Manaaki Whenua
Landcare Research

How pest-fenced ecosanctuaries and Predator Free 2050 can work together better

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How pest-fenced ecosanctuaries and Predator Free 2050 can work together better

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Summary

Project and client

- The Department of Conservation (DOC) contracted Manaaki Whenua – Landcare Research to write an insights paper on the potential for predator-fenced projects to be better integrated into the overall design of the Predator Free 2050 (PF2050) programme

Objectives

- Explore the role of the existing fenced sanctuary network and the contribution it makes to PF2050.
- Reflect on the potential for predator fences to be integrated into the overall design of the PF2050 programme, clearly identifying where and how they can play a role.
- Consider how the PF2050 strategy and its implementation can better acknowledge and partner with the sanctuary network to support the realisation of the PF2050 vision.

Methods

- I reviewed the available literature and unpublished reports to describe the number, locations, structures, purposes and conservation achievements of existing pest-fenced ecosanctuaries.
- I describe the scope and intent of the PF2050 strategy and programme, and identify overlaps and disparities between them and pest-fenced ecosanctuaries.
- Based on the above, I suggest ways in which the PF2050 strategy and its implementation can 'better acknowledge and partner with the pest-fenced ecosanctuary network to support the realisation of the PF2050 vision'.

Results

- There are seven ring-fenced and seven peninsula-fenced ecosanctuaries larger than 25 ha undertaking multi-species pest control for ecosystem recovery objectives. Most are small (<500 ha), and none have been built since the Brook Waimārama Sanctuary (Nelson) in 2016.
- Ecosanctuary visions focus on restoring and enhancing biodiversity at their particular sites, and on collaborating in relevant research and education.
- Pest-fenced ecosanctuaries remove all introduced mammal species (up to 15) present at a site; the fence 'keeps out most mammals most of the time' with mice the most problematic.
- Pest-fenced ecosanctuaries have enabled documented recovery of ecological mutualisms such as seed dispersal and pollination; have celebrated the return of several extirpated, iconic, endemic taxa such as saddlebacks, hihi, tuatara, and kākāpō to the mainland; and have hundreds of thousands of visitors annually who experience a here-and-now version of PF2050.

- Biodiversity halos around fenced ecosanctuaries catalyse community riparian restoration, wetland stewardship and associated predator control, fuelling a movement towards greener farming and greener cities.
- The PF2050 programme is predominantly funded from central government, and DOC is the lead agency for strategy and coordination of investment (cf. the PF2050 movement, which is much more diverse). Delivery is undertaken by DOC (islands, tool development, research) Zero Invasive Predators (developing testing scale and defence approaches), Predator Free 2050 Ltd (determining scalable approaches for urban and rural landscapes and 'breakthrough science'), and the Predator Free NZ Trust (community support and communications).
- PF2050 also contributes to biodiversity restoration as a component of Te Mana o te Taiao – Aotearoa New Zealand Biodiversity Strategy.
- Predator Free 2050 landscape projects mostly target one to five mammal pest species (up to three rats, stoats, possums) and assume that biodiversity benefit will follow. Exceptions are investments in Rakiura, Maukahuka, and the national 'Islands Programme'.
- Predator Free 2050 Ltd and the national PF2050 programme broadly fund numerous valuable research projects relevant to their respective agendas.
- The main contributions of pest-fenced ecosanctuaries to the PF2050 vision are as exemplar sites showing the biodiversity outcomes of the vision; 'shop window' sites where thousands of visitors and volunteers learn about the vision; sites with excellent working relationships with iwi, including co-governance; and sites with ambitious, pioneering staff, who now hold a significant proportion of New Zealand's knowledge and skills about how to do pest control in the presence of threatened endemic species.

Conclusions

- Ecosanctuaries and the PF2050 programme share the same vision but operate at different sites and geographical scales, and with different outcome emphases and funding.
- Reasoned, joint and prioritised contributions of the two regimes to agreed regional and national biodiversity strategies are described nowhere.
- The PF2050 vision has captured the hearts and minds of thousands of New Zealanders, and PF2050 has funded valuable research and trialled at least one significant new potential pest control regime (in south Westland).
- Pest-fenced ecosanctuaries are only lightly acknowledged in PF2050 literature, including the PF2050 strategy, despite having pioneered mainland eradication of multiple pest mammals and documented the resultant and ongoing spectacular mainland biodiversity responses.
- As a result, ecosanctuary practitioners do not feel part of PF2050 in 2024. New Zealand cannot afford such a schism in national biodiversity restoration at this time of critical declines and scarce conservation resources, when these two parties share the same vision and have so much to offer each other.

Recommendations

The following actions will help pest-fenced ecosanctuaries and PF2050 to work together better.

- Acknowledge the achievements and the current and future relevance of pest-fenced ecosanctuaries more thoughtfully in key PF2050 planning documents so that ecosanctuary practitioners can actually see themselves in them and see that their aims align.
- Frame, acknowledge, and celebrate the demonstrated biodiversity gains made by pest-fenced ecosanctuaries as short- to medium-term exemplar gains for PF2050 as a whole, so that ecosanctuaries can be fairly acknowledged for this significant contribution.
- Use the high visitor numbers in ecosanctuaries to publicise the larger-scale, unfenced, PF2050 efforts.
- Write both PF2050 and ecosanctuaries into joint, reasoned, and prioritised Biodiversity Strategy implementation plans so that strategic roles for each and synergies between them are clearly identified. Such planning should be regional as well as national.
- Support struggling, key, pest-fenced ecosanctuaries with some PF2050 funding, and consider relevance to ecosanctuaries when choosing PF2050 research projects.
- Explore building more pest-fenced ecosanctuaries, starting with renewed consideration of the value proposition presented at Wainuiomata (Lynch 2021). Reconsider the costs and benefits of the 100,000 ha core-and-two-buffers concept of Jim Lynch and Sir Paul Callaghan. This would enable both regimes to work together at a common site towards the same objective.
- Build more pest-fenced ecosanctuaries in urban areas, build more rodent fences around food-processing facilities, and build numerous small pest fences to protect particular fauna such as lizards, frogs, invertebrates, nesting seabirds, and juvenile kiwi. More experimentally, build '10-pest fences' around vegetation remnants such as significant natural areas and QE II covenants, and trial using fences to manoeuvre pests towards smart killing devices, perhaps in conjunction with natural landscape barriers such as rivers. All such, pest fences could be conspicuously branded as PF2050 devices.
- Define restoration language for all PF2050 participants, especially regarding 'eradication' vs 'elimination' and other equivalents.
- Consider how or if an annual combined PF2050–ecosanctuaries technical workshop would help to get key practitioners to get to know each other and to feel they are working more together. Greater exchange of ideas is needed between diverse practitioners to maximise cohesion and the outcomes of a national biodiversity restoration agenda.
- Link PF2050 projects more closely to known, urgent biodiversity restoration challenges and opportunities, such as restoring kākāpō and takahē to 30,000+ ha breeding sites on the mainland, thus embedding multi-species-control, unfenced ecosanctuaries into the PF2050 landscape agenda.

1 Introduction

New Zealand has a well-known history of ecological loss caused by two waves of human colonisation, and ecological decline is ongoing. Key pressures still affecting terrestrial biodiversity include introduced invasive species, climate change, land-use change (mainly, forest loss), and pollution (DOC 2020a). The required restoration actions are correspondingly broad and complex, requiring significant funding, shared visions, and collaboration across land uses and people, including iwi and local communities (Lyver et al. 2015; Peters et al. 2015; Norton et al. 2016; DOC 2022). There are restoration agendas for islands (Towns et al. 1997; Parkes et al. 2017) and 'the mainland' (North, South Islands and Rakiura), including peopled landscapes of both (Wittmer et al. 2018).

The most well-known invasive species are mammals, introduced by both Polynesians and Europeans, some accidentally and others deliberately. Thirteen of the 32 resident introduced mammals have become widespread: brushtail possum (*Trichosurus vulpecula*), hedgehog (*Erinaceus europaeus*), rabbit (*Oryctolagus cuniculus*), brown hare (*Lepus europaeus*), Norway rat (*Rattus norvegicus*), ship rat (*R. rattus*), house mouse (*Mus musculus*), stoat (*Mustela erminea*), ferret (*M. furo*), cat (*Felis catus*), feral pig (*Sus scrofa*), feral goat (*Capra hircus*), and red deer (*Cervus elaphus*) (King & Forsyth 2021).

The introduced mammals have diverse sizes, diets, and behaviours. They also have broad impacts but are primarily targeted as conservation pests. Their varied diets mean that indigenous leaves, fruits, invertebrates, and vertebrates such as lizards and birds are all vulnerable to consumption, limiting indigenous populations and diverting food supply away from valued indigenous fauna. Many small mammals (possum, ship rat, house mouse, stoat, and cat) are excellent climbers, and so tree-borne fauna such as nesting birds are also potential prey. Many also carry zoonotic diseases such as leptospirosis, toxoplasmosis, trichinellosis, and murine typhus. Rodents scavenge and pollute human food supplies and may damage buildings and appliances by gnawing electrical wires, insulation, timber and walls (Wilson et al. 2018).

Long-standing 'major pest control regimes' (mature and verified combinations of tools and tactics that achieve certain outcomes) in New Zealand include island eradications, large-scale aerial poisoning with sodium fluoroacetate (1080), unfenced ecosanctuaries (also known as mainland islands), and pest-fenced ecosanctuaries (Byrom et al. 2016; Innes et al. 2023). There are also hundreds or thousands of community or backyard pest control projects that do not yet collectively qualify as a regime (Peters et al. 2015; Innes et al. 2023). However, as part of the 2016 International Union for Conservation of Nature (IUCN) World Conservation Congress in Honolulu, Hawaii, the New Zealand Government made a commitment that 'the country will be free of the most damaging invasive alien species (rats, stoats, possums) by 2050'. A Predator Free 2050 strategy was published in 2020 (DOC 2020b), followed by 5- and 7-year progress reports (DOC 2021, 2023) and a renewed implementation plan (DOC 2024).

The concept of being 'predator free' has been widely taken up by diverse agencies and communities, so that for many people it is now the main moniker for 'restoration'. Published responses to this bold vision vary from hopeful ('We would be foolish not to imagine what can be achieved 50 years from now', Russell et al. 2015) to sceptical ('A

flawed conservation policy displaces higher priorities and better, evidence-based alternatives', Linklater & Steer 2018).

The present suite of target species for Predator Free 2050 Ltd is ship, Norway and Pacific rats, stoats, ferrets, weasels, and possums (DOC 2021), and other potential targets are currently being reviewed.

2 Background

The PF2050 national strategy (DOC 2020b) acknowledged the significant role that pest-fenced ecosanctuaries have played in the decades-long national journey towards pest mammal control and eradication in larger and larger mainland sites. However, they are explicitly mentioned just three times in 43 pages, including p. 23, 'Pest-free islands and fenced mainland sanctuaries illustrate that more is possible', and 'Without the use of fences, eradication (the complete removal of predators), is a much more difficult goal than sustained control.' The third mention is in the second of seven 'Interim 2025 goals' (p. 25): 'By 2025, we will have demonstrated that predator eradication can be achieved in areas of mainland New Zealand of at least 20,000 hectares and that these areas can be defended from reinvasion without the use of fences'. Furthermore, ecosanctuary practitioners cannot easily find themselves among the 15 groups or agencies listed in the strategy's 'Who's involved' roles and responsibilities (pp. 39–41). Are they 'Communities (including businesses and NGOs)' or 'Landowners and land managers'?

As a result, the 2020 strategy drove a focus on demonstrating that predator eradication could be achieved on the mainland without the use of pest fences, and created a perception that the PF2050 movement has discounted the use and value of pest-fenced ecosanctuaries as a tool on the path to a predator-free 2050. In the context of this perception, this report is a contribution to a wide-ranging 2024 review of the PF2050 programme and considers how pest-fenced projects and the PF2050 vision and strategy can support each other better.

3 Objectives

- Explore the role of the existing fenced sanctuary network and the contribution it makes to PF2050.
- Reflect on the potential for predator fences to be integrated into the overall design of the PF2050 programme, clearly identifying where and how they can play a role.
- Consider how the PF2050 strategy and its implementation can better acknowledge and partner with the network to support the realisation of the PF2050 vision.

4 Methods

- I start by defining key terms relevant to this report.
- I then review the available literature and unpublished reports to describe the number, locations, structures, purposes, and conservation achievements of existing pest-fenced ecosanctuaries.
- I describe the scope and intent of the PF2050 strategy and programme, and identify overlaps and disparities between them and the goals and actions of pest-fenced ecosanctuaries.
- Based on the above, I then suggest ways in which the PF2050 strategy and its implementation can 'better acknowledge and partner with the pest-fenced ecosanctuary network to support the realisation of the PF2050 vision'.

5 Results

5.1 Definitions of key terms

Ecosanctuary – A project larger than 25 ha implementing multi-species, pest mammal control for ecosystem recovery objectives, and with substantial community involvement (Innes et al. 2019).

Eradication – The complete and permanent removal of all wild populations from a defined area by a time-limited campaign. There are three essential criteria to achieving this: (1) the rate of removal exceeds the rate of increase at all population densities, (2) immigration is prevented, and (3) all reproductive animals are at risk (Bomford & O'Brien 1995).

Pest fencing – A fencing system involving a particular mesh size and construction, a curved hood and underground foot, and vehicle, pedestrian, and water gates designed in aggregate to (as far as practicable) stop reinvasion by pest mammals (Hitchmough 1994; Day & MacGibbon 2007).

PF2050 (Predator Free 2050) – The goal set politically in 2016 to make New Zealand free of ship rats, Norway rats, kiore, possums, stoats, ferrets and weasels by 2050 (DOC 2021, p. 13).

PF2050 programme – A programme to implement the PF2050 goal, funded predominantly from central government and with DOC as lead agency. Delivery is undertaken by DOC (islands, tool development, research, implementation activities), Zero Invasive Predators (developing and testing scale and defence approaches), Predator Free 2050 Ltd (determining scalable approaches for urban and rural landscapes and 'breakthrough science'), and the Predator Free NZ Trust (community support and communications).

PF2050 strategy – The planning framework involving six 'pathways' that help guide involved New Zealanders towards achieving PF2050.

PF2050 projects – Pest control and support projects funded by the PF2050 programme, Predator Free 2050 Ltd, the Predator Free NZ Trust, and Zero Invasive Predators.

Predator Free 2050 Ltd – A Crown-owned company responsible for organising large-scale, landscape, predator-free projects and substantial relevant research.

Predator Free NZ Trust – An independent trust established in 2013 to 'connect and energise the nation towards Predator Free 2050'.

Wider PF2050 projects – The greater suite of possibly thousands of pest control projects, from backyards to ecosanctuaries and islands, and including aerial 1080 operations, that are not funded by the PF2050 programme.

Zero Invasive Predators Ltd (ZIP) – a company funded jointly by the Department of Conservation and NEXT Foundation that develops and trials technology and tactics for eradication of target species at landscape scales.

5.2 Origins and attributes of present pest-fenced ecosanctuaries

5.2.1 Origins of pest-fenced ecosanctuaries

Pest-fenced ecosanctuaries evolved from 1998 onwards to resolve particular problems with the unfenced ecosanctuaries ('mainland islands') that preceded them in the 1990s. These problems included the following.

- Without fences, no target pests could be eradicated because reinvasion was inevitable, so that some highly vulnerable native species such as saddlebacks (*Philesturnus carunculatus*) could not be restored to the sites.
- Control of one pest, such as possums, frequently led to increases in others, such as ship rats (Sweetapple & Nugent 2007; Ruscoe et al. 2011).
- Due to resource limitations, effort was targeted mainly at ship rats, stoats and possums, and less so at other pests regarded as less important or more difficult (e.g. hedgehogs, feral cats, ungulates).
- Unfenced ecosanctuaries were and remain highly dependent on toxins used decade after decade as key control tools (Innes et al. 2019, 2023).

Pest-fenced ecosanctuaries pioneered a fencing system that limited or stopped reinvasion of all pest mammals, enabling the eradication of pests on the inside followed by sustained detection and removal of reinvaders. Advertisements of the day (year 2000) promised 'An end to trapping and poisoning of pests!' that turned out to be only partially true. Pest eradication in fenced ecosanctuaries substantially used techniques developed for island eradications (helicopter, GPS, cereal baits, brodifacoum; Towns et al. 2013) but instead of simply waiting to see if some individuals had survived, ecosanctuary eradication practitioners actively sought out survivors and removed them (Speedy et al. 2007). This shift was subsequently also implemented in the successful eradication of eight small mammal pests from Rangitoto and Motutapu Islands by 2011 (Griffiths et al 2015) and

became the main strategy of the current 'remove and protect' systems being trialled by ZIP in south Westland (e.g. ZIP 2018).

Sites where pest-fenced ecosanctuaries have become established have not been subject to systematic, national, conservation prioritisation processes (Leathwick et al. 2023). Campbell-Hunt et al. (2010) suggested that community-driven sanctuaries in New Zealand are examples of 'community-based entrepreneurship' (Peredo & Chrisman 2006), and that the trigger to action was 'a shared perception of ecological loss, together with a motivation to take action in the landscape that has meaning for that community'. This is a cogent description of the origins of ecosanctuaries, including original DOC mainland islands, where key individuals drove the establishment of early restoration sites. This means that the 'ecosanctuary network', represented perhaps by the Sanctuaries of NZ Inc. (SONZI) gathering, is primarily social rather than connected in any reasoned, geographical way.

5.2.2 Attributes of pest-fenced ecosanctuaries

For the purposes of this report we use the definition of an ecosanctuary (5.1 above) from Innes et al. 2019. As explained in that 2019 paper, there is no right or perfect definition, and ours excludes numerous large and small biodiversity restoration projects, such as those focusing on single species recovery (e.g. kiwi crèches) and some smaller pest fences erected around seabird colonies, lizard populations, and industrial food-processing facilities, all of which collectively add to what may be considered a 'wider PF2050 movement' (DOC 2024).

In 2019, there were seven ring-fenced ecosanctuaries (counting the multiple smaller exclosures at sites such as Maungatautari as one), seven peninsula-fenced ecosanctuaries, and 51 unfenced mainland ecosanctuaries (Innes et al. 2019; Table 1, Figure 1). All of the pest-fenced ecosanctuaries were built in the 13 years between the first (Zealandia; formerly Karori), in 1999, and The Brook Waimārama in 2016. No new ring-fenced or peninsula-fenced ecosanctuaries have been built since 2016, except for Point Bush Ecosanctuary at Waimate, Canterbury.[1]

Table 1. Name, region, and visions/objectives of New Zealand peninsula-fenced and ring-fenced ecosanctuaries. Vision sources are project websites or Sanctuaries of New Zealand: Projects (sanctuariesnz.org)

Project name	Region	Vision
Peninsula-fenced ecosanctuaries		
Kotuku Peninsula	Great Barrier Island (Aotea Island)	'Restore, enhance and protect the biological diversity of flora and fauna on the Kotuku Peninsula. Facilitate the protection and restoration of the ecological integrity of the Kotuku Peninsula such that native biodiversity flourishes. Provide an environment that supports experiential education, interpretation and advocacy. Ensure the sanctuary is an exemplar of best practice adaptive ecological management that benefits the local, island and national environment.'

[1] 94 ha, fence completed June 2021, eradications incomplete; www.pointbush.co.nz.

Project name	Region	Vision
Tawharanui	Auckland	'To create and maintain an open sanctuary that integrates conservation with recreation and farming; free from plant and animal pests; where native plants, birds and animals can live and breed successfully.'
Shakespear	Auckland	'The broad aim of the Shakespear Open Sanctuary Society Incorporated is the conservation and enhancement of the natural, recreational, historic and cultural features and values of the Sanctuary. Our primary roles include working on predator control, promoting and enhancing the Sanctuary and raising funds for the reintroduction of new species'
Young Nick's Head	East Cape	'To turn back the clocks recreating a self-sustaining ecosystem containing flora and fauna as it would have been present in pre human times and for a challenge, do it while still running a viable farming operation.'
Cape Sanctuary	Hawke's Bay	'To create an environment where production and conservation exist co-operatively and cohesively.'
Kaipupu Point	Picton	'Working together to enrich the community through restoration and guardianship of Kaipūpū Sanctuary, where native flora and fauna flourish.'
Mamaku Point	Rakiura	'The Trust's strategy is to conserve the existing native fauna, to help grow the populations of the resident species, and to seek opportunities to re-establish other absent natives.'
Ring-fenced ecosanctuaries		
Maungatautari	Waikato	'To increase indigenous dominance and species occupancy on Maungatautari by the sustained removal of introduced species and by translocations, so that the original and natural character of ecosystems is as far as possible restored and to increase the number of people who treasure the Sanctuary Mountain Maungatautari project and are involved with its operation'.
Wairakei	Taupō	'Imagine the experience of playing golf on a world class championship course, immersed in the natural beauty of a wildlife sanctuary … In 2012, an agreement was established between Wairakei Golf + Sanctuary and the Department of Conservation to work cooperatively together to make the most of conservation and restoration opportunities within the sanctuary.'
Rotokare	Taranaki	'To restore Rotokare Scenic Reserve's biodiversity to its full potential to achieve a mainland island and have due regard for recreational users of Rotokare Scenic Reserve. This will be achieved through pest-proof fencing, eradication, restoration and re-introductions, monitoring, education and active on-site management.'
Bushy Park	Wanganui	'This diverse forest, combined with a moderate climate, several small streams and protection from most mammalian predators and competitors, provides an outstanding environment for many native and endemic species – plants, fungi, birds, lizards and invertebrates.'
The Brook	Nelson	'To restore a mammal pest-free mature native forest, enabling people to engage with the natural world in a way that promotes environmental responsibility and our community's health and wellbeing, and contributes to the recovery of our local and national ecosystems. To be an eco-sanctuary nationally recognised for its exemplary conservation practices, where wildlife, education, and research flourish.'
Zealandia	Wellington	'Zealandia Te Māra a Tāne has a vision to restore this valley to the way it was before the arrival of humans. With its 8.6 km fence keeping out introduced mammalian predators, birds such as the tūī, kākā and kererū, once extremely rare in the region, are all now common sights around central Wellington. Other vulnerable native species such as tīeke, hihi, little spotted kiwi, and tuatara remain thriving safely in the sanctuary.'

Project name	Region	Vision
Orokonui	Dunedin	'A healthy, self-sustaining ecosystem, free of all introduced mammals and comprising indigenous species that are appropriate to the Orokonui forest, where people can enjoy a peaceful encounter with nature, and from which they may take recreation, refreshment, new knowledge, new skills and a new commitment to conservation.'

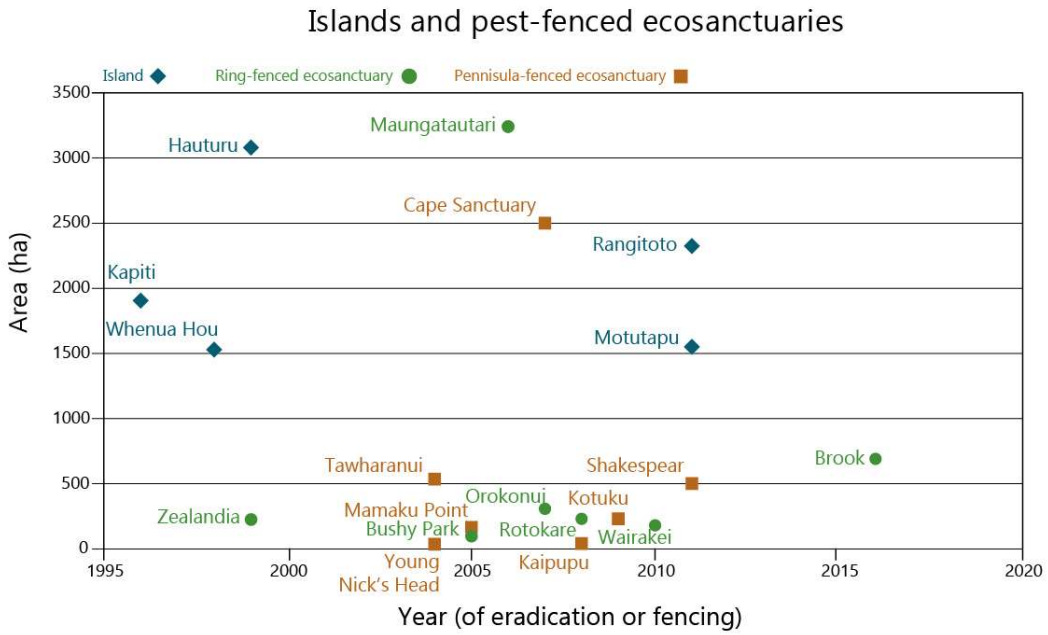

Figure 1. Area (ha) and year of pest mammal eradication or pest-fencing of peninsula-fenced and ring-fenced ecosanctuaries >25 ha, and of some nearshore island reserves in New Zealand.

Most of the pest-fenced ecosanctuaries are small (<500 ha). Maungatautari is twice the size of the other ring-fenced ecosanctuaries combined, and larger than each of Hauturu, Kapiti, Whenua Hou, Rangitoto, and Motutapu islands (Figure 1).

Vision statements of pest-fenced ecosanctuaries are very similar, focusing on restoration of indigenous biodiversity at each of the sites; on being a learning and recreation opportunity for local people; and on implementing quality conservation research and management (Table 1).

5.2.3 Conservation achievements of pest-fenced ecosanctuaries

Number of pest mammal species removed, remaining, and reinvading

Eradications at mainland, pest-fenced sites targeted more mammal pest species (up to 15) than island eradications, simply because more target species were present (Speedy et al.

2007; Figure 2). Worldwide, the most mammal species ever eradicated on an island is 10, from the joined, near-shore Rangitoto and Motutapu Islands (Griffiths et al. 2015).

Islands and pest-fenced ecosanctuaries share a common goal of eradicating all introduced mammals present to restore indigenous dominance and to enable extirpated native taxa to be returned (improving 'species occupancy'; Lee et al. 2005).

Reinvasion is always possible (Figure 2) – to islands by boats and swimming, and to pest-fenced sanctuaries by mammals finding a hole in the fence system – and in practice it is hard to verify how long a reinvader has been inside the fence. Staff attended 110 fence callouts at Maungatautari in the 2022/23 year, a decrease from 129 the year before; 17 fence breaches by mammals occurred and 22 pest incursions were resolved (MEIT 2023).

At Maungatautari during 2008–2018, 80 ship rats, 16 weasels, 6 hedgehogs, 2 stoats, a cat, and a possum were trapped inside the 47 km fence (Kate Richardson, Waikato Regional Council, Geoff Churchill Maungatautari Ecological Island Trust, unpubl. data, 2018). None of the ship rats are known to have penetrated the reserve interior; ship rat reinvaders averaged one per 7 km of pest fence per annum. However, house mice have been abundant since 2011, when project managers decided they could no longer afford the cost of the constant detection effort required to remove them all (Watts et al. 2022). Having house mice persist as the only mammal present is a frequent outcome in mainland pest-fenced ecosanctuaries due to the combined difficulties with current tools to detect and remove mice at large spatial scales, especially in human-populated environments (Samaniego et al. 2024).

Mice reinvaded Orokonui soon after the initial eradication and are now managed *in situ*. Stoats established for almost a year in 2015 but were then eradicated. During 2007–2024 there were seven ship rat incursions, three of stoats, and one each of weasel, hedgehog, and rabbit (Elton Smith, pers. comm., Orokonui operations manager, 2024).

Rotokare Scenic Reserve Trust has remained free of 11 of the 13 pests eradicated from the sanctuary in 2009, with ship rats (16 individuals total) and mice being the exceptions. Mice have reinvaded quite often, but all have been removed with targeted toxin pulses or trapping, and the site is currently mouse-free again (Fiona Gordon, pers. comm., Conservation Manager, 2024).

Reinvasion of peninsula-fenced ecosanctuaries is inevitably greater, and initial eradication is harder because fence-ends cannot be closed off. At Tawharanui Open Sanctuary, 7 of the 10 mammal species initially present were successfully eradicated (2004), but house mice, rabbits, and hedgehogs remained. During 2005–2010 there were 75 incursions involving 83 individuals of 6 mammal species, mainly cats and ship rats, all of which were subsequently removed (Maitland 2011).

Most of the reinvading mammals in pest-fenced ecosanctuaries are removed before they cause significant harm to resident native biodiversity. The most conspicuous exceptions to this in the 25 years of pest-fenced ecosanctuary experience so far were stoat impacts on saddlebacks (*Philesturnus carunculatus and P. rufusater*) that occurred at Orokonui and Tawharanui before the offending pests could be removed. Impacts on biodiversity of mice when present alone are described by Watts et al. (2022) and Samaniego et al. (2024).

As PF2050 will face, detecting and removing reinvading pests becomes even more important after more threatened endemic species have been translocated to a site. Furthermore, the endemics (such as saddlebacks and kākāpō) place restrictions on the use of traps and toxins because they are potential non-target victims of some methods. All pest-fenced ecosanctuaries have to fund ongoing pest detection and removal.

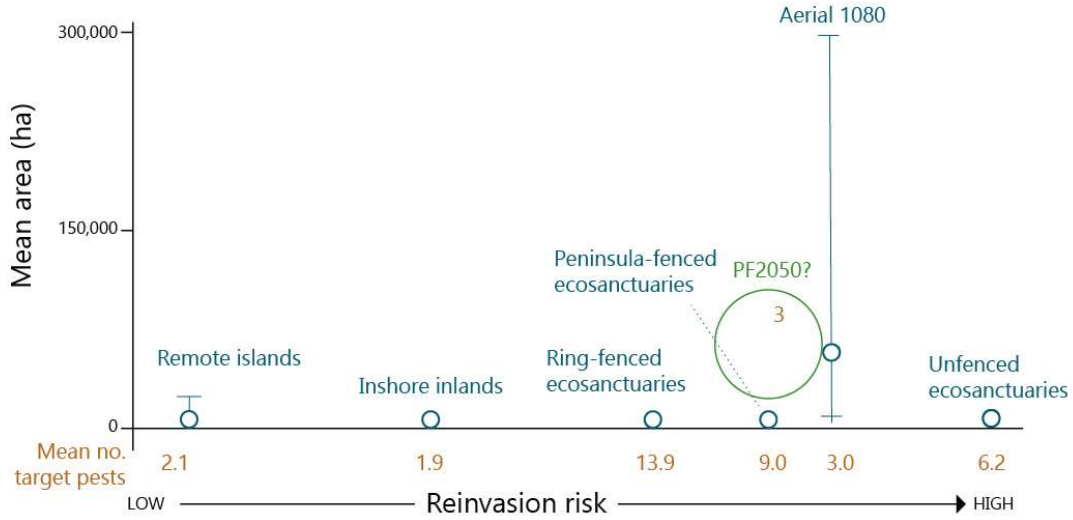

Figure 2. Scale, reinvasion risk (x-axis, scale is relative only), and mean number of pest species targeted (orange numbers) in major pest control regimes in New Zealand. Data are from Table 2 in Innes et al. 2019. PF2050 (green circle) is placed provisionally and subjectively, based on publicised 'pest-free cores' in south Westland potentially being up to 50,000 ha, and being similar to peninsula-fenced ecosanctuaries regarding mammal reinvasion.

Biodiversity responses

Notwithstanding the reinvasions noted above, maintained ring pest fences 'keep out most mammals most of the time' (Elton Smith, pers. comm Orokonui operations manager, 2015), which has spectacularly enabled the return of some highly vulnerable taxa to the mainland after years or decades of extirpation due to mammal pests, including tuatara (*Sphenodon punctatus*), Cook Strait giant weta (*Deinacrida rugosa*), Hamilton's frog (*Leiopelma hamiltoni*), little spotted kiwi (*Apteryx owenii*), North and South Island saddlebacks, hihi (*Notiomystis cincta*), and (in 2023 to Maungatautari) kākāpō (*Strigops habroptilus*).

There are also numerous other endemic forest birds such as kākā (*Nestor meridionalis*), tūī (*Prosthemadera novaeseelandiae*), North Island robin (*Petroica longipes*), and red-crowned kākāriki (*Cyanorhamphus novaezelandiae)* that become adundant in fenced ecosanctuaries and spill over into surrounding landscapes (Miskelly 2018; Bombaci et al. 2018; Fitzgerald et al. 2019). Increasing endemic bird densities also results in increased mutualism processes such as seed dispersal (Bombaci et al. 2021).

There is now widespread evidence that endemic New Zealand forest birds have an 'Achilles heel' of vulnerability to mammalian predation but once freed of this they can outcompete more bigeographically recent taxa such as silvereye (*Zosterops lateralis*), grey warbler (*Gerygone igata*), and fantail (*Rhipidura fuliginosa*) (Miskelly 2018; Fea et al. 2020; Binny et al. 2021). Being mammal pest-free is also likely to benefit wetland birds (Miskelly et al. 2023), and there is evidence for this at Rotokare Scenic Reserve with spotless crakes (*Porzana tabuensis*) and fernbirds (*Bowdleria punctata*) (Fiona Gordon, pers. comm., Rotokare Scenic Reserve Trust Conservation Manager, 2024).

Several studies suggest that although biodiversity responses to all major regimes are positive, benefits are greater when more pest species are entirely absent, both on the mainland and on islands (Fea et al. 2020; Binny et al. 2021; Miskelly 2018). This is not surprising given the diverse possible impacts of rodents, pigs, mustelids, cats, hedgehogs, and ungulates, and the plethora of possible synergies between plants, invertebrates, and vertebrates, of which only a few have ever been studied.

Pest fencing is also routinely now used for the protection of vulnerable single species, including lizards (Turner & Norbury 2023), seabirds, kiwi (in crèches and 'kōhanga' – kiwi farms, especially western brown kiwi [*Apteryx mantelli*] on Maungatautari), and takahē at the breeding facility at Burwood Bush, Te Anau, and on the 17 island or pest-fenced ecosanctuaries that are scattered but safe breeding sites for them.

Visitor numbers, education, and research

Most pest-fenced ecosanctuaries depend on and welcome visitors, volunteers, and students and so are significant advocacy sites for pest control and its associated restoration. Tourism is a viable way for visitors to assist in supporting operations at pest-fenced ecosanctuaries. In 2022/23:

- Maungatautari had 15,452 visitors, of which 27% were international; 192 volunteers contributed 14,749 volunteer hours; and there were 3,699 education visits to the maunga
- Zealandia had 136,327 visitors and 526 volunteers (Zealandia 2023)
- The Brook (Nelson) received 16,457 paying visitors and 3,969 free-of-charge entries, and 300-plus volunteers delivered 28,247 volunteer-hours in (Brook 2023)
- Orokonui (Dunedin) had 12,593 self-guided visitors and 761 guided visitors; volunteers there donated 4,466 hours of labour, and 2,382 students from 50 education providers (early childhood to tertiary) participated in the Education Programme (Orokonui 2023).

Rotokare has about 32,000 visitors annually (free entry); about 2,200 students visit through the education programme; 290 people took paid night-tours in 2022/23, and volunteers contribute about 10,000 hours per annum on average (Fiona Gordon, pers. comm., Rotokare Scenic Reserve Trust Conservation Manager, 2024). There are c. 230,000 visitors annually to the peninsula-fenced Tawharanui (North Auckland).

As with island eradications, there have been numerous scientific publications about the mechanics, strategies and outcomes of pest-fenced ecosanctuaries, but no ecosanctuaries

employ researchers, nor do they have volitional research funds available. They are therefore dependent on fundraising, and on nearby universities and other tertiary institutes or Crown Research Institutes, to do most research.

5.3 Origins and attributes of PF2050

5.3.1 Origins of PF2050

While there had been significant pushes for a predator-free New Zealand by various organisations and individuals, the acknowledgement for publicising the PF2050 concept is frequently (e.g. DOC 2020b, p. 20) credited to Sir Paul Callaghan, who spoke to a Wellington audience in February 2012 about Zealandia and the possible benefits of extending such actions.[2] However, Sir Paul clearly said that there should be 'twelve' 100,000 ha pest control zones placed carefully in intact, connected ecosystems around New Zealand as a starting point for making New Zealand predator-free. He suggested that each zone should consist of a 1,000 ha pest-fenced ecosanctuary surrounded by 10,000 ha of unfenced ecosanctuary and then 89,000 ha of less intensive pest control, perhaps aerial 1080.

In 2016, however, politicians took his next suggestion of removing a reduced number of key pests from all of New Zealand and provided funds to embark on this while skipping his suggestion of spaced biodiversity restoration zones centred on pest-fenced sanctuaries. During the 2016 IUCN World Conservation Congress in Honolulu, Hawaii, there were calls for greater action to address invasive alien species to protect biodiversity and human well-being. The New Zealand Government made the commitment that 'the country will be free of the most damaging invasive alien species (rats, stoats, possums) by 2050'.

The *intent* was that in the long term (by 2050) New Zealand would be free of the three perceived key pests of forest fauna; one unintended *outcome* was that in the short to medium term (to 2024) no more large, pest-fenced ecosanctuaries have been built, although one (at Wainuiomata) has been mooted (Lynch 2021).

5.3.2 Attributes of PF2050

There are hundreds or even thousands of very diverse PF2050 sites throughout New Zealand, but broadly two kinds of project: those conceived and structured by the PF2050 programme, and myriad others in the wider PF2050 movement. I am unclear what pest control projects may *not* be now regarded as part of a 'wider PF2050 movement' or 'wider PF2050 projects'.

The PF2050 5-year progress report lists relevant funding to include all (now ceased) Jobs for Nature projects, plus all of DOC's National Predator Control Programme (formerly Tiakina Ngā Manu), plus other work of OSPRI, DOC, philanthropists, regional councils, local

[2] https://www.youtube.com/watch?v=noIP5lbuJHk.

communities, private landowners, iwi, and numerous others. I am not aware of any structured prioritisation of these sites, as is also the case with pest-fenced ecosanctuaries. The roughly 20 Pest Free 2050 Ltd 'landscape-scale projects' were partly determined commercially ($2 leveraged local funding for each $1 PF2050 funding was required), and they needed to be willing, so to some extent they were self-selected. Numerous sites seem to have been selected on peninsulas and islands and between rivers and mountains where mammal reinvasion may be restricted.

Just like pest-fenced ecosanctuaries, the vision of the PF2050 strategy is about biodiversity recovery; i.e. to 'Return the voices of the insects, bats, reptiles, and birds back to the forests, farmland, towns, cities and coasts' (DOC 2020, p. 9).

5.3.3 Conservation achievements of PF2050

Number of pest mammal species removed, remaining, and reinvading

Across broad New Zealand mainland landscapes most PF2050 site projects inevitably have large suites (6–15 species) of pest mammals present. Currently only a few of the pest species present are targeted, although which mammals should be included in the PF2050 strategy is now being reviewed.

The present suite of target species for PF2050 is ship rats, Norway rats, kiore, stoats, ferrets, weasels and possums (DOC 2021), but there are no Predator Free 2050 Ltd landscape sites that target all of these. Other potential targets have received little scrutiny but may be controlled in some projects.

Predator Free 2050 Ltd (one part of the PF2050 programme) has contributed funding to about 20 'landscape-scale projects' averaging 43,700 ha of pest control, mostly on mainland New Zealand. 'Rats' (species not stated) are targeted for 'eradication' at only six sites, while 'rats' and 'predators' are to be 'suppressed' at a further eight sites. The remaining six sites target either stoats or possums, or both. Only ZIP is targeting all three of ship rats, stoats, and possums for eradication at scale in a mainland forest (south Westland, a project jointly funded by Predator Free 2050 Ltd, DOC, and others).

In fact, eradication as defined by the IUCN ('complete and permanent removal of all wild populations of a species from a defined area by means of a time-limited campaign', Bomford & O'Brien 1995) is currently impossible because reinvasion cannot be stopped with current tools. Some projects funded by Predator Free 2050 Ltd now instead aim at 'elimination', meaning that 'a small number of animals may exist within a predator-free site until they are detected and removed' (Cook & Mulgan 2022). Target indices or densities to which species should be suppressed are not stated.

Previous modelling suggested that the most cost-effective way to locally eliminate possums in perpetuity was to remove all residents, followed by perimeter control to intercept reinvaders (Morgan et al. 2006). Only three toxins (1080, brodifacoum, pindone) are legally registered for aerial application in New Zealand, and of these only 1080 is widely used for sustained predator control on the mainland. The method of choice for early trials attempting local elimination of possums, black rats, and stoats together has

been two or more applications of pre-fed 1080 (Nugent et al. 2019; Nichols et al. 2021). Only a small number of these '1080 to zero' operations have so far been monitored, yielding similar mixed results as aerial 1080 used conventionally (single pre-feed and single operation) (Nichols et al. 2021; O'Malley et al. 2022) and so requiring numerous 'mop-up' smaller (c. 1,000 ha) aerial 1080 operations.

Large-scale PF2050 trial sites run by ZIP include 'virtual fences' comprising multiple lines of closely spaced traps to intercept reinvaders at the operation perimeter, but not all invaders are intercepted (Bell et al. 2019). ZIP's current main approach in south Westland is to target reinvading pests in a 'buffer zone' to protect a 'core' inside it, but, while promising, it is too early to evaluate its success. This project is trialling a large-scale regime of removing ship rats, stoats, and possums and then detecting and removing reinvaders, especially in the buffer zone.

Biodiversity responses

Despite the clear biodiversity driver for Predator Free 2050, there has not been a strong focus on measuring biodiversity gains so far in most Predator Free 2050 Ltd or ZIP landscape-scale projects, although in fairness there has been much less time to measure and report on responses than has been possible in pest-fenced ecosanctuaries and island eradications that started decades ago. In the Capital Kiwi project near Wellington, mustelid suppression enabled the translocation of western North Island brown kiwi back to the site. Tracking of target pests towards elimination and some biodiversity outcome monitoring are undertaken at all ~20 large Predator Free 2050 Ltd landscape projects, but there is no coordinated monitoring of pests or outcomes across sites, nor did DOC prescribe this for ZIP's large-scale project in south Westland until 2024.

The outcomes of aerial 1080 operations for New Zealand's indigenous species are diverse and complex, because several mammal pest taxa are killed in the same operation. It is frequently difficult to attribute outcomes to the reduction of a particular pest species unless just one pest causes the impact, such as foliage consumption by possums alone. Vegetation generally benefits from possum control (Byrom et al. 2016). Stoat control increases the survival and nesting success of large-bodied birds such as whio (*Hymenlaimus malacorhynchos*, Steffens et al. 2022) and kea (*Nestor notabilis*, Kemp et al. 2018).

Some uncertainty remains about the long-term population benefits of repeated aerial 1080 operations alone for small forest birds, which are vulnerable to ship rat predation as roosting or nesting adults. Ship rat control improves nesting success of rat-vulnerable birds immediately following aerial 1080 operations, but without intercepting reinvaders the benefits are short-lived (Powlesland et al. 1999; Bell et al. 2021). The mean duration of bird monitoring projects after 10 aerial 1080 operations assessed by Byrom et al. (2016) was only 2.2 years. There are no long-term (10-plus years) data of the abundances of forest birds in areas subjected to 1080 alone (without trapping in the intervening years).

Many species, including forest birds, do not need to be at pest-free sites to be increasing or abundant (Norbury et al. 2015; Byrom et al. 2016; Binny et al. 2021). North Island kokako have recovered at unfenced ecosanctuary sites, but even they do better when all

mammals are absent; growth rates of translocated North Island kokako on Maungatautari have been the fastest observed anywhere by the Kokako Recovery Group. PF2050 projects can reasonably assume that there will be diverse benefits from effective control of all of ship rats, stoats, and possums at any forested site, and there is evidence that biodiversity responds most when residual numbers are extremely low (Binny et al. 2021).

Visitor numbers, education, research

The wider PF2050 movement operates in such a diverse and geographically spread way that it does not have core focus sites that the public go to see, unlike pest-fenced ecosanctuaries. It does, of course, have huge public participation, valuably guided by the DOC- and philanthropist-funded Predator Free NZ Trust (founded 2013). The Trust's role is 'to support the grassroots predator free movement with a mission to connect and energise all New Zealanders towards a predator free Aotearoa'.[3]

The wider PF2050 movement also has substantial research funding, via DOC, ZIP and its associated philanthropists, and especially Predator Free 2050 Ltd. There are about 50 research and development initiatives underway to advance PF2050, funded by Predator Free 2050 Ltd, and numerous collaborating agencies and technical companies (Tompkins 2018; Murphy et al. 2019; DOC 2021, Appendix A; DOC 2024, Appendix 1). Investigations span species-specific toxins, social and cultural acceptance of control methods, animal behaviour and personalities, pest genomics, lures, traps and monitoring devices, and technology to send notifications and digital images of detected or trapped pests to managers via cellular or satellite networks. The PF2050 vision also undoubtedly assisted the chances of successful funding of Endeavour programmes by the Ministry of Business, Innovation and Employment, such as Manaaki Whenua – Landcare Research's 'Eradication science', exploring why some individual pests survive eradication attempts.

As is typical with research, there is likely to be much information gathered that makes a difference in the medium to long term. There are already many new gadgets, such as re-setting traps, auto-dispensing lures, and several kinds of remote detection devices that send signals to operators. These have already been used in pest-fenced ecosanctuaries; for example, to locate and remove reinvading individual stoats and rats. There are some new minor pest control techniques, such as putting toxin in dead rats to target stoats (Nichols et al. 2022), but no substantial new breakthroughs in terms of pest control methods. The main tool used by ZIP in south Westland (pre-fed aerial 1080) was already well known, although their strategy to subsequently detect and remove all reinvaders is new and will be significant if verified to cost-effectively control ship rats, stoats, and possums to near-zero density, and to restore pest-sensitive taxa to large mainland areas.

[3] https://predatorfreenz.org/about-us/predator-free-new-zealand-trust/our-mission.

5.4 Contributions of the existing fenced sanctuary network to PF2050

The main current contributions of the existing fenced sanctuary movement to the PF2050 vision are as follows.

- **Pest-fenced ecosanctuaries demonstrate spectacular and conspicuous biodiversity gains at mainland sites, including in Wellington and Auckland, that previously were confined to inaccessible, offshore islands. These gains, and diverse others from predator suppression, fuel and sustain ongoing political and public support for PF2050, even though there are currently no tools other than pest fences that can stop reinvasion of diverse predators, which means achieving PF2050 with the current tools is unachievable. In other words, pest-fenced sites routinely demonstrate biodiversity gains that PF2050 cannot currently (or for the foreseeable future) achieve.**
- Fenced ecosanctuary sites enable visitors, volunteers, and students to experience the biodiversity benefits of being predator free and so are sharp focus sites for PF2050-supportive advocacy. The use of pest-fenced ecosanctuaries as education sites is an investment in future 'wider PF2050' activities.
- Pest-fenced ecosanctuaries have yielded insightful data for PF2050-relevant research about pest behaviour, detection, and control (Innes et al. 2018; Watts et al. 2022); biodiversity outcome responses, including spillover, movement, and connectivity between sites (Binny et al 2021; Burge et al. 2021); and social processes associated with project leadership and participation (Campbell-Hunt et al. 2010; Campbell-Hunt & Campbell-Hunt 2013). Research learnings related to the growing abundance of minor and less-studied pests such as weasels and mice in ecosanctuaries will be very valuable for PF2050.
- Ecosanctuaries hold a significant amount of the country's knowledge on restoration and are carrying out most of the pioneering and ambitious restoration actions attempted on mainland New Zealand, but they are generally not included in national conversations. There should be more active knowledge sharing, exchange, and discussion between ecosanctuaries and PF2050 about 'difference made' and how it is achieved.
- Ecosanctuaries generally work very effectively with iwi partners. Maungatautari, for example, has iwi and non-iwi co-chairs. This is not at all to imply that other agencies do not work also effectively with iwi.
- Ecosanctuaries have dealt with and are testing methods to reduce native species by-kill while maintaining effectiveness for catching mammals. These conflicts will increase as diverse endemic taxa become more widespread, while the need for mammal control will continue.
- Biodiversity halos around fenced ecosanctuaries catalyse community riparian restoration and wetland stewardship and associated predator control, fuelling a movement to greener farming and greener cities.

5.5 Similarities in and differences between pest-fenced ecosanctuaries and the PF2050 programme

Comparisons of pest-fenced ecosanctuaries and the PF2050 programme are summarised in Table 2.

Table 2. Attributes of pest-fenced ecosanctuaries and the PF2050 programme

	Pest-fenced ecosanctuaries	PF2050 programme
Vision	Restore biodiversity, including the most pest-sensitive	Restore biodiversity, but not the most pest-sensitive, because not all pests are targeted (except on islands)
Sites	14 nationwide (depending on definition)	c.20 at landscape scale plus numerous smaller projects
Geographical scale	Mostly small (<500 ha). Only Maungatautari is large (>3,000 ha)	From Miramar (800 ha) to extremely large. Predator Free 2050 Ltd landscape projects average 43,000 ha. Aerial 1080 totals c. 600,000 ha annually.
Target species	Up to 15 (all species present), but mice frequently persist	On mainland, 1–3, mainly ship rats, stoats, and possums (the main 'system-changer' species)
Biodiversity outcomes	Known. Enable any pest-sensitive taxa to recover	Assumed. Has not yet demonstrated significant biodiversity gain, but brown kiwi were returned to Capital Kiwi near Wellington.
Research	Fund raise. Use local tertiary institutes and CRIs. Focus on biodiversity outcomes, including spillover.	Substantial capability, especially Predator Free 2050 Ltd. Focus on control and monitoring tools and their application; pest behaviour.
Advocacy	Online and on-site. Demonstrates the biodiversity restoration vision as a here-and-now outcome.	Online and national, especially via DOC and Predator Free NZ Trust.
Volunteers	Crucial, active	Important at many mainland sites
Education	On-site, active	Online, active, especially via DOC and Predator Free NZ Trust
Funding	Insecure. No new investment since The Brook (2016).	More secure. Constant new substantial investment.
Coordination	Use SONZI as a national social and support network, but substantially operate alone.	Primarily via DOC 'backbone' team, plus Predator Free 2050 Ltd, ZIP, Predator Free NZ Trust.
Risk	Perceived as expensive to build and maintain, but costs and benefits known	Costs and benefits not yet known. Risks huge expenditure and complete failure, like all eradication attempts.

Pest-fenced ecosanctuaries and PF2050 nominally share the same biodiversity restoration vision, both rely on staff and volunteers and undertake advocacy and education. However, they operate at very different scales, target significantly different proportions of the mammal species present, and measure biodiversity outcomes differently. Whether controlling just 'rats, mustelids and possums' will enable restoration of the most pest-

vulnerable endemic species, such as kākāpō, takahē, hihi, saddlebacks, which may be of most interest to New Zealanders remains to be seen.

In terms of actual experience with restoration, pest-fenced ecosanctuaries are decades ahead of PF2050, and pest-fenced ecosanctuary staff have much knowledge about managing threatened species, such as how to do ongoing pest control when highly threatened taxa are present as potential non-targets.

Notwithstanding the shared vision and numerous shared tools, ecosanctuary practitioners do not feel part of the PF2050 movement. I sought views on this from attendees at the August 2024 annual SONZI workshop. Regarding the statement 'I feel part of predator-free NZ' (one vote per attendee), 6 strongly disagreed, 30 disagreed, 12 didn't know, 16 agreed, and 1 strongly agreed. Regarding the statement 'My project is under the PF2050 umbrella' (one vote per attendee), 45 strongly disagreed, 8 disagreed, 3 didn't know, 4 agreed, and 1 strongly agreed.

My explanations for this disjunction are as follows.

- As stated earlier, ecosanctuary practitioners cannot find themselves in key documents such as the PF 2050 strategy and all of its subsequent reports, despite their decades of innovative, energetic, and effective contribution to this cause. The PF2050 interim implementation plan (DOC 2024) has a section titled 'Who is involved in Predator Free 2050?' and this lists DOC, iwi, Predator Free 2050 Ltd, Predator Free NZ Trust, ZIP, and regional councils. The definition of 'community group' (in the glossary, p. 43 of the PF2050 strategy) is too narrow because ecosanctuaries are clearly nationally significant. The PF2050 5-year progress report lists (p. 19) 'organisations that contribute' to the PF2050 collaborative groups, including those focussed on 'Communities taking action', 'Advancing our knowledge, innovation and development', and 'Moving from sustained predator control to eradication;' neither ecosanctuaries nor SONZI are represented here. The PF2050 interim implementation plan 2024–2030 has a 10-page work programme with 43 tasks and named 'Leaders', none of which are pest-fenced ecosanctuaries.
- PF2050 is perceived as having huge expenditure in a climate of sparse resources for conservation, while the goal of eradicating pest mammals without fences is widely perceived in the ecosanctuary movement to be impossible. This is reinforced by actual failed outcomes of all attempts to eradicate on the mainland so far, and the subsequent language changes (especially changing from 'eradicating' to 'eliminating') sought by sectors of PF2050 in response. In contrast, ecosanctuary practitioners have always been open about pest presence and the possibility of reinvasion, and the value of pest suppression if eradication cannot be achieved.
- Ecosanctuaries always sought to be larger, and restoration needs to happen at many more places, but the widespread adoption of PF2050 is coincident with the cessation of this 'organic' growth, perhaps by diversion of scarce research and implementation resources.
- There has been no regular interest shown by PF2050 project leaders or DOC staff in attending annual SONZI workshops, although PF2050, the Predator Free NZ Trust, and DOC staff have all willingly and valuably accepted invitations to speak over the years.

My own view is that islands are a parallel strand to ecosanctuaries in that expert island eradication staff were not consulted nor involved much, perhaps until the 2021 formation of the National Eradication Team, who have 'developed a proactive island's plan, are delivering biosecurity response work and the PF2050 budget contributes funding to enable' (Brent Beaven, DOC, pers. comm., 2024).

It is clear that both ecosanctuary and larger-scale (e.g. PF2050) strategies may be valuable and complementary, but there is no conspicuous integration of their value propositions anywhere. In the present biodiversity crisis in New Zealand (DOC 2022), the costs and benefits of different regimes should somewhere be tabled and discussed, and difficult decisions taken about priorities for expenditure. Perhaps this occurs already inside DOC, but the ecosanctuary movement is now substantially independent of DOC and could be included more as a valued and trusted partner. This integration should presumably be led by the Biodiversity Strategy, and there should be underpinning science-based application of a reasoned site prioritisation system (e.g. Overton et al. 2015; Ribeiro & Atadeu 2019; Hernandez et al. 2021; McKessar et al. 2020; Leathwick et al. 2023). Regional operations plans were also recommended in a recent independent review of the New Zealand conservation management planning system (Koolen-Bourke et al. 2023).

Pest fences are perceived to be expensive to build and maintain (Scofield et al 2011), but nobody has ever costed the alternative of how much it would be to control all c. 14 pest mammal species at one site and maintain a core area of zero density for all target pests, without fences. Norbury et al. (2014) did such an analysis on protecting lizards in Otago, but did not have the usual full suite of mainland mammals (e.g. rats) as targets. Nor have the biodiversity gains in pest-fenced ecosanctuaries ever been valued in economic terms as returns for the investment.

The main risk of PF2050 – like all eradications – is that deciding to embark on something that is currently unachievable may have large opportunity costs for little final gain. That is, the risk is that 'A flawed conservation policy displaces higher priorities and better, evidence-based alternatives' (Linklater & Steer 2018). So far, 'key PF2050 policy and public discussion includes little consideration of either the possible harms or benefits of falling short of nationwide eradication' (Palmer & McLauchlin 2023).

It is also likely that PF2050 activities and outcomes will have effects on pest-fenced ecosanctuaries, although this report is mainly about the reverse influence. Might an effective PF2050 campaign outside an ecosanctuary result in more weasels and mice in the outside community? Might more trap-shy target individuals reinvade the ecosanctuary? How could a PF2050-led buffer zone outside an ecosanctuary be best designed to minimise invasion pressure on the sanctuary and maximise biodiversity outcomes?

5.6 Ways for pest-fenced ecosanctuaries and the PF2050 programme to work better together

5.6.1 Possible future contributions of pest fencing to a PF2050 field programme

The history of fencing as a tool to exclude diverse animals in New Zealand is described by Burns et al. (2012). While trials of various kinds have spanned decades, there is undoubtedly huge scope for further development of new fence designs for diverse objectives.

Possible current applications with known outcomes

The following applications of existing pest-fence designs have known positive outcomes that would support the PF2050 vision and programme.

- Build more large (>3,000 ha) pest-fenced ecosanctuaries in priority, connected sites, surrounded by zones of landscape-scale control using 'best PF2050 methods'. In this way, pest-fenced ecosanctuaries and PF2050 would be working together at the same site. A first step could be to model the costs and benefits of something like the 100,000 ha core-and-two-buffers concept of Jim Lynch and Sir Paul Callaghan. One could be experimentally constructed somewhere as a trial template, effectively merging pest-fenced ecosanctuary and PF2050 regimes and strategies. The Brook Waimārama sanctuary at Nelson is surrounded by Nelson Council and DOC land and is 'shovel-ready' as a trial core-and-buffer site. Possible benefits to biodiversity of the mooted Wainuiomata Ecosanctuary are described by Pindur (2021). There are also opportunities around such cores and buffers to trial 'conservation evolution' (Urlich 2015) or 'coexistence conservation' (Evans et al. 2022), which mitigate predation impacts by changing the relationships between predators and prey rather than just killing predators (Manning et al. 2021).
- Build more pest-fenced ecosanctuaries in urban areas. One example is the mooted Waiwhakareke Natural Heritage Park, a 65 ha site adjacent to Hamilton Zoo, where enrichment planting into pasture started in 2004 and a pest fence is planned (Clarkson & Kirby 2016). Inevitably, available sites are small but they have the advantage of numerous volunteers and visitors.
- Build more rodent ('low') fences around food-processing industrial sites (Figure 3). This removes the need for traps and bait stations to be scattered and checked throughout the sites, and exemplifies the benefits of being pest-free for a not-conservation sector.

Figure 3. 'Low' or 'rodent' fences built to protect food-processing sites in the North Island.

- Build numerous small, special-purpose fences to protect particular fauna, such as built already for grand and Otago skinks, robust grasshoppers, creched kiwi, or colonial seabirds. A 'low fence' (also known as a '10-pest fence') may be sufficient if cats and deer that can jump over it are not key problems. Pest fences are ideal for protecting conservation assets that are very confined. This would include many lizards, frogs, invertebrates, and seabird colonies.

Possible new applications of pest fences

- Place low or 10-pest fences around forest fragments, perhaps by adding to existing post-and-wire stock fences. Cats and deer that may jump over the fence would need to be dealt with in other ways. Such fences would enable most conservation pests to be eradicated inside the fragments. They would add next-generation protection to sites such as significant natural areas and QE II covenants.
- Build short fences (perhaps in combination with lighting and with natural landscape barriers such as rivers) to manoeuvre pests towards smart killing devices. Devices are already placed outside many pest fences and at peninsula fence-ends, but perhaps fences hundreds of metres long could be placed strategically in landscapes. A recent example of a fence being used to constrain pest movement is the mesh fence constructed to impede dama wallaby (*Notamacropus eugenii*) dispersal outside Whakarewarewa Forest, Rotorua.

In aggregate and with appropriate branding and communications, diverse, mostly small pest-fenced ecosanctuaries could become public icons of the PF2050 vision and programme, with examples in forests and other natural landscapes as well as on farms and in cities.

5.6.2 Other ways that pest-fenced ecosanctuaries and PF2050 can work together better

- Include mention of pest-fenced ecosanctuaries more explicitly in key PF2050 planning documents so that ecosanctuary practitioners and the wider PF2050 community can more see them there. The successes of pest-fenced ecosanctuaries in eradicating most mammals most of the time and achieving conspicuous biodiversity benefits are big communications gains for PF2050.
- Include both ecosanctuaries and PF2050 in a reasoned, integrated, and prioritised Biodiversity Strategy implementation plan so that strategic roles for both are clearly identified. Such planning should be regional as well as national, and should make clear that ecosanctuaries have more focus and expertise on biodiversity restoration than PF2050 does, and so ecosanctuaries are already in the restoration space that PF2050 is heading into. More comprehensive regional restoration planning would:
    - help ensure that both PF2050 and ecosanctuary projects align with overarching goals;
    - assist organisations to be complementary;
    - help both ecosanctuaries and PF2050 to target their efforts at nationwide species priorities;
    - enable more reasoned decisions about which projects (such as Wainuiomata) should be implemented. Currently, ecosanctuaries get very little support with threatened species work, despite holding the only mainland populations of some species.
- Celebrate and champion the known biodiversity gains in pest-fenced ecosanctuaries as short- to medium-term exemplar gains for PF2050 as a whole, so that ecosanctuaries can more proudly carry the PF2050 flag with due acknowledgement.

- Use the high visitor numbers in ecosanctuaries to publicise the larger PF2050 efforts. That is, use pest-fenced ecosanctuaries as this-is-what-it-looks-like 'shop windows' to a PF2050 future. Higher visitor numbers would result in greater input of tourist dollars to a wider PF2050.
- Support struggling, key, pest-fenced ecosanctuaries with some PF2050 funding. It seems wrong that New Zealand's only large ring-fenced ecosanctuary (at Maungatautari), which enabled the return of kākāpō to the New Zealand mainland after a 26-year absence and has a 40,000 ha halo, is financially imperilled in 2024 when numerous PF2050 landscape-scale projects are being funded for the suppression of one to three pest species for no priority biodiversity gain.
- Consider how pest-fenced ecosanctuary projects could continue to be used as research partners for shared agendas. Options include: undertaking trial releases of pests to see how they behave in a congeneric-free environment (e.g. Innes et al. 2011); studying the biodiversity outcomes of pest removal; and studying the movement and behaviour of valued taxa out of pest-fenced ecosanctuaries, so that the true scale of possible benefit of pest-fenced ecosanctuaries is better revealed. The PF2050 programme is driving a substantial R & D programme that has already had value for pest-fenced sanctuaries (devices to locate reinvading stoats), but (to my knowledge) pest-fenced sanctuary people have had little input into that programme.
- Link PF2050 projects more closely to known, urgent biodiversity restoration challenges and opportunities. Both kākāpō and takahē recovery programmes are urgently seeking substantial new areas (>30,000 ha) as mainland breeding sites because existing sites are 'full'. These may be too large to be fenced, but this action would marry PF2050 priorities with those of current biodiversity more clearly, immediately embedding unfenced ecosanctuaries into the PF2050 landscape movement.
- Define restoration language for all PF2050 participants, especially regarding 'eradication' vs 'elimination' and other equivalents.
- Consider how or if an annual combined PF2050–ecosanctuaries technical workshop would help to get key practitioners to get to know each other and to feel they are working more together. Careful thought would be needed to make such a meeting worthwhile, given the other meetings currently held. The present SONZI meeting could be a template.

6 Conclusions

Ecosanctuaries and PF2050 share the same vision but operate at different geographical scales, and with different outcome emphases and funding, and their possible reasoned, joint, and prioritised contributions to agreed regional and national biodiversity strategies are described nowhere.

The PF2050 vision has captured the hearts and minds of thousands of New Zealanders, and the PF2050 programme has funded valuable research and trialled at least one significant new potential pest control regime (in south Westland). Unfortunately, it has also left some of its most valuable potential supporters behind by a funding focus on

approaches that are large-scale, expensive, and quasi-experimental, instead of 'more reasoned conservation alternatives' (Linklater & Steer 2018). Consequently, New Zealand small mammal and social researchers have frequently suggested alternative approaches for PF2050 (Parkes et al. 2017; Peltzer et al 2019; King 2023; Leathwick & Byrom 2023; Palmer & McLaughlin 2023; Samaniego et al. 2024).

Pest-fenced ecosanctuaries are barely acknowledged in PF2050 literature, including the PF2050 strategy, despite having pioneered the mainland eradication of multiple pest mammals and documented the resultant and ongoing spectacular mainland biodiversity responses. As a result, ecosanctuary practitioners do not feel part of PF2050 in 2024. New Zealand cannot afford such a schism in national biodiversity restoration at this time of critical declines and scarce conservation resources, when these two parties share the same vision and have so much to offer each other.

7 Recommendations

I suggest that the following actions will assist pest-fenced ecosanctuaries and the Predator Free 2050 programme to work together better.

- Acknowledge the achievements and the current and future relevance of pest-fenced ecosanctuaries more thoughtfully in key PF2050 planning documents so that ecosanctuary practitioners can actually see themselves in them, that their aims align, and that their efforts are communicated to the wider PF2050 community.
- Frame, acknowledge, and celebrate the demonstrated biodiversity gains made by pest-fenced ecosanctuaries as short- to medium-term exemplar gains for PF2050 as a whole, so that ecosanctuaries can be fairly acknowledged for this significant contribution.
- Use the high visitor numbers in ecosanctuaries to publicise the larger-scale, unfenced, PF2050 efforts.
- Write both PF2050 and ecosanctuaries into joint, integrated, and prioritised Biodiversity Strategy implementation plans so that strategic roles for each and synergies between them are clearly identified. Such planning should be regional as well as national.
- Support struggling, key, pest-fenced ecosanctuaries with some PF2050 funding, and consider relevance to ecosanctuaries when choosing PF2050 research projects.
- Explore building more pest-fenced ecosanctuaries, starting with renewed consideration of the value proposition presented at Wainuiomata (Lynch 2021). Reconsider the costs and benefits of the 100,000 ha core-and-two-buffers concept of Jim Lynch and Sir Paul Callaghan. This would enable both regimes to work together at a common site towards the same objective.
- Build more pest-fenced ecosanctuaries in urban areas, build more rodent fences around food-processing facilities, and build numerous small pest fences to protect particular fauna such as lizards, frogs, invertebrates, nesting seabirds, and juvenile kiwi. More experimentally, build '10-pest fences' around vegetation remnants such as significant natural areas and QE II covenants, and trial using fences to manoeuvre

pests towards smart killing devices, perhaps in conjunction with natural landscape barriers such as rivers. All such pest fences could be conspicuously branded as PF2050 devices.

- Define restoration language for all PF2050 participants, especially regarding 'eradication' vs 'elimination' and other equivalents.
- Consider how or if an annual combined PF2050–ecosanctuaries technical workshop would help to get key practitioners to get to know each other and to feel they are working more together. Greater exchange of ideas is needed between diverse practitioners to maximise cohesion and the outcomes of a national biodiversity restoration agenda.
- Consider how pest-fenced ecosanctuary projects could continue to be used as research sites for the broad PF2050 agenda.
- Link PF2050 projects more closely to known, urgent biodiversity restoration challenges and opportunities, such as restoring kākāpō and takahē to 30,000+ ha breeding sites on the mainland, thus embedding multi-species-control, unfenced ecosanctuaries into the PF2050 landscape agenda.

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