review of experimental research

Issues

The current work programme has an emphasis in determining the agents of decline for Otago and grand skinks. Modelling undertaken so far suggests a high probability of functional extinction of both species within 10 years. A review of the research results to document numbers, distribution and genetic diversity will be essential in 2009. This will allow enough time for the required management actions to take effect. An improved PVA model will be an obvious tool. The review will need to be independent to make the process robust.

Objective 6.1: Review results from experimental management.

Actions	Accountability	Responsibility	Priority
6.1 Analyse experimental data and decide by July 2009, at the latest, (after the last population monitoring for that season) whether the treatments have benefited skinks.	Technical Support Manager & Area Manager, Coastal Otago	Science coordinator, Technical Support Officers	High
6.2 Present assessment of results to Regional General Manager & Conservator by December 2009.	Grand & Otago Skink Recovery Group.	Programme Manager (Grand & Otago Skinks), Science coordinator	High

Topic 7: Ex-situ and in-situ management

In situ issues

Given their genetic distinctiveness and isolation, in-situ management should be applied to the western populations, and at a large enough scale to encompass a functioning meta-population for both species. The general lack of sympatry in the western part of the range for grand and Otago skinks means that a minimum number of management sites will be needed for each species compared with the eastern part of the range where both species can be managed together at some sites.

If proven successful as a management technique, the current level of fencing at the Macraes Flat Reserve (under an Outcome B scenario) will need to be expanded to include a functioning metapopulation. As described in Topic 3 we do not know the appropriate size of a metapopulation for grand and Otago skinks. Until this is defined we define it as: '*at least four distinct but interacting sub-populations (number of individuals to be based on experimental outcomes and modelling,, up to 1km apart",* which we will call a 'quasi-metapopulation'. A single management unit should therefore aim to include one quasi-metapopulation. We also advise that at least two disjunct quasi-metapopulations be secured in each of the eastern and western ranges.

Secure sites should ideally be inside their former range and on the mainland where management staff can readily visit them. However, no such site is currently known and the methods for translocation and self-maintenance of either species in the wild have not been tested.

There are many skinks scattered in small, unsustainable populations outside protected areas. They can be left alone, monitored, or brought into captivity. The latter is the preferred option because it provides better security and allows greater options, such as research or translocation to secure sites. Protocols for determining which actions will be applied to any given population are included in the Captive Management Plan and the Translocation Proposal.

Ex situ issues

There are a number of Otago skinks already in captivity – these are of varying genetic makeup from outbred to others which are highly inbred. The former are clearly important for maintaining genetic diversity in captivity. The latter are still useful for research and public awareness.

Translocation to offshore or lake islands will not be attempted at present because:

- despite investigation of the options no habitat has been identified that is agreed by all to be suitable,
- source animals from reserve populations are not available without potentially upsetting population structure / balance,
- wild to captive translocation is a better, less risky, solution,
- because resources limit the ability to do the action,
- because private landowners are reluctant to allow translocation of outlying populations.
- no offshore island is known to be part of their former range.
- The latest results from the experimental work suggest we may in fact have management tools for in situ management inside their range.
-

Comment [b4]: Suggested change in response to tech peer review

It is preferable to translocate skinks to secure sites within the existing range, if and when they become available.

A Captive Management Plan will be written to support the Recovery Programme. It will contain more detail than here about ex situ management needs.

Comment [b5]: Suggested change in response to tech peer review

Whilst Otago skinks are breeding in captivity, grand skinks are not. Attention must be devoted to developing captive management skills for grand skinks.

The captive management programme is critical as insurance against failure of the in situ management treatments to restore skink populations. Currently, the captive operations lie entirely with private individuals or NGOs. If recovery in situ is unattainable and captive management becomes the central focus of the recovery programme, it will clearly need to be incorporated into departmental operations.

Objective 7.1: Secure representative populations of grand and Otago skinks through captive management by 2007 for Otago skinks, and by 2008 for grand skinks

Objective 7.2: Secure representative populations of grand and Otago skinks in their eastern and western range

Actions	Accountability	Responsibility	Priority
7.1 Implement the Captive Management Plan (2006-2016) as insurance for the species' existence, by 2007.	Area Manager (Coastal Otago)	Programme Manager (Grand & Otago Skinks), Coastal Otago Area. Captive Management Coordinator.	Essential
7.2 *(If experimental management produces outcome A)*. Seek resources to expand the Captive Management Programme to salvage the species from extinction, by 2010.	Conservator, Otago		Essential
7.3 *(If outcome B)* Seek resources to establish large scale fencing and mammal eradication in the eastern and western ranges by 2010 to protect quasi-metapopulation.	Conservator, Otago		Essential
7.4 *(If outcome C)* Seek resources to establish either fencing/mammal eradication or large-scale multi-species mammal control (depending on cost-benefit analysis) in the eastern and western ranges by 2010.	Conservator, Otago		Essential
7.5 Seek resources to secure protection of key habitats as opportunities arise.	Conservator, Otago		Medium
7.6 *(If outcome B or C)* Seek resources to translocate captive and/or wild stock to secure sites by 2010.	Conservator, Otago		Medium
7.7 Continue to review options for using islands to secure grand and Otago skinks, both inside and outside the known range, with a specific interest in Mou Tapu, Lake Wanaka.	GAOS RG Area Manager (Wanaka)	Programme Manager (Grand & Otago Skinks), Programme Manager Bioassets, Wanaka	Medium
7.8 (*If outcome D*) Maintain current treatments and extend monitoring spatially to verify trends.	Area Managers Coastal Otago/ Wanaka	Programme Manager (Grand & Otago Skinks), Coastal Otago Area, Programme Manager Bioassets Wanaka	Essential
7.9 (*If outcome E*) Maintain current treatments and defer any decisions pending external review of data.	GAOS RG, Conservator Otago	Programme Manager (Grand & Otago Skinks), Coastal Otago Area	Essential

Topic 8: Monitoring

Issue

Monitoring is an essential aspect of determining the outcomes of the management experiments and in generating data to understand trends in wild populations and their behaviour (dispersal, colonisation, extinction). It is imperative that current monitoring methodologies are adhered to for the duration of the management experiment. These include photo-mark/photo-recapture for estimates of survival rates and abundance, and occupancy surveys of habitat patches. Access to sites in the western part of the range is dependent on permission from pastoral lessees.

Objective 8.1: Maintain knowledge of status of both species across their range

Actions	Accountability	Responsibility	Priority
8.1 Implement annual population monitoring for those western populations that are accessible to department staff.	Area Manager (Wanaka).	Programme Manager (Grand & Otago Skinks), Coastal Otago Area Programme Manager Bioassets Wanaka	High
8.2 Continue population monitoring at Macraes study sites to infer longer-term effects of experimental management.	Area Manager (Coastal Otago)	Programme Manager (Grand & Otago Skinks),	Essential
8.3 Investigate reports of new sightings of grand and Otago skinks.	Area Manager (Coastal Otago) Area Manager (Wanaka).	Programme Manager (Grand & Otago Skinks), Programme Managers Biodiversity Wanaka, Central	Medium

Topic 9: Legal status of reserves

Issue

The classification of public land managed by the department at Macraes Flat and Glenfoyle is not completed. The appropriate classification of these lands that are managed for grand and Otago skink conservation requires resolution to ensure that the most appropriate protection and designation is afforded to these lands.

As tenure review is completed in the western part of the skinks' range, it can be expected that more protected land will come into public ownership. Classification of these lands will be required to ensure appropriate management objectives.

Objective 9.1: Clarify classification and legal status of Public Conservation Estate that is managed for grand and Otago skinks.

Actions	Accountability	Responsibility	Priority
9.1 Undertake a formal land classification exercise for the public conservation land at Macraes Flat and Glenfoyle by 2007	Area Manager Coastal/ Wanaka		Medium

Community Relations

Topic 10: Stakeholders

Issues

Public awareness of the conservation status and threats faced by grand and Otago skinks is higher than it was three years ago, through articles, talks and use of skinks as promotional material. Maintaining this momentum should lead to improving the public commitment to the species' conservation in the long term.

A number of skink populations remain on private land. Engaging with landowners, understanding the management pressures they face, and developing a mutually beneficial approach to the both species conservation is necessary to provide a future for these populations. The establishment of the Central Otago Ecological Trust, which is focused on grand and Otago skink conservation through education, captive management and habitat restoration, is an opportunity for the recovery programme.

Additional tools available to the recovery programme that could assist landowners where skinks occur on private land include: Biodiversity condition fund, QEII Open Space Covenants and conservation covenants or Protected Public Land Agreements under the Reserves Act 1977.

Objective 10.1: Raise community awareness and support for skink conservation.

Actions	Accountability	Responsibility	Priority
10.1 Build better relationships with landholders and stimulate awareness of, and options for, grand and Otago skink conservation.	Area Manager Coastal Otago, Wanaka, Central Otago, Community Relations Manager, Otago.	Programme Manager (Community Relations), Wanaka, Coastal & Central	Essential
10.2 Foster support for community-led skink conservation initiatives, including support for the development of COET	Area Manager Coastal Otago, Wanaka, Central Otago, Community Relations Manager, Otago.	Programme Manager (Community Relations), Wanaka, Coastal & Central	High

initiatives.			
10.3 Complete a communication strategy to enable engagement with the community.	Community Relations Manager, Otago.	Community Relations Officer (Public Awareness)	High
10.4 Encourage Otago schools to participate in the grand and Otago skink programme with information and opportunities to be involved.	Area Manager Coastal Otago, Wanaka, Central Otago ,	Programme Manager (Community Relations), Wanaka, Coastal & Central	Medium
10.5 Stimulate awareness of grand and Otago skink conservation by the farming community generally.	Area Manager Coastal Otago, Wanaka, Central Otago, Community Relations Manager, Otago.	Programme Manager (Community Relations), Wanaka, Coastal & Central	High
10.6 Engage the general public and interest groups about grand and Otago skink conservation.	Area Manager Coastal Otago, Wanaka, Central Otago, Community Relations Manager, Otago.	Programme Manager (Community Relations), Wanaka, Coastal & Central	Medium
10.7 Consult with relevant runanga on the skink programme and any significant change in direction it may take, such as tikanga with skink translocations and salvaging skinks in captivity.	Area Manager Coastal Otago, Wanaka, Central Otago, Community Relations Manager, Otago. Grand & Otago Skink Recovery Group.	Programme Manager (Grand & Otago Skinks),	Medium
10.8 Seek rural participation in the Recovery Group.	Conservator, Otago		High

Topic 11: Sponsorship

Issues

Corporate sponsorship is a means of promoting species like grand and Otago skinks and raising corporate profile and public awareness. First priorities for any corporate interest will be to increase the public profile of the skinks.

Objective 11.1: Explore sponsorship options to support skink conservation

Actions	Accountability	Priority
11.1 Explore sponsorship options to fund skink conservation by 2009.	Community Relations Manager, Otago, External Relations Group, Head Office.	Medium

4. Acknowledgements

The development of this plan was helped by the commitment of other recovery group members (Tony Whitaker, Hoani Langsbury, Dave Houston & John Gordon, led by Carolyn Burns). Discussions with Karina Holmes, Alison Cree, Phil Seddon and Trent Bell were also instructive in the preparation of this plan.

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