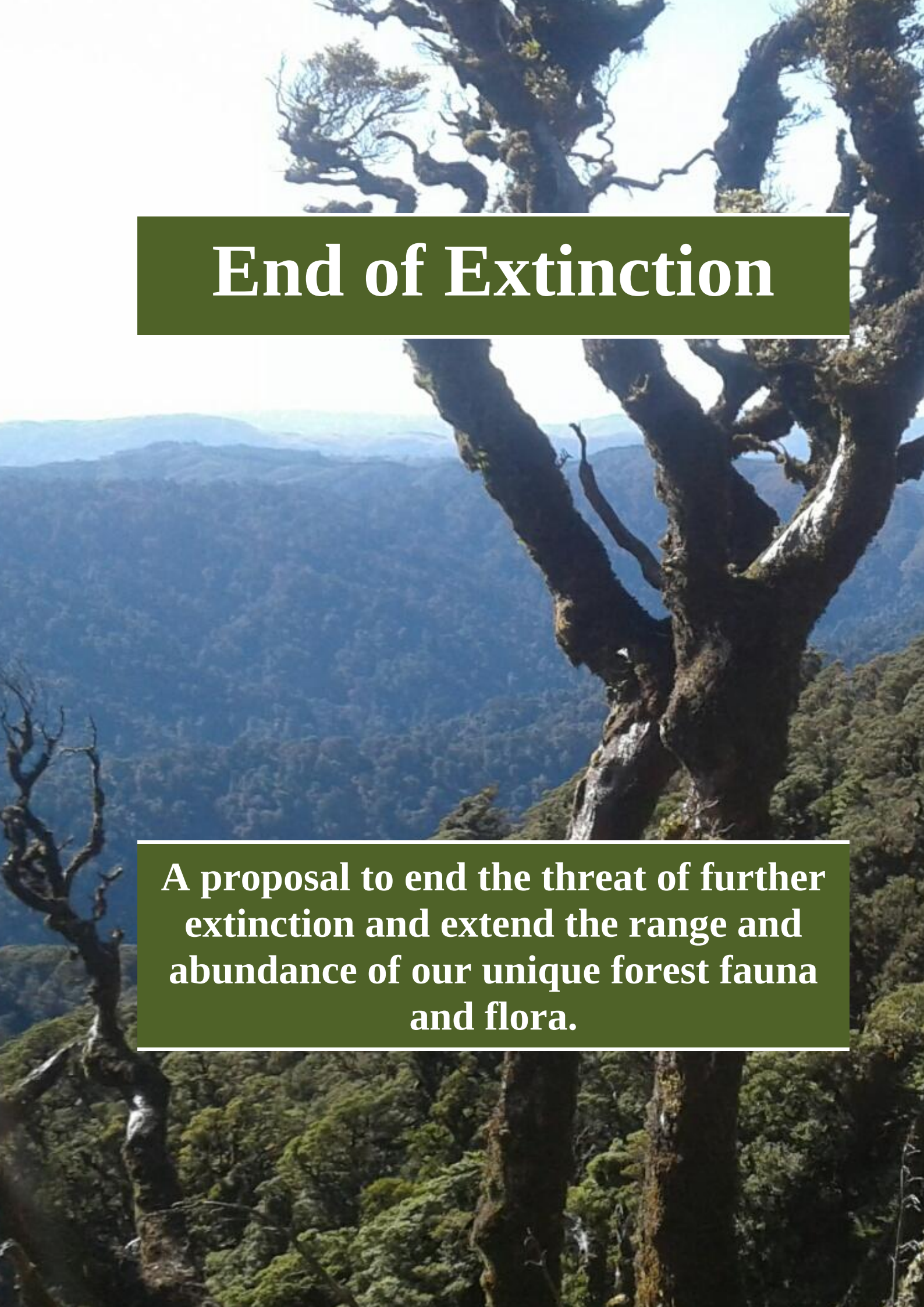
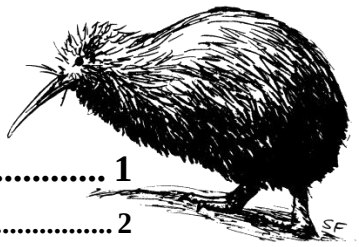


End of Extinction

A proposal to end the threat of further extinction and extend the range and abundance of our unique forest fauna and flora.



Contents

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About the author

James Lynch QSM is the founder and Vice-Patron of Zealandia. His work in conservation has been significant in developing novel solutions (e.g. pest exclusion fencing and community sanctuaries) and the rise of community conservation in NZ over the last 35 years. He has 30-years of experience in designing large scale management systems and training programmes for national scale organisations, including DOC. He has two WCC civic awards and a Queens Service Medal for services to conservation. He has been a board member of Sanctuaries of New Zealand Incorporated (SONZI) and is an authority on fenced eco-sanctuaries.

Part One: The Vision

Aotearoa needs a new vision for our unique biodiversity; one which is inspiring and engaging and will provide a lasting solution to enable us to hand our natural heritage on to the next generations in better condition than we found it.

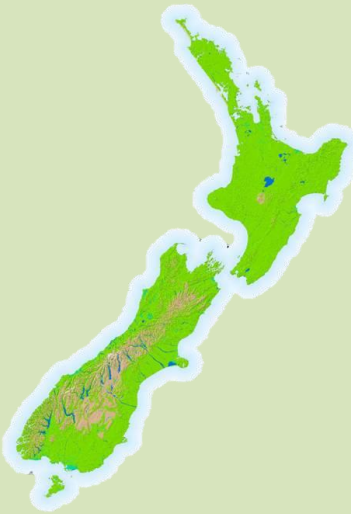
Such a vision also needs to be effective, workable and achievable within a single generation but also practical and realistic given the size and complexity of the task, the nation's priorities and economic circumstances.

This part briefly sets out what makes NZ biodiversity so special and what the current situation is. It then proposes a vision for the near future, (the next fifty years) and outlines the fundamental model which will be needed to achieve that vision.

1.1. Proposal summary

- The 2020 Aotearoa NZ Biodiversity Strategy (ANZBS) *te Mana o te Taiao* describes outcomes and goals which emphasise 'no new human induced extinctions', the improvement of ecosystems, the improvement of status and range of species, cultural well-being, connection with nature, partnerships and economic value.
- Many of our unique and iconic forest species are still at risk of extinction and many others are range restricted and in low abundance. Some species are still largely restricted to pest-free islands or fenced sanctuaries. Our once great forests are in poor condition.
- Our indigenous biodiversity suffers from many intractable problems with the impacts of invasive exotic pest species (predators and browsers) being the most difficult of these.
- Our pest management toolbox is very small and limited and the prospects for its improvement are not encouraging. We depend totally on islands, fencing, hunting and a handful of trap types and toxins.
- Our national biodiversity management is a patchwork of strategies, often with unclear or unrealistic aims which have evolved piecemeal over time.
- Our most effective tool and the only one capable of ensuring 'predator-free' zones on the mainland is pest-exclusion fencing. This method has not been deployed by the key agencies nor are there plans for its use in the future.
- Lessons from the fenced eco-sanctuary movement have shown that long term restoration of species populations and ecosystems is possible with pest-exclusion fencing and the 'halo' effect from fenced areas is potentially effective in aiding migration and increasing species occupancy and abundance over a wide area.
- This proposal is that pest-exclusion fencing, through careful selection of sites and integration with surrounding 'predator free' zones, can produce potentially transformative and cost-effective biodiversity outcomes at a landscape and national scale with existing technology and at a cost within existing broad budget parameters.
- The proposition is that a network of up to ten large (3,000 plus ha) pest-exclusion fenced sanctuaries with surrounding large managed 'predator-free' halo zones (up to 100,000 ha each), spread across the nation to cover representativeness, could end the prospect of extinction for all forest species and greatly expand the range and abundance of many other forest species.
- It would also have the bonus of empowering iwi and engaging communities and could potentially, over time, earn or attract funds to assist in defraying costs.
- These mega-sanctuaries would rapidly become biodiversity, social, cultural and economic hubs for regions as Zealandia has done for Wellington. They would add materially to the local and national economy.
- Such a programme is affordable and can be achieved with existing technology and proven governance structures. The costs and risks are well known and manageable.
- A programme of this nature would materially assist the achievement of many of the key goals of the ANZBS *te Mana o te Taiao*.

1.2. Old New Zealand



New Zealand was once a world where vast temperate rain forests and freshwater swamps covered 87% of the land, reaching from mountains to ocean, and birds, many of them flightless giants, dominated. Sir David Attenborough described Aotearoa as “A window into a world which might have been had mammals never evolved. The land of the birds”.

Separated and isolated from our nearest neighbours for over 60 million years, evolution took a different pathway in these islands. With mammals and snakes being conspicuously absent, birds filled ecological niches taken by these species elsewhere.

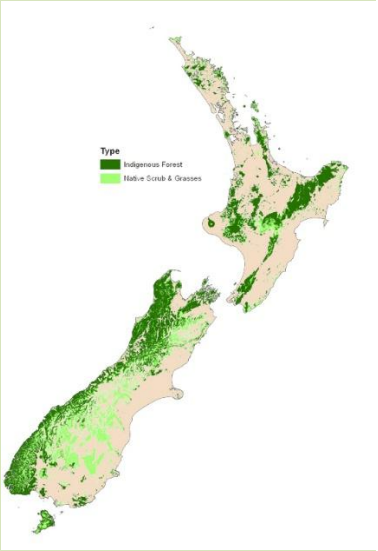
The longer a species lived in New Zealand the slower, larger and more vulnerable it became. With no predatory or browsing mammals and reptiles, our fauna and flora could afford to loaf in the evolutionary slow lane.

New Zealand fauna and flora is not diverse, but it is unique with one of the world’s highest levels of endemism (species found nowhere else). New Zealand’s vast warm and moist forests and extensive wetlands were extraordinarily productive, producing enormous, all-year-round quantities of nutritious nectar, shoots and fruit to support an exceptional abundance of fauna, an abundance which was still intact as recently as 800 years ago and, except for those first arriving Polynesians in the thirteenth century, has barely been witnessed by humans.

Those old New Zealand forests rang with birdsong and hummed with life. They were special and New Zealand was like no other place.

This uniqueness and abundance are the legacy handed to our forebears to appreciate and protect.

1.3. Our Tattered Legacy



That amazing legacy has not been well tended by our forebears and ourselves.

New Zealand was the last large landmass on earth to be populated by humans and our arrival was catastrophic for our unique indigenous fauna and flora.

Since humans arrived in NZ about 800 years ago:

- Our once endless forests have been reduced from 87% coverage of the land to 23% by fire, land clearance and logging. Wetlands have been reduced by 95%.
- What forest that remains is in poor condition, intensively browsed by exotic herbivores, damaged by fire and hollowed out by logging. Its ability to support the abundance of old has been devastated.
- Lowland and coastal forests, especially kauri, podocarp and swamp forests, are particularly diminished with some localised ecosystems being functionally extinct.
- Over 50 of our unique fauna species have become extinct. This is one of the highest extinction rates in the world. Some species cannot exist on the mainland and are restricted to pest-free island reserves, only a disease outbreak or pest invasion away from extinction.
- Our forests are mostly empty of native birds and deathly silent: mere skeletons and shadows of their former glory. In a typical New Zealand forest, 99% of the fauna will be exotic pests.
- The ranges of many recently common species have drastically retracted, and true abundance is now very rare.

There have been some success stories, e.g. pest-free islands, ‘mainland islands’, community sanctuaries and pest control in our forests. Birdlife has bounced back in some cities (e.g. Wellington and Dunedin). Mostly this has done no more than arrest the decline, have localised effects or benefited just a few species. Despite over a century of endeavour and considerable expense, we still have many species at grave risk, abundance is still low, and for many species, their ranges are still retracting

The extent of the damage to our biodiversity is so huge that much of what has been lost to extinction and land clearance is now irrecoverable.

Even the job of preserving and improving what we have left is enormous and will require clever thinking and intense effort over a long period.

This proposal puts forward one option intended to make a significant and long-term difference.

1.4. Imagine…….

It is 2050 and you are entering a large lowland forest somewhere in New Zealand. It is over 3,000 hectares in size and surrounded entirely by a robust 35-kilometre long pest proof fence. All pests have long been removed and are excluded from the area. This forest is one of a chain of ten large similarly fenced sanctuaries spread across New Zealand in prime forested areas.

As you walk through this forest you are immediately struck by the noise and the busyness; large clusters of bellbirds call continuously in a rotating chorus, noisy tui chime and flutter through the branches, flocks of whitehead (mohua in the South Island) trill in a continuous stream, kakariki chatter and flash green through the treetops in noisy groups, flocks of rowdy kaka wheel overhead.

At almost every turn in the track a pair of robins hop down to investigate, families of saddleback leap from branch to branch through the shrubbery, flighty hihi chirp and flutter about, and the 'whoosh' of pigeon wings is everywhere. From the higher branches the long liquid chime of the kokako floats across the forest, lifting above the constant bird song.

As you walk along (and depending on the season) you will be struck by the show of flowers, the crimson aerial swathe of the tall rata and the yellow and red blush of the mistletoe. Closer investigation reveals the massed flowers and fruit of fuchsia, five-finger and hinau. Closer still and you will see the quick movements of lizards and large insects. The undergrowth is dense and varied, with strong signs of growth and rude health, as is the tops of the tall trees which carry a huge load of epiphytes – mini-ecosystems in the air. Where the occasional big tree has fallen, a thicket of seedlings jostles to take its place.

If you are there at dawn you will hear the rising cacophony of chimes and chatter that signal the dawn chorus and, in the evening, the equally impressive dusk chorus rings through the forest as it settles down. As the day birds quieten, the ruru start, followed shortly by the shrill calls of kiwi echoing through the dense forest from every swale and valley. In the breeding season, kakapo boom from the central ridges.

If you walk out to the river, you will see the pairs of blue duck which space themselves out carefully along the banks, and the kingfisher and shags that glide up and down the river. Takahe forage in the grassy areas. This is a living and vibrant place with the obvious stamp of New Zealand.

Further out, in the surrounding ranges, the forest is thriving and the birdlife booming. Close to the sanctuary even the most threatened and vulnerable of birds are in healthy numbers, protected by a comprehensive on-the-ground 'predator-free' style management system which effectively keeps threats at bay. Further out, the abundance is still evident and increasing, benefiting from broad-scale management and the wide-ranging 'halo' effect from the fenced core 'nursery' area.

But this is also a place for people. Local iwi are integrally involved in managing and operating the sanctuary. Volunteers help the professional staff with all manner of essential tasks. Tours of visitors and school children set off from the visitor centre, led by experienced guides. Trampers set off to do the world famous 'great walk'. The area is generating a huge amount of people involvement and economic activity which is greatly benefiting the surrounding communities socially, culturally and economically.

Nationally the picture is improving fast. Kakapo numbers exceed 2,000 and hundreds are added to the population every mast year. Hihi have four more large mainland populations and kokako are thriving and spreading. Other formerly

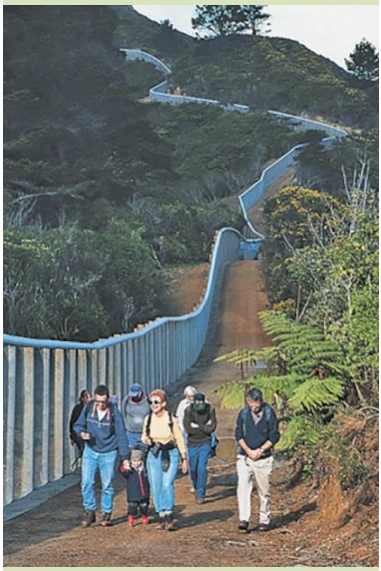
threatened species are being upgraded in their threat rating. Populations of more common birds like tui, bellbird, kiwi, kaka and kereru are expanding their ranges and increasing in abundance. Over 40,000 hectares of prime habitat is entirely pest free and over a million hectares of ‘halo’ habitat adjacent to the sanctuaries is under careful management for pests and threats. New Zealand’s biodiversity is on the improve.

Could this scene really happen? Indeed, it can. We now have the ways and means to make it happen and yes, we can afford it. We have a potential solution at hand.

1.5. The Solution

There is one strategy which could achieve this vision. All the key elements have been successfully tested and proven effective; and it is affordable. This solution involves combining all our available existing technologies around a '**nursery and halo'** model, as successfully tried in Wellington City, and resizing it to a large-scale and a national level. This 'nursery and halo' model involves:

- Selecting up to **ten** very large (up to 100,000 ha each) intact forested areas with high quality core zones, spread across the country.
- This ensures **scale** (one million hectares plus) and national coverage and will account for the varying geographic spread of species and ecosystems. These zones would be in prime places such as Waipoua Forest, Coromandel, Pureora Forest, the Remutaka range, Northwest Nelson, the West Coast and Waitutu Forest.
- A core area, ideally 3,000+ hectares within each zone, is pest exclusion fenced, and all pests permanently removed. This becomes the '**nursery**' where even the most sensitive species (e.g. kakapo, hihi, tieke) can breed in safety and establish populations which are secure and viable long term.
- 3,000 ha is large enough to accommodate genetically viable populations of almost every forest fauna and flora species. These populations provide security against further extinction and in time become a source of migration beyond the fenced 'nursery'.
- Beyond the fenced inner zone, the wider 100,000 ha '**halo**' zone is intensively managed to reduce pest populations to zero or very low levels, capturing advances from the current 'predator free' programme. This provides a relatively safe habitat for more resilient species (e.g. kaka, mohua, kokako), allowing them to migrate beyond the fence and breed.
- Species establish in the security of the fenced 'nursery' and, when that space is full, they migrate out and repopulate the outer 'predator free' zone. This is the '**halo**' effect. In time they will fill the entire managed area and beyond, thus increasing both the abundance and range of most species.
- The same principle works for flora. Freed from browsing, threatened plants such as mistletoe and rata can establish populations and their seed can spread, via the abundant birds or wind, beyond the fenced area into the managed zone where browser numbers are low.
- Such a national scale programme would create 30,000 ha of permanently pest-free habitat (in addition to existing islands and community sanctuaries), enough to ensure **no further extinction** of our sensitive forest fauna and flora species. It would create up to 1 million ha of secure, predator controlled habitat and greatly expand the abundance and range of more resilient species.
- Ten mega sanctuaries with predator controlled halo zones would become **cultural, social and economic** hubs which would engage iwi and communities and expand local businesses. The benefits extend well beyond biodiversity.



Such a programme is affordable within existing budget allocations and the outcomes, technologies and processes have all been tested and proven. The costs and risks are well known. We go into detail on the ways and means in Part Three. But first we must set out the extent of the problem we are trying to solve.

Part Two: The Problem

Before we can design a solution, we must define the extent and nature of the problem we are trying to solve.

In conservation management in NZ there are many intractable problems to overcome. These include the resilience and ubiquitousness of invasive pests, the inadequacy of our existing tools and the sheer size, difficulty and cost of the task.

We have already tried many approaches and continue to try new ways and means. Are these existing technologies and approaches not sufficient?

We address these issues in this part.

2.1. The Pest Problem

Since human occupation of NZ, invasive exotic pest mammals have progressively established in and depredated our forests and fauna and are the primary cause of extinction of indigenous species. This pest loading amounts to fifteen widespread species. In the absence of many of their natural predators or controls, these species proliferate and cause immense damage to forests and fauna that have few defences against, what is for them, novel threats.

The impacts of mammalian pests in NZ indigenous forests are well known so there is no need to detail these. See Appendix 2 for a full account of the invasive pest mammals which typically inhabit NZ forested ecosystems and their impacts on our forests. These can be summarised as follows.

Herbivores (possums, pigs, deer, goat, wallabies and mice) are stripping trees and understory of leaves, flowers and fruit and in the process, they remove whole suites of plant species. **Predators** (rats, cats, stoats, weasels, ferrets and hedgehogs) are consuming birds, lizards and invertebrates and their eggs).

These pest mammals are highly resilient They are fast breeders (especially natural prey species like deer, mice and rats) and can recover populations quickly and spread rapidly. Having a natural wariness and some ability to learn and adapt and in time even evolve, they can be exceptionally difficult to control, or to eradicate.

In unmanaged forests, exotic pest species constitute 99% of forest vertebrates. Native vertebrate fauna will consist of only the most resilient species in low abundance and there will be a high degree of local extinction. These forests will have a low level of ecological integrity with many natural processes arrested. These forests will consist primarily of plant species that have some resilience to intense browsing. Generally, they will have low or near zero regeneration rates, lower fruit and seed productivity and a high rate of adult tree death rate. The normally highly productive shrub layer will be greatly depleted and, in extreme cases, virtually absent. The carrying capacity of indigenous fauna will be massively compromised. Mass erosion and canopy collapse will be common, especially in areas prone to stochastic events. Some forests will in time be reduced primarily to unpalatable species such as leatherwood and horopito.

Restoring ecosystems and populations from this level of damage has seldom been attempted on the mainland and in the best scenarios can take many decades to make material progress. Some elements may be irrecoverable.

In addition to pest mammals, invertebrates such as exotic wasps, ants and spiders, prey on and compete with native invertebrates. Exotic weeds compete with native plants for space. Some exotic birds compete with native birds for resources.

Interaction between various predators and herbivores are known to occur (e.g. cats supress mustelids, cats and mustelids prey on rodents, etc). Many of these interactions are poorly understood, are complex, vary from place to place and change with seasons or over time and, if not recognised or managed, they can have unintended consequences or provide mixed results for biodiversity managers. This means that managers may need to remove or suppress the entire predator and herbivore suite to minimise these consequences.

The pest problem in NZ is so enduring, difficult and complex that some pests are currently unmanageable (e.g. mice). At best they represent a seemingly intractable problem which compounds with scale and there are no easy solutions.

2.2. The 'Tools' Problem.

The toolbox for managing pest mammals in New Zealand is alarmingly small and ineffective. Essentially all pest control depends on about six key tools, and all of these have major limitations.

These tools are **exclusion barriers** (water and fences), kill devices such as **firearms** (hunting), two or three **traps,** and two or three key **toxins**. **Biological controls** are not widely used anymore. Associated with kill devices are systematic delivery methods (such as aerial application and ground grid lines), lures and detection devices.

Barriers. Barriers seek to prevent the invasion of pest mammals to a managed area. Barriers include water (islands), geographic features (rivers, peninsular) and pest-exclusion and pest resistant fences.

Barriers are our most effective tool. Water (islands) and pest exclusion fences are the only tools which can assure a near pest-free environment. (The exception is mice. Mice are proving to be almost uncontrollable at even a relatively small scale, i.e., over 100 ha). The limitations of barriers are that the number of suitable islands, geographic features and places to fence is limited, and we have run out of suitable near shore islands. Islands and fenced areas are limited in scale. The largest island cleared of pests in NZ is 11,000 ha and the largest fenced area is 3,200 hectares. Islands and fenced sanctuaries still require a surveillance and incursion response system to be in place permanently

Fences have a higher capital cost, need a maintenance and repair programme and have a life span of approximately thirty years. Fences can block the migration of ground dwelling birds and islands have limited outward migration of species. However, fencing is now a proven and optimised technology, and its potential is underutilised.

Firearms/Hunting. Hunting, employing firearms and detection aids such as dogs, has been used in NZ since the 1930's when wild animal control became government policy. Apart from modern firearms, infra-red detection and helicopter shooting, the technology has advanced little since those early days.

Hunting is still the only realistic control method for large herbivores (deer, goats, pigs, thar) but is ineffective against mustelids, cats, rabbits and possums and impractical against rodents and hedgehogs. It is dependent on the skill of specialist hunters and becomes an expensive option when numbers are very low as diminishing returns for increased effort kicks in and surviving animals become gun shy. Hunting to eradicate deer attracts social opposition. Hunting is an optimised technology with better detection at low densities being the only potential area for innovation.

Trapping. Traps have been used in New Zealand for predator control since the late nineteenth century. The variety and types of traps has expanded in recent times and there has been intense research into more efficient and humane trap technology, especially around self-resetting traps and automatic luring.

Traps are employed against small mammals such as possums, rodents, cats, hedgehogs and especially mustelids. Trapping can be effective in getting the last few baits shy animals or in smaller sites but generally traps are ineffective in eradications. It is essentially useless in larger and more remote areas.

So far there has been no major breakthrough with trap technology and given the inherent limitations of trapping it is hard to see any such breakthrough ever occurring. These limitations are very labour intensive and costly, highly dependent on skilled operators, liable to result in trap shy populations and only useful in small scale sites which are easily accessed.

Toxins. Toxins have a long history of use in NZ. Toxins (mostly phosphorous, arsenic and strychnine formulations which are dangerous to humans) were used in rabbit control as early as the 1880's. Cyanide (another toxin highly dangerous to humans) was used from the mid twentieth century by possum hunters and is still occasionally employed under the brand Feratox.

Rodenticides (first generation warfarin) were used to clear small islands, beginning with the Noises in the 1970's. In 1987 Landcare research and DOC achieved the first serious eradication of rodents from Breaksea Island (187 hectares) using a systematic ground bait station grid and brodifacoum (a second-generation warfarin). Kapiti Island (1,915 ha) was the first large island to be cleared of rodents (1996) using brodifacoum applied aerially.

Aerial application of 1080 to control possums became standard practice in the 1980's and this toxin became and remains the nation's major pest control tool.

Cholecalciferol, para-amino propiophenone (PAPP), zinc phosphide and sodium nitrite are other toxins registered for use in NZ.

Toxins are still by far the most effective and widely used pest control tools and islands and fenced areas depend on toxins to achieve eradication. Aerially applied toxin which is optimised to achieve secondary poisoning of predators is the only tool that can be used in larger scale rodent and predator eradication operations. Only one toxin (1080) is widely used for aerial application on the mainland. Brodifacoum is the only tool available to achieve eradication on islands and within fences and can be applied aerially only with a special permit in enclosed areas.

Toxin use is controversial and is subject to many controls. Many toxins are dangerous to humans and non-target species. Some toxins can accumulate in the environment with prolonged use. Acute toxins such as 1080 can result in bait shyness or resistance. The ethics of toxin use is often questioned. Long term and intensive use of toxins invariably attracts social opposition.

There is still room for improvement with toxins, especially in third generation warfarins which have brodifacoum's delayed effect without the residual properties. New toxins become available from time to time but given the astonishing resilience of most pests, the reliance on the research programmes of large multi-national chemical companies and the public hostility to toxins in general, major breakthroughs are hard to imagine and the extended use of toxins will always be controversial.

Biological agents. Biological pest control is the use of predators, parasites or pathogens to control or eradicate a pest species. NZ has a long and inglorious history in the use (or misuse) of biological controls. Rabbits have been the primary target of biological control, initially through the import of mustelids as predators (a catastrophic failure) and myxomatosis and calicivirus as pathogens (temporary but short-lived success). Other efforts have seen the importing of plant parasites such as heather beetles and wasp parasites (limited results). In the late 1990's and early 2000's intense research was conducted to develop biological agents and genetic engineering (CRISPR) for the control of pests, especially possums. So far none of these programmes has borne any fruit.

Research in this area moves very slowly and in fits and starts, the track record of these methods is very poor and there are huge social and ethical hurdles to address. Biological control remains the great future hope of conservation, but the goal seems to recede further with every passing decade.

Lures and detection devices There is probably still mileage in developing better lures to attract pests to kill zones. This may improve efficiency and effectiveness of traps and toxins but is unlikely to result in major breakthroughs. Lures tend to lose their effectiveness over time.

Detection devices such as cameras, EDNA and AI have great potential to locate animals at low abundance (which is very useful) to improve the effectiveness of traps, hunting and toxins; but these methods won't achieve eradication on their own. They still depend on an efficient kill technology.

Conclusion on the pest control toolbox. The following conclusions can be drawn from the above.

- Given the scale and complexity of the job, the current toolbox is woefully inadequate for the task of eradicating pests on the mainland or even for securing large predator-free zones and preventing reinvasion.
- Given the progress of research undertaken recently, the prospect of this situation changing in the foreseeable future is remote.
- All pest control methods have some strengths, and all have inherent weaknesses. There is no single 'silver bullet' that will magically appear.
- The nearest thing we have to a 'silver bullet' is barriers and on the mainland (and especially the North Island), this means pest-exclusion fencing, the only method which can currently assure a long-term pest-free zone on the mainland. Even this requires the use of all other available tools and excludes mice. Such fenced zones will always be limited in size due to the need to manage incursions, lack of suitable sites and cost to build, maintain and renew.
- When it comes to technology and tools, we can't depend anymore on new developments. In the foreseeable future we will need a solution which works with the tools we have, however limited.

2.3. Conservation Management in NZ

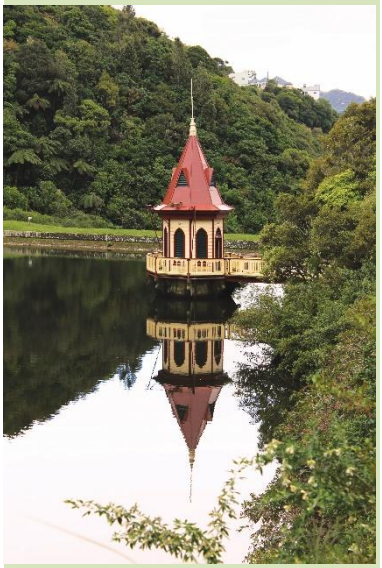
So, haven't we been doing well in NZ with preserving our biodiversity and isn't what we are doing enough? Much has been achieved over the years but there is some evidence that we have 'hit a wall' and progress has stalled.

Efforts to maintain indigenous biodiversity in the face of worsening pest problems have evolved overtime, often in response to emergencies. Each phase saw new technologies and approaches which have enabled advances. These are:

'Safe' islands. Pest-free islands have been a primary tool for preventing further extinction in NZ since the 1890's when Hauturu and Kapiti Islands were dedicated as nature reserves in response to mass extinctions. In the 1970's and 1980's the island programme received a major boost when methods to eradicate rodents were perfected. Over time the pest-free island network expanded to over 100 islands and today provides over 10,000 ha of secure near shore habitat. This programme has been essential for the survival of our most sensitive species. However, the island programme has peaked as we have run out of suitable near shore islands and the bigger islands such as Rakiura, D'Urville, and Great Barrier are not yet within our ability to make pest free or have significant private ownership. Islands are cost effective to clear and maintain but are not always ideal as many are too small for large populations, many have degraded habitat, most are dry, and they are difficult to access. They have a limited 'halo' effect, and their social and economic value is small and limited to those islands close enough for the public to visit.

Wild animal control. This programme emerged in the 1930's under the Forest Service in response to forest collapse due to browsing by deer and goats. The Wild Animal Control Act is still current and ungulate control, almost entirely by hunting, is still undertaken across large areas of both islands and is still needed.

Broad scale management. This management, mostly involving the aerial application of 1080, was introduced in the 1980's in response to forest collapse from possum browsing. It covers large areas (20-100,000 ha) and is aimed at retaining the basic structure and health of a forest ecosystem. Over a million hectares is still managed every year in this way through DOC and Regional Councils. This programme has been controversial and has attracted a lot of opposition, but it has been effective in keeping forests from degrading further. The aerial application of toxins is now an optimised technology and an essential tool in conservation management.



'Mainland Islands'. This concept emerged in the late 1980's as a way to maintain threatened species populations on the mainland, specifically kokako and kiwi. It involved intensively managing areas up to 10,000 ha through constant trapping and toxin application and has had some success in preserving these extant populations. The idea was widely adopted from the 1990's onwards and now the number of intensively managed areas is probably in the hundreds with around 100,000 ha under such management. Some projects such as Rotoiti and 'The Ark in the Park' in the Waitakere's have been running for decades with mixed results. Mainland islands have been successful in retaining extant populations and increasing the numbers of more resilient species but have not been successful in restoring the most sensitive species back to the mainland.

Fenced Eco-sanctuaries. Karori Sanctuary (now Zealandia) was the first community eco-sanctuary, founded in Wellington in 1995 with its novel 8.6 km pest-exclusion fence being built in 1999 enclosing an area of 225 ha of central city habitat. In the 25 years since then, Zealandia has been an unqualified success, re-establishing viable populations of the most sensitive species on the

mainland for the first time (e.g. little spotted kiwi, hihi, tieke, tuatara) and returning populations of more common birds (e.g. tui, kereru, and kaka) to the city. The enterprise has transformed Wellington and since then over 30 fenced sanctuaries have been established across the nation, covering over 12,000 ha of prime lowland habitat. The largest of these is 3,214 ha Maungatautari near Cambridge. Several sites have repeated the species translocation success of Karori.

Fenced eco-sanctuaries are now a proven technology and governance model and it is the only method which enables long term restoration of habitats and the return of sensitive species populations to the mainland. They have been highly successful in engaging communities and in some cases, earning revenue. (See 3.2 for more detail on fenced sanctuaries).

Predator Free NZ (PFNZ). This programme emerged in 2010 from the enthusiasm and optimism generated by the fenced community sanctuaries. It started as a community initiative but rapidly gained traction and government support after Sir Paul Callaghan's "Moonshot" speech in 2012 (see Section 3.4) and became DOC and Forest and Bird policy. The concept was to clear NZ of its worst pests "without fences". The movement was supported by a research programme managed by a private/public organisation called Zero Invasive Predators (ZIP).

The programme has an ambitious goal to rid NZ of six pest species (possums, two rat species and three mustelid species) by 2050. This goal was predicated on rapidly developing a suite of new technologies that would enable managers to clear large areas of pests and prevent their reinvasion.

So far, despite enormous effort and considerable investment, results from PFNZ have been less than expected. No new breakthroughs in technology have been forthcoming and innovations have largely involved marginal improvements to existing technologies (aerial 1080, traps, lures, EDNA, cameras). The flagship programmes have been the Perth River in Westland which aims to reduce pests to zero over 100,000 ha plus and Miramar Peninsular in Wellington which has been trying to eradicate and keep out possums, rats and mustelids from an area of about 1,000 hectares. While these appear to have been locally successful, it is a long way from making NZ 'predator free' and the goal of eradicating three species from the mainland by 2050 looks unrealistic. Moreover, there seems to be no record of successful translocations of species into these 'predator-free' zones. See next Part section 3.4 for more on PFNZ.

In summary: the island programme has peaked at an optimum extent, wild animal and broad scale 1080 programmes are useful in keeping forests intact but offer limited help to our most threatened species, mainland islands are widely used but again have not proven effective for the most threatened species and have been limited in scale, Predator Free NZ seems to be a larger scale extension of mainland island technology and, given the difficulty of the task and the lack of adequate tools, it is unlikely to achieve its aims in the medium term.

This leaves only fenced sanctuaries with genuine untapped potential. Even fencing has limitations, especially scale and cost. However, there is one thing we haven't tried nationally, and that's using them all together in concert especially sanctuaries with 'predator free' zones. All methods have their strengths and weaknesses and if we could maximise the strengths to overcome the weaknesses we may have a winning formula.

2.4. The Resource Problem

Conservation management in NZ has always been underfunded in comparison to other activities.

In 2024/5 DOC was allocated budget of approximately $400 million for biodiversity related activities. Local government agencies will spend approximately $150 million on biodiversity and private organisations and individuals will spend about another $50 million pa. This means all biodiversity related annual expenditure will be about $600 million pa.

NZ GDP for 2023 was approx. $400 billion. This means expenditure on biodiversity is around 0.15% of GDP. This is a very small number to manage a third of NZ and its forests and fauna.

This funding level has not changed significantly over the years. It reflects that biodiversity is not a major priority for New Zealanders and given that number has not changed materially through various changes of government, it is unlikely to change much in future. Labour governments tend to beef up conservation spending when in power and National governments either hold the line or cut when they take over. This means overall conservation spending long term tends to be static when inflation is taken into account and may even have diminished in real terms.

By comparison defence spending in NZ is $5 billion pa, about 1.8% of GDP.

This trend indicates that significant increases in resources and funding will be most unlikely to eventuate, and it will make initiatives that depend on huge injections of government funding, like Predator Free NZ, even more unrealistic to achieve.

The conclusion is that we will need to offer solutions that can be funded with little or no additional cost increases and that are good value for money.

Part Three: The Solution

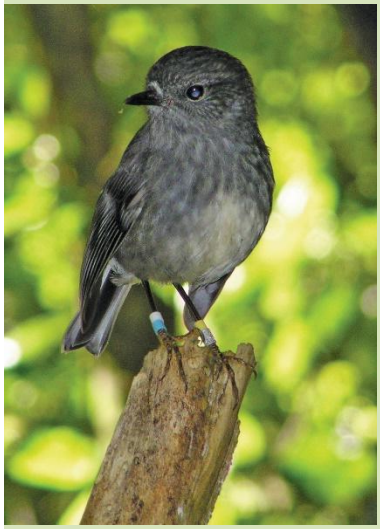
We summarised the potential solution in Part One (1.5), proposing the nursery and halo model at a national scale.

In this part, we look more closely at how to do this and the rationale and practicality.

3.1. The Resilience of Indigenous Species.

No-one seems to have asked the question "Do we need to make NZ entirely pest free?" There are indications that we don't need to go this far in order to end extinction. The clue for this lies in Wellington City.

Between 1995 and 2015 the Wellington OSNZ undertook a long-range (20-year) study to measure the change in diurnal forest bird structure before and after the construction of the pest-exclusion fence at Karori Sanctuary (now Zealandia). This involved five-minute bird call counts over three, three-year blocks: before the fence (1995/8), immediately after the fence (2001/4) and ten years after the fence (2012/15). The results, which have since been replicated on an island in Fiordland, have considerable relevance to the wider management of forest birds in NZ.



The findings were as follows.

- The more endemic species (tui, whitehead, tieke, kaka, robin, kereru, kakariki) quickly became dominant after the fence was constructed and as they were reintroduced to and established in the sanctuary. These species are now the most abundant birds in the sanctuary. Rifleman have since been reintroduced and are also doing very well.
- The less endemic species (silvereye, grey warbler, fantail) did not increase in abundance and in some cases reduced considerably in numbers. Exotic species (blackbird, thrush and chaffinch) have also reduced in abundance. Habitat restricted species or parasites such as kingfisher, welcome swallow and shining cuckoo did not change in abundance. By 2015, the structure of the forest bird suite at Zealandia was strongly tracking towards matching that of Kapiti Island in diversity and abundance.
- The conclusion was that the more deeply endemic birds thrive and out-compete less endemic and exotic species in pest-free environments. Predation is a major control on their populations. It appears that the controls on the populations of those less-endemic species are not so much predation (most are rapid breeders and more recent arrivals from Australia which are used to some level of predation) but food supply, often tied to habitat quality, climate fluctuations and competition.

- Those more endemic species which have hung on around Wellington and the Hutt valley over many years of intense predation and habitat loss also give a strong clue to which native species have more innate resilience than other indigenous species. Many have bounced back well with recent widespread regional pest management. These 'slightly tougher' forest species are tui, bellbird, morepork, kereru, yellow crowned kakariki, whitehead, tomtit, and rifleman.
- This means that there is a suite of native birds that do just fine in a NZ awash with predators and in highly modified environments and need no management at all. There is also another suite which hang on well and only need some moderate assistance to thrive. Then there is another group that need a very low presence of predators and just a few that cannot stand any predator presence at all.

A quick summary of these forest and field birds in relation to their resilience could be as follows.

Require no management. Do fine or OK in NZ the way it is. (12 species) Silvereye, grey warbler, fantail, kingfisher, welcome swallow, harrier hawk, morepork, pukeko, paradise duck, shining cuckoo, spur-wing plover, NZ pipit.
Require some management. Can survive in the wider world with a little help. (13 species.) Tui, bellbird, whitehead, yellow crowned kakariki, kereru, tomtit, rifleman, long tailed cuckoo, bush falcon. NI and SI brown kiwi, SI weka, brown creeper.
Require more long-term management. At risk of extinction without ongoing intervention. (11 species) Great spotted and rowi kiwi, kaka, kea, kokako, NI weka, mohua, red crowned and orange fronted kakariki, NI and SI robin.
Require predator-free habitat. Cannot survive in the presence of predators and/or have slow breeding issues. (6 species) Kakapo, NI and SI tieke, hihi, little spotted kiwi, takahe.

A similar assessment can be made for reptiles, bats, frogs and invertebrates.

This means that of forty-two species of forest and field birds, only six require a predator-free environment to survive.

This would indicate that we may not need to make all of NZ ‘predator free’ even if we could. We just need to make large areas of NZ safe for most species and ensure the very sensitive few have enough predator-free habitat to survive long term.

This has major implications for future conservation management in NZ and it is the fundamental on which the ‘nursery and halo’ model is built.

3.2. The Fenced Sanctuary' (the Nursery).

The key to the nursery and halo model working on the mainland is the fenced sanctuary.

The first fenced sanctuary was proposed by the author in 1992 for the 250 ha Karori Reservoir in central Wellington. Karori Sanctuary was built on two novel concepts: pest exclusion fencing and the community trust governance and funding model.

The Karori Sanctuary Trust was formed in 1995, and NZ's first multi-species pest exclusion fence was built in August 1999. The 8.6 km fence enclosed an area of 225 ha. This was a novel concept at the time. All pests (bar mice) were eradicated from the fenced area by January 2000 and the first species reintroductions (little spotted kiwi and NI robin) occurred that year.

Costing $2.1 million ($245 per metre) the fence enabled the reintroduction of even the most sensitive threatened species (e.g. little spotted kiwi, tieke, hihi, robin, tuatara, kaka, etc). The fence has been remarkably secure as no rat, possum, cat, stoat, ferret, deer, pig, goat, hedgehog or dog has breached the barrier in its 25 years of operation. Only weasels (two incursions) and mice have beaten the fence. Some small sections have been replaced but the fence still has years to go before major upgrades are needed. 18 species of bird, lizard and invertebrates were reintroduced to the sanctuary and 29 species of native bird now have resident populations in the valley, up from 9 in 1999. Many of these populations are at carrying capacity. The Karori fence has been an unqualified success.

Equally successful has been the trust governance model. This model has assured the long-term stability of funding and governance which many conservation projects lack. It has facilitated community engagement through volunteering and membership and education through a structured long-term programme. It adds about $30 million pa to the city in economic value added. It hosts over 130,000 visitors per annum and earns about 80% of its revenue from its membership and commercial businesses. It is a genuinely successful biodiversity, social and economic hub for the city and region.

Over 200 community and city conservation support groups have sprung up around Wellington to compliment and expand the sanctuary's biodiversity work. The sanctuary has transformed Wellington from a biodiversity cot case to an international showcase. Bird populations in the city continue to expand and grow. In 2023/4 Welington received a special citation from the Lee Kwan Yew World Cities Awards for its biodiversity work.

It should be noted that this success is in spite of Wellington being a sub-optimal site for such an endeavour. Zealandia is small, and the habitat is primarily pine plantations and shrub forest, the adjacent city forest 'halo' habitat is limited in size (3,000 ha), immature, of mixed quality and disjointed and there is a large population of domestic and feral cats in the city. If it can work in Wellington City, it should work anywhere.

Following Karori's example, other sanctuaries were rapidly established around NZ, beginning with Tawharanui (a 500-ha peninsula park near Warkworth) and Bushy Park (near Whanganui) in 2005, Orokonui (300-ha) near Dunedin, and Rotokare (250-ha) near Stratford. There are over 30 fenced areas in NZ at last count although only about 10 could be described as serious sanctuaries (near 100 ha in size). Together these ten sanctuaries protect over 10,000 ha of

important lowland habitat and house many threatened species populations. (See Appendix 3)

After Zealandia, the most significant sanctuary established was Maungatautari near Cambridge. Here a 48 km network of fences was constructed to ring fence a mountain, enclosing an area of 3,214 ha. The Maungatautari fence was built in 2006, and a number of threatened species have been reintroduced to the managed area, including an experimental kakapo release in 2023. Maungatautari has demonstrated that large areas over 3,000 ha can be fenced, cleared and kept clear of pests for extended periods of time. At Maungatautari, the highest rate of increase ever recorded for kokako has been achieved. NI brown kiwi on the mountain are now estimated to number approximately 2,500 birds (from a founder group of 80 birds) and the sanctuary supplies numerous birds to other projects.

After 25 years of operation, fenced sanctuaries are now a proven model with an effective and mature supporting technology and governance system. Costs and risks around constructing fences and maintaining them for long periods of time are now well known, as are procedures for eradicating pests and maintaining incursion and damage responses.

The fenced sanctuary movement, while relatively small, has been massively influential in conservation in the twenty-first century. Its broad achievements for biodiversity over the last twenty years are as follows:

- The return to the mainland of populations of eight species formerly restricted to offshore islands.
- The improvement in status and extension of range of many at-risk species, especially kaka, kakariki, tieke, hihi, robin, kokako, whitehead, rifleman, pateke, karearea.
- The securing of over 10,000 ha of predator-free space in some of NZ's most threatened and valuable environments (lowland and coastal). This is 40% (3,845 ha) more than the combined size of the three premier island reserves; Hauturu-o-Toi (2,817 ha), Kapiti (1,915 ha) and Whenua-Hou (1,400 ha)
- The pursuit of the restoration of this land over time, targeted at its original state of ecological integrity. Fenced sanctuaries only improve with time.
- The improvement in local abundance of the more common species, especially birds such as tui, bellbird, kiwi and kereru.

While the biodiversity achievements have been impressive, the social and economic accomplishments of fenced sanctuaries over the last 20 years have been even more spectacular.

- The raising of awareness of biodiversity issues with national and local politicians and the changes this has made to government and local authority programmes.
- The direct recruitment of over 20,000 active members and supporters and over 2,000 active volunteers.
- The direct exposure of as many as 3 million visitors to a rich nature experience, including species that many people would never otherwise have encountered.
- The direct exposure of as many as 250,000 children to a rich nature experience through education programmes.
- The acquisition of as much as $60 million in capital for infrastructure (fences, buildings etc). Money which would not otherwise have come to conservation.

- The acquisition of as much as $12 million per annum (2022 estimate) in operating budgets. Over 20 years this would have amounted to an injection of approximately $100 million in operating funds. This is also funds which would not otherwise have come to conservation.
- Added economic value to the nation from the capital and operating injection will be approximately $800 million.
- The inspiring of many other local biodiversity projects which have chosen not to use a fence but pursue similar goals. Manaaki Whenua-Landcare Research estimates the fenced sanctuaries have inspired hundreds of additional projects.
- The inspiring of the Predator-Free NZ movement. As evidenced by Sir Paul Callaghan's 2012 'Moonshot' speech (when he was a trustee of Zealandia).
- The massive growth in community support and professional community and private conservation in the twenty-first century can be directly traced to Zealandia and the emergence of the fenced sanctuary movement. It has been the most significant event in conservation this century.

This is not to say that other traditional pest control and biodiversity programmes have not achieved any positive outcomes. They most definitely have. However, the results from fenced sanctuaries far outstrip those of the traditional control programmes in all aspects: biodiversity, social and economic.

DOC has generally not fully participated in the fenced sanctuary movement. DOC built an early small-scale fence at Pitt Island and have sponsored some small-scale fences for lizard and seabird protection. They have supported some local sanctuaries with small amounts of funding and technical advice but have not engaged in larger scale fencing.

Forest and Bird have been opposed to fences over the years and have pursued and supported other models such as 'The Ark in the Park' in the Waitakere's which has employed an intensive mainland island approach for 25 years with limited results. Forest and Bird claim Bushy Park as a society managed fenced sanctuary, but this was organised by the local branch and the society's policy has been unhelpful on fences.

The conclusion is that the fenced sanctuary movement has over the last 25 years, proven that pest exclusion fencing, and the 'nursery and halo' model works and that the trust governance model is viable long term. All technologies to scale this model up have been tested and optimised and costs and risks are well known and highly predictable.

3.3. The Halo Effect.

The term ‘halo effect’ was applied by the author in relation to the Karori Sanctuary proposal in 1995[1] and expanded on in 2012 by Sir Paul Callaghan[2].

The ‘halo effect’ refers to the migration of species which is expected to occur from a secure predator-free zone (the ‘nursery’) into the surrounding, less secure, habitat (the ‘halo’). Little research has occurred into migration from fenced areas. The most notable and recent has been in Wellington City, where a significant increase in diversity and abundance of indigenous birds has been recorded in the city environs over the last two decades. This has been attributed to the ‘halo effect’ from Zealandia[3]

In Wellington, the increase has been most pronounced for five species (tui, kererū, kākā, karearea and red-crowned kākāriki) with titipounamu/rifleman more recently settling outside the fence. The increase in these birds, especially kākā, has been spectacular with kākā now a common sight all around the city. Other species have struggled to establish in the city (korimako/bellbird, pōpokatea/whitehead, miromiro/tomtit) and the more sensitive species (toutouwai/robin, hihi/stitchbird, tīeke/saddleback), are still largely restricted to Zealandia and its immediate surrounds. As predator control increases around Wellington city, these less robust species are expected to increase in abundance.

However, the presence of a large population of feral and domestic cats in the city (estimated at 60,000) represents a significant threat, the exact impact of which is not well known. It is also unclear as to what effect the patchy and largely secondary growth habitat in the city would have on depressing fauna carrying capacity. Note that this will improve over time as the Outer Green Belt and parts of the inner Town Belt (approximately 4,000 ha) regenerates naturally and through planting programmes.

Most fenced sanctuaries are either in urban or peri-urban situations or are surrounded by farmland and/or partly by water (peninsulas), the exception being the more recently (2016) established Brooke-Waimarama Sanctuary near Nelson, which is adjacent to the huge Mt Richmond Forest Park (169,200 ha). (It is too early to draw any lessons on migration from Brooke-Waimarama and no control work is done in the wider park). This means that with most existing fenced sanctuaries, the opportunity for migration into high quality habitat is limited. However, even from isolated sanctuaries, significant migration of strong flying species, such as tui, kereru and kaka, occurs.

The experience from Zealandia and other sanctuaries demonstrates that the ‘halo effect’ does occur around a fenced area, especially for the more robust species, and it will be enhanced if backed up by widespread predator control. In Wellington, the benefit for less robust species could be limited by the continuing presence of unmanaged predators (cats) or the quality of habitat, and the assumption is that in a better situation, the ‘nursery and halo’ effect could be fully capitalised on. This ‘fully integrated management model’ or ‘nursery and halo’ model has never been tried in New Zealand, and it could revolutionise the way we manage our forests. It could achieve a near optimum level of diversity and abundance across a wide area with existing technology.

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[1] Lynch, J. (1995) Back to the future. Karori-from reservoir to wildlife sanctuary. Forest & Bird. Issue 275.

[2] Callaghan, Sir Paul. (2012) The Zealandia vision for a predator free NZ. You Tube.

[3] McArthur, N.; Flux, I.; Harvey, A. (2021). State and trends in the diversity, abundance, and distribution of birds in Wellington City. Client report prepared for Greater Wellington Regional Council, Wellington.

3.4. The Role of Predator Free NZ.

The Predator Free NZ 2050 programme was initiated in 2016 and has gained considerable traction since then. In May 2024 PFNZ reported that 80,000 ha had been cleared of the target pests at a total cost of $300 million. Questions have since been asked of the long term viability of the programme in light of these results and the availability of future funding[4].

The notion of making New Zealand 'predator free' was promoted by Sir Paul Callaghan in his 'Moonshot' speech delivered at Victoria University in 2012. See Sir Paul's full speech on You Tube
https://www.youtube.com/watch?v=noIP5lbuJHk

In his speech Sir Paul was primarily advocating what he described as the "The Zealandia Programme"- a network of Mega Sanctuaries across NZ surrounded by 100,000 ha managed zones: basically, this proposal. His challenge that we make NZ "predator free" was meant as an ultra-long term goal and he saw that a network of giant fenced sanctuaries with predator controlled zones around them should be the essential first step towards that goal. It is now becoming clear that the lack of these mega sanctuaries and his 'Zealandia Programme' is a gap in the Predator Free NZ programme. Some people have seen these two approaches as mutually exclusive or even in opposition, (PFNZ 2050's charter specifically excludes the use of fences), when in fact they are highly complementary in that each provides an advantage that compensates for the other's disadvantages.

PFNZ weaknesses are that it deals only with a few predators and excludes cats and most herbivores. It is narrowly focused on a few pests and underplays restoration of ecosystems and species populations and all the other threats to species. At present we don't have the tools to make and keep very large areas genuinely 'predator free' as we cannot prevent reinvasion; therefore, the goal depends on new technology which is not on the immediate horizon. Moreover, the costs of the programme do not appear to be sustainable. There is the possibility of much wasted effort and resource on places (70% of NZ?) where little or no indigenous biodiversity value remains (e.g. the Manawatu Plains, Canterbury Plains, etc). It is difficult to build economic models around PF Zones to earn revenue and defray costs.

However, PFNZ has injected essential research resource and effort into conservation and energised the sector. Its big advantage is that it seeks to operate at a landscape scale which is important and something fenced areas cannot realistically do. Its capital and operating costs per hectare are lower. It seeks a permanent long term solution to an intractable problem (although it is possible this may not be achieved or at best is many years away).

The weaknesses of sanctuaries is that they have higher up front capital costs and operating costs per ha. They can only operate over comparatively small areas (up to 3,000 ha) and can only ever be small pinpoints in the landscape.

Conversely sanctuaries are the only approach which can genuinely restore complete ecosystems and re-establish missing species populations, both fauna and flora. They can create a genuine pest free environment (bar mice) and assure long term security. The species breeding nursery role is unique to sanctuaries and it is the best method to rapidly create a critical mass sufficient to allow migration from the safe zone. Moreover, robust revenue generating economic models can be built around them that can make them sustainable in the long term and they can have a positive long term economic impact on the

[4] 'Why Predator Invasion Fears Have Been Raised'. RNZ Article. 30th March 2024.

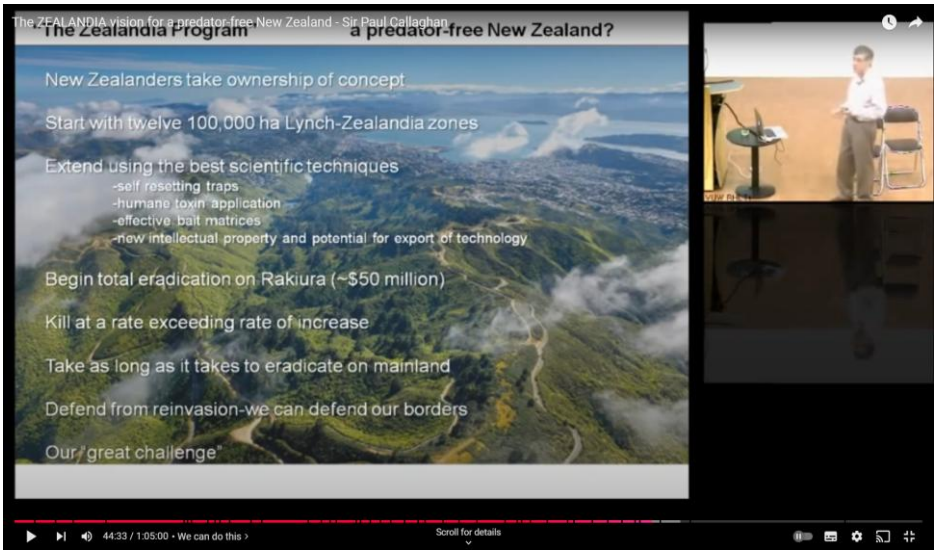
region. They can provide an accessible and rich indigenous experience to New Zealanders and visitors to promote awareness of conservation issues.

Both are strong on engaging iwi and communities.

Logically, sanctuaries should take the role of securing the core and nursery and providing the community and economic hub. Predator Free should take the role of securing the halo zone and extending safe species dispersal across landscapes.

It follows then that each needs the other to succeed, at least in the realistically medium term (next 50 years). These approaches should be seen as complimentary rather than in competition and should be deployed together rather than in isolation.

This proposal can be the medium term Plan B to the ultimate aim of a predator free NZ. The interim strategy that we know will work. If PFNZ does not appear technically or economically feasible in the future, then it can become plan A.



Sir Paul Callaghan at his "Moonshot" speech 2012. Note the second line on the slide.

3.5. The Mega Sanctuary

We can now imagine how to apply this 'nursery and halo' model at a landscape scale with the mega-sanctuary.

Size is important. 3,000 plus hectares is the suggested minimum for a core nursery zone as this will accommodate genetically viable populations (500 plus) of almost all forest species and has been proven to be manageable. Note that we have a mega-sanctuary of this size in Maungatautari which has been operating for 18 years. Maungatautari has been highly successful, but the benefits would have been maximised had it been surrounded by forest. The halo zone should be as big as possible, up to 100,000 ha, and be comprised of the best quality intact forest. We currently manage zones this size under the ZIP predator-free programme.

An optimised large scale 'nursery and halo' model could work like this.

- A good quality forested area of up to 100,000 ha with a centrally located 'fencible' nursery core of up to 3,000 ha is selected. Very large sites may select two fenced areas to give full coverage.

- The core nursery zone is pest-exclusion fenced, and all pests are eradicated from the nursery zone. The nursery zone is targeted for full ecosystem restoration over time. The nursery zone becomes the public hub with a visitor centre and management base.

- Resident species immediately begin to increase in number and quite soon will begin migrating outside the fenced area or, in the case of ground fauna, be available for relocation. Typically, these species include tui, bellbird, kereru, yellow crowned kakariki, tomtit, karearea, harrier hawk, ruru, whitehead (NI) brown creeper (SI), and shining and long tailed cuckoo. Brown kiwi and weka can be relocated when a surplus has been established.. Robust species such as silvereye, grey warbler and fantail may actually reduce slightly in abundance as the more endemic birds increase.

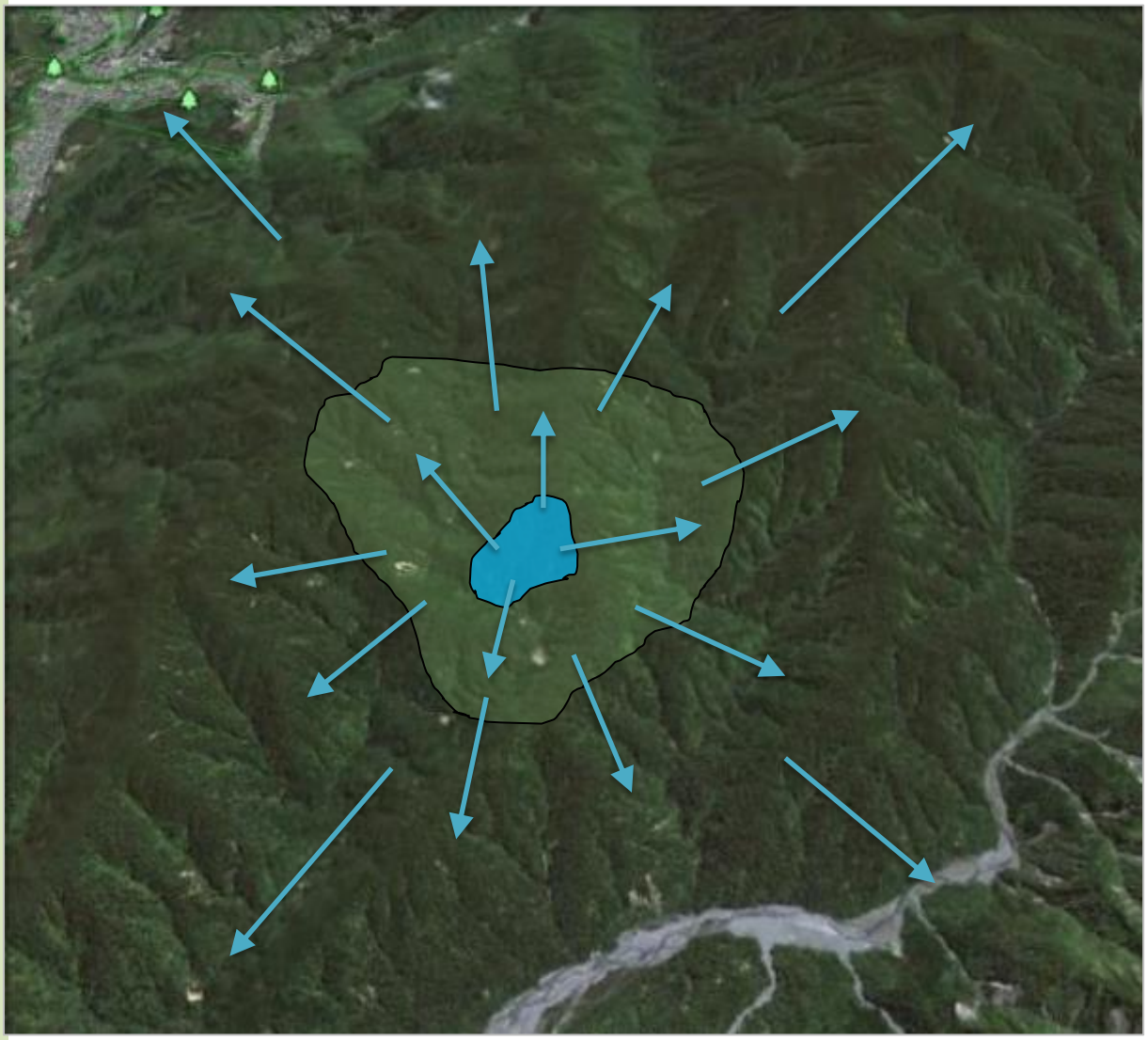
- Extant but missing species are reintroduced to the zone. Typically, this will include species such as kakapo, rifleman, little spotted kiwi, takahe, tieke, hihi (NI), kokako, kaka, red crowned and orange fronted kakariki, robin, mohua (SI) and weka (NI). Frogs, tuatara, lizards, snails and mega invertebrates can also be reintroduced. Some will take 10 to 20 years to fill the zone and begin migrating. Others will be prevented from migration by the fence and will have to be physically relocated.

- The surrounding halo zone is managed at suitable levels of intensity depending on the pest species present and indigenous species being protected. This would normally entail an intensive ground operation around the nursery zone of 10-15,000 ha (to protect the immediate emigration) and in key pest entry points and accessways such as rivers. The remaining area would be targeted for intensive and long-term aerial toxin application targeting rodents, possums and mustelids and ground and aerial hunting for ungulates. These 'predator free' zones and management can be adjusted as lessons are learnt to optimise effectiveness and cost efficiency. Local community programmes can be integrated with the overall programme.

- The indigenous species build up in the nursery zone and over time begin migrating out into the wider more lightly protected area. Species occupancy

and indigenous dominance increases greatly over the full zone and ecological integrity improves with the re-establishment of natural processes.

- A permanent governance structure partnering with local iwi, central government, local government, landowners and the community could manage the entire area to maximise public support, maintain long term continuity, generate revenue and share costs. Core funding is provided by the crown.



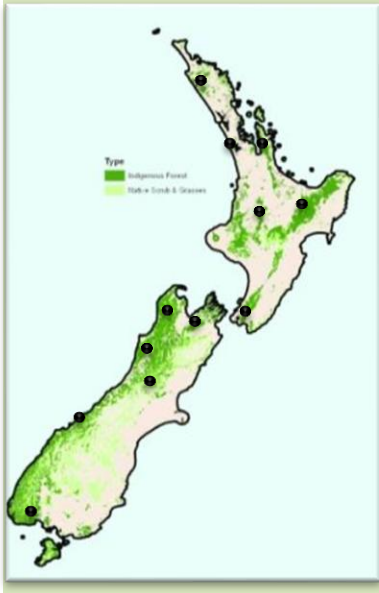
3.6. A National Network of Mega Sanctuaries and PF Zones

Nationally, an optimised programme could work like this.

- Up to ten sites are selected for optimum representativeness of national ecosystems and species distribution and for the presence of a fencible nursery zone. Logically this may mean five in each major island to ensure representativeness. Places ideal for these sites include Waipoua Forest, the Waitakere's, Coromandel, Pureora, Erua Forest, North Taranaki, Remutaka, Marlborough Sounds, Abel Tasman, NW Nelson, Okarito, South Westland and Waitutu.

- Each site is set up as close to the model described in 3.5 as can be achieved. Each enterprise could be managed by local partnership trusts and receive core crown funding.

- This would provide up to 30,000 ha of genuinely pest-free habitat (in addition to the pest-free islands and community sanctuaries) and up to a million hectares of managed 'predator-free' habitat with an improving ecological integrity.



- Such a programme would permanently ensure the future of every forest fauna species across their natural range and extend the existing ranges of many range-restricted and at-risk species. It would also fully capitalise on the potential for public support and involvement and ensure meaningful iwi engagement.

- Over the long term, additional sites can be added to the network or the 'predator-free' halo zones extended outwards. There is really no limit to such a programme other than suitable sites and funding.

- Such a programme directly supports the majority of ANZBS goals related to forest biodiversity, especially those focused on preventing extinction, improving the threat status range and abundance of species, managing ecosystems and providing predator-free habitat. It also supports ANZBS goals of empowering iwi and engaging communities.

3.7. Resources and Costs

A programme of this nature is achievable with current technology and outcomes, costs and risks have a high degree of predictability. There is nothing speculative about it and it is affordable.

Pest exclusion fencing in NZ costs approximately $500 to $600 per metre to construct. This includes all design, surveying and consenting, a perimeter road, gateways and watercourse crossings. A typical large site of 3,000 plus hectares will require between 30 and 40 km of fenceline depending on the terrain and boundary configuration. A general rule is that the larger the site the smaller the perimeter to area contained ratio. This means a typical 3,000 ha site could be fenced for between $15 and $20 million.

Conducting an eradication of all pests has been assessed for similar scale sites at approximately $5 million. Other capital items such as roads, equipment, vehicles and service buildings etc can cost up to $5 million. This means a single mega sanctuary can be fenced, eradicated and equipped for about $30 to $40 million.

Operating costs for such mega sanctuaries (based on Maungatautari) are in the range of $2.5 to $3 million pa.

A typical Predator Free style management operation across 100,000 ha will cost approximately $10 million to set up and $3 to $5 million pa to maintain.

This would mean a one-off capital programme of $400 million in 2024 dollars. Because it is logistically and organisationally impossible to start all these sanctuaries at once, such a programme would take several decades to design and implement, this would mean capital expenditure of about $20 million a year for twenty years with a replacement and upgrade programme commencing after 30 years.

Nationally, operating expenses will cost approximately $30 million per annum for the nursery zones and $40 million p.a. for the wider halo zones. When fully operational after twenty years this would mean an annual national operating budget of $70 million pa in 2024 dollars. Much of this could be funded by reallocating funds from existing projects with low biodiversity outcomes.

If breakthroughs in technology occur, the programme could be adjusted but it is unlikely such breakthroughs will ever make a programme of this nature redundant. Breakthroughs are likely to reduce operating costs and improve effectiveness and efficiency.

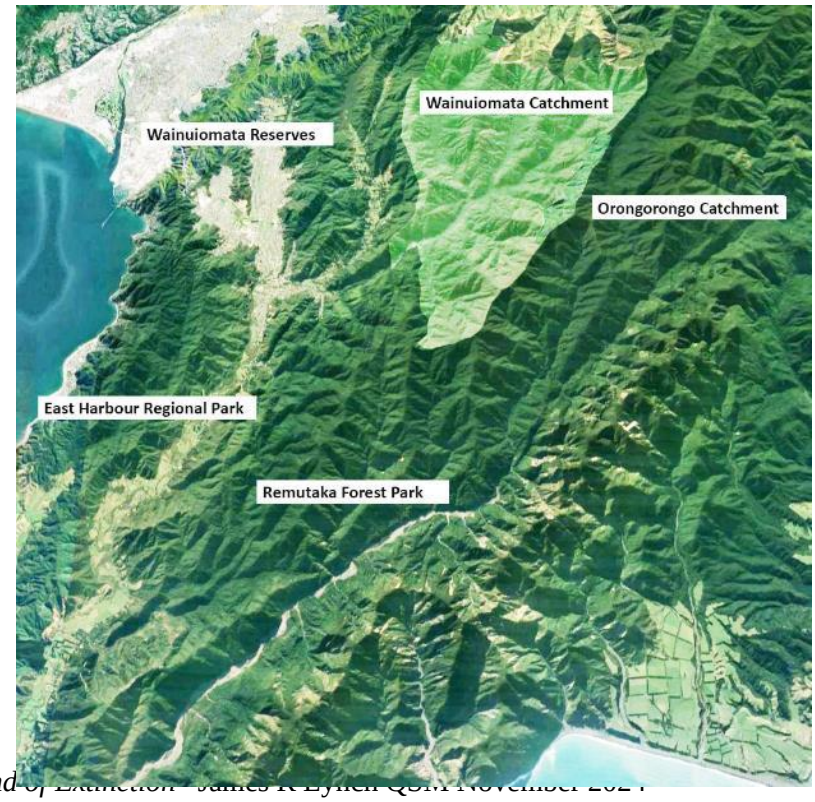
This means a national network of mega-sanctuaries is feasible with current technology and within the broad parameters of existing funding levels.

3.8. Wainuiomata as a Pilot

There is a proposal, submitted to the Greater Wellington Regional Council and DOC in 2020, to fence the Wainuiomata Water catchment near Wellington (Lynch 2021). Wainuiomata catchment has the potential to be the ideal pilot site for a national programme of giant fenced sanctuaries. Its unique characteristics are as follows:

- It has a potential nursery zone of 3,313 ha of the highest quality structurally intact lowland forest with very little active restoration required.
- It has a very efficient 'fencible' boundary of 28.8 km.
- It has sufficient habitat suitable for all extant North Island Forest species.
- It has a contiguous forest 'halo' zone of 40,000 ha with much still structurally intact. The southern quarter of this area has a natural oceanic barrier, and much of the remainder is contained by natural ridgelines.
- It is available for use as a fenced sanctuary and has a supportive landowner (GWRC) and iwi (Taranaki Whānui).
- There are existing local LTA, Community and DOC management programmes to build on.
- It has widespread community support and potential to attract third party funding. It is in a region which has a history of supporting novel conservation ventures.
- It is close to an existing centre of excellence in fenced eco-sanctuaries and has broad political support.
- A feasibility study has been undertaken for the fenced sanctuary nursery zone and has confirmed that the project is technically and financially feasible.

See Appendix A for a summary of the project and its potential to improve species occupancy in the catchment and on the wider Remutaka range



3.9. Credits

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Part Four: Appendices

Appendix 1:Nomenclature

The following terms and concepts are referred to in this paper and are defined as follows.

Ecological integrity. The degree to which indigenous biotic systems and features are being sustained as fully functioning ecosystems, communities, habitats and landscapes. Ecological integrity has three key elements. Environmental representation, species occupancy and indigenous dominance.

Eco-sanctuary. Generally applied to an enterprise which operates a fenced managed area for the purpose of ecological restoration of the enclosed area over an extended period of time.

Environmental representation. The degree to which specific environments, ecosystems and communities still exist and are represented in the protected area network, i.e., how much do we have left and what proportion is protected.

Hubs. A site which becomes a focal point for intensive biodiversity programmes centred on restoration through pest exclusion fencing, which can be managed to maximise social interaction and economic opportunities for the surrounding communities.

Indigenous dominance. The degree of indigenous influence on ecosystem structure, composition, and process at a particular place, i.e., how natural is it?

Mainland island. An intensively managed protected area where all tools (except fencing) are applied to reduce target pests to a minimum. The mainland island was originally conceived as a means to recover threatened species (1990 kokako at Mapara Forest) but was later specifically defined to mean six intensively managed research sites operated by DOC. It has since come to be applied to any substantial intensively managed area, public, LTA or private.

Pest-exclusion fences. Exclusion fencing has commonly been called ‘predator fencing’ or ‘predator proof fencing’. Exclusion fences are completely enclosed ring fences aimed at excluding all mammalian pests including browsers and predators. While the intension of fences is to exclude all target pests, all of the time for the lifespan of the fence, no fence can be completely secure from breeching and regular incursions can be expected and must be dealt with.

Pest-resistant fencing. Resistant fencing generally refers to fences on such geographic feature as peninsulas or enclosed valleys where pests can access the enclosed area by skirting around the fence ends. These fences greatly reduce pest presence and access but are not as effective as ring fences.

Species occupancy. The extent to which all species occupy their natural range at their normal abundance.

The ‘halo’ effect. The occurrence of migration by indigenous species from a managed and safe area of habitat into the surrounding lesser managed or unmanaged habitat.

The ‘nursery’ zone. A pest-free area (usually fenced) which acts as a safe house for more sensitive species to breed and proliferate and in time create a biological surplus which can migrate beyond the nursery zone.

Tools. This refers specifically to devices, procedures, practices and methods applied in the field, primarily for the purposes of managing exotic pest mammals. There are many other biodiversity management tools, including field tools for managing exotic birds, fish, weeds and invertebrates, protective legislation and regulations, and field tools for ecosystem and protected species management.

Appendix 2. Mammalian Invasive Pests.

Following is a summary of invasive pest mammals in New Zealand which are commonly targeted for exclusion by fencing.

Species	Arrival	Range	Effect	Control
Rattus exulans **Kiore Rat**	With māori	A few isolated areas and islands	Omnivore Does not fare well in the presence of other rodent spp.	Rodenticide toxin Rat traps
Rattus norvegicus. **Norway rat**.	1780 and on with early European explorers.	Widespread including remaining on some larger offshore islands, but rare in places.	Omnivore. More ground dwelling and commensal.	Rodenticide toxin Rat traps.
Rattus rattus. **Ship rat.**	Later 19th century.	Widespread including remaining on some offshore islands. The dominant rat in NZ forests.	Omnivore. Excellent tree climber.	Rodenticide toxin Rat traps.
Mus musculus. **House mouse**.	1800 and on with early European explorers.	Widespread including some offshore islands.	Omnivore. More ground dwelling and seed/fruit eating. Suppressed by other rodent spp and predators.	Rodenticide toxin Mouse traps.
Mustela erminea. **Stoat**	1880's for rabbit control.	Widespread through both main islands and islands within swim range. Absent Stewart Island.	Carnivore. Diet 40% native birds in unmanaged forest. Supress rat and rabbit populations.	Trapping. Various toxins Secondary poisoning.
Mustela nivalis. **Weasel.**	1880's for rabbit control.	Widespread through both main islands and islands within swim range. Absent Stewart Island.	Carnivore. Diet is more rodents, insects and lizards.	Trapping. Various toxins Secondary poisoning.
Mustela putorius. **Ferret.**	1880's for rabbit control.	Widespread through both main islands but with some localised absence. Absent Stewart Island.	Carnivore. Diet is mostly rabbits and hares. Preys on larger birds if available.	Trapping. Various toxins Secondary poisoning.
Felis catus. **Feral cat**.	Arrived with first European settlers.	Widespread through both main islands and Stewart Island.	Carnivore. Diet is mostly rabbits and rats. Preys on birds and mustelids.	Trapping. Secondary poisoning.
Oryctolagus cuniculus. **Rabbit.**	Introduced 1850's.	Widespread through both main islands, especially in grasslands.	Omnivore. No effect on native fauna other than habitat damage.	Trapping shooting Toxins.
Trichosurus vulpecula. **Possum.**	Introduced late nineteenth century.	Widespread through both main islands and Stewart Island. Primarily a forest dweller.	Primarily a herbivore but can be opportunistically omnivorous.	Trapping shooting Toxins.

Species	Arrival	Range	Effect	Control
Erinaceus europaeus. **Hedgehog**.	Introduced nineteenth century.	Widespread in both islands and Stewart Island.	Primarily insectivorous but can be opportunistically carnivorous.	Trapping Toxins.
Cervidae *spp.* **Red deer** **Fallow deer** **Sika deer** **White tail deer** **Samba deer**	Introduced in nineteenth and twentieth centuries.	Widespread (except Northland) with some species more localised, e.g., White Tail on Stewart Island.	Herbivore. Primarily a forest or forest margin dweller in New Zealand.	Shooting.
Capra hercus. **Goat.**	Introduced by early European explorers	Widespread on two main islands. Removed from most offshore islands.	Herbivore.	Shooting
Sus scrofa. **Pig**	Introduced by early European explorers	Widespread on two main islands. Removed from most offshore islands.	Omnivore. Primarily a forest or forest margin dweller in New Zealand.	Shooting
Macropus spp. **Damar Wallaby** **Bennett's Wallaby**	Introduced in the nineteenth and twentieth centuries.	Damar centred in the Bay of Plenty and Bennett's on Mid-Canterbury.	Herbivore. Inhabits both forest and grassland.	Shooting Trapping.

Appendix 3. Fenced Eco-sanctuaries

Ring fenced sanctuaries

Name/location.	Area enclosed	Fence length date built	Species reintroduced. (Note. Lists may be out of date or incomplete)	Governance
Zealandia Wellington City	225 ha	8.6 Km 1999	Reintroduced sixteen species, seven were the first to be reintroduced to the mainland. LS kiwi, RC kakariki, tieke, hihi, tuatara, giant weta, Hamilton's frog, plus kaka, NI robin, pateke, rifleman, bellbird.	Wellington City Council trust
Bushy Park Whanganui.	100 ha	4.8 km 2005	Tieke, NI robin, hihi, whitehead.	Forest and Bird charitable trust
Maungatautari Cambridge	3,240 ha	48 km 2006	Hihi, kiwi, tīeke, kaka, takahe, tuatara, whitehead, YC kakariki, NI robin, kokako, banded kokopu, giant weta, rifleman.	A trust in partnership with iwi, district and regional councils and landowners.
Orokonui Dunedin	307 ha.	9 km 2007	Kaka, Haast kiwi, tieke, takahe, SI robin, tuatara, Otago skink.	Charitable trust owned by the Otago Natural Heritage Trust.
Rotokare Stratford.	250 ha	8.2 km 2008	Hihi, tieke, NIB kiwi, NI robin, rifleman, whitehead, pateke.	A charitable trust, the Rotokare Scenic Reserve Trust.
Brooke Waimarama Nelson.	690 ha.	14.4 km 2016	SI Tieke, OF kakariki. Reintroduction programme just beginning.	A charitable trust run by the Brook (Waimarama) Sanctuary Trust.
Six	4,812ha			

Peninsular fences

Name location	Area enclosed	Species reintroduced	Governance
Tawharanui Wellsford	535 ha	Tieke, kiwi, robin	Auckland City Council
Shakespear Whangaparoa	500 ha	Tieke, kiwi	Auckland City Council
Cape Sanctuary Havelock North	2,500 ha	NIB kiwi, little spotted kiwi, pateke, tuatara, takahe, Cook Strait giant weta, tomtit, NI robin, whitehead, rifleman, RC kakariki, kaka, shore plover, Cooks petrel, grey faced petrel, diving petrel	Private trust
Young Nicks Head Gisborne	1,350 ha	Not known	Private
Kotuku Peninsula Great Barrier Island	240 ha	Not known	Private trust
Kaipupu Point Picton	40 ha	Not known	Community Trust
Six	5,165 ha		

Appendix 4. Wainuiomata/Puketahä

1. The problem is a lack of pest-free, rimu dominant, high quality, mainland breeding habitat for kākāpō and other critically endangered species.
2. The proposal is to construct a 28.8km predator proof fence around the Wainuiomata Water Catchment (3,313 hectares), eradicate all pests (predators and browsers), keep the area pest-free in perpetuity and restore kākāpō and other endangered species to the enclosed area.
3. This site has qualities which make it uniquely suitable for this purpose, including size, abundant rimu, habitat quality, optimum configuration for fencing, and location.
4. The site has high biodiversity value as it could change the status of three nationally critical endangered species, (kākāpō, rowi kiwi and hihi) and transform the Remutaka Range.
5. In addition to the biodiversity value, the project has considerable cultural, social and economic value, including substantial economic value added to a low-income area, the creation of permanent jobs and opportunities for social engagement. It aligns with many national goals in the Aotearoa Biodiversity Strategy-Te Mana o te Taiao.
6. The site is owned by Greater Wellington Regional Council (GW) and is operated as a water supply facility under a service agreement with Wellington Water. The site could be managed in tandem with the water supply function which must continue.
7. Taranaki Whänui, through the Port Nicholson Block Settlement trust, are the mana whenua. They support the proposal. DOC and GW also support the proposal.
8. The potential partners are Taranaki Whänui as mana whenua, GW as landowner and the Department of Conservation as the national biodiversity agency. They would all need to agree to participate as partners for the project to proceed.
9. There is an option for a legal entity and governance structure which could meet the needs of all partners. This is a partner (GW/iwi/DOC) controlled charitable trust. It would need the partners to be willing to participate and a service agreement with GW for joint use of the land with Wellington Water.
10. The project is challenging but technically feasible. There is a practical route on which a fence can be constructed and once fenced, pests can be eradicated and kept out of the area, (bar mice). Mice will not affect the primary purpose.
11. The project will go through three phases over the first ten-year period. These are:

    1.Preparatory (three years) 2. Development (four years) 3. Operations (year eight +)
12. Each phase has been described in terms of its key tasks and resource requirements.
13. The total cost has been calculated as $41,414,752 over the ten-year period.
14. This is broken down into OPEX of $22,032,828 over ten years and CAPEX of $16,680,000, plus a 15% contingency allowance.
15. The operational cost after year ten is calculated as $2,561,402 p.a. in current dollars.
16. There are significant risks involved in the project. Four risks could result in abandonment of the project if they occur and cannot be managed and mitigated. These are 1. Partners do not want to participate, 2. No funding available. 3. Wellington Water does not support the project, 4. Resource consent provisions too difficult.
17. The remaining risks are mostly technical and can be managed or mitigated.

Upper Wainuiomata catchment from the north ridge. Lower. The road and deer fence on the north ridge. Photo GW