NEW ZEALAND'S INDIGENOUS FORESTS - THEIR STATUS AND DRIVERS OF CHANGE

Dr Robert Allen
Landcare Research, Lincoln
roballen1706@gmail.com

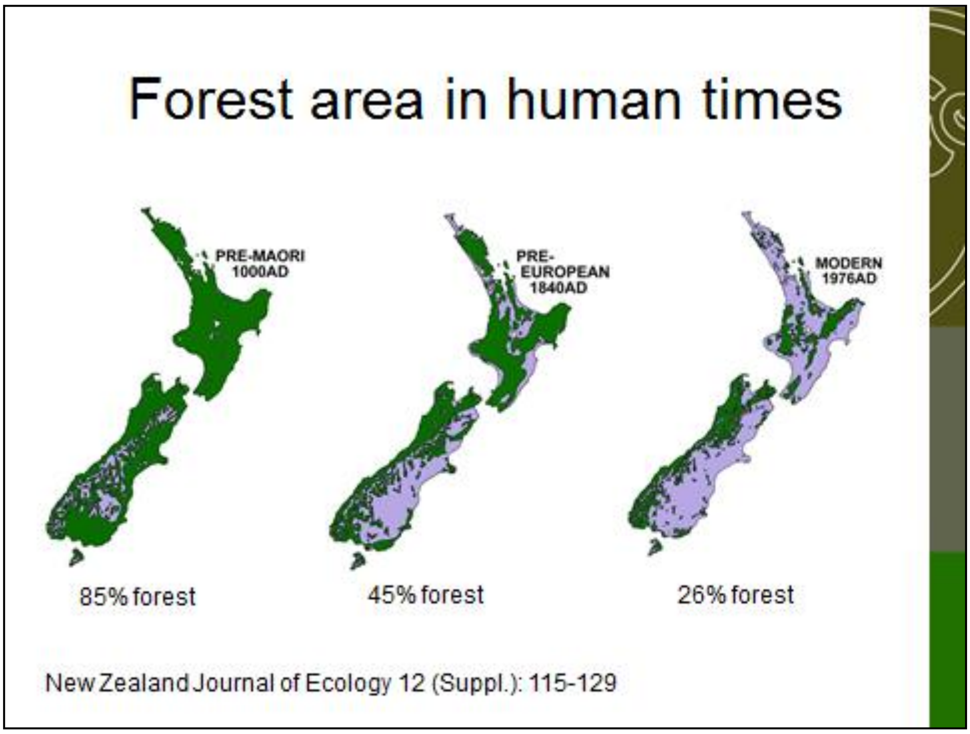
Rob grew up in Galatea, studied forestry (University of Canterbury), worked as a forester for the New Zealand Forest Service and then undertook a PhD (University of North Carolina) on the biogeography of Rocky Mountain forests. Returning to New Zealand he researched invasive species impacts, forest dynamics and biodiversity management while working as a Scientist, Science Team Leader and General Manager at Landcare Research. He has co-authored >130 peer-reviewed science journal publications and several books (e.g. Allen, R.B., Lee, W.G. (eds.) 2006. Biological Invasions in New Zealand. Springer, Heidelberg. p.457). He has also worked in Germany, China, Tonga, USA and Chile. The research in Chile focusses on forest dynamics on Tierra del Fuego and the impacts of invasive animals. He has been on several governing bodies (e.g. Australian Research Council), panels (e.g., Marsden Fund) and facilitation groups (e.g. for Te Kotahi ā Tūhoe).

ABSTRACT
New Zealand's remaining indigenous forests and shrublands are of immense cultural, environmental, and economic significance. A representative plot-based sample of these forests and shrublands has recently allowed an unbiased depiction of their composition and structure. This is necessary for international reporting, performance assessment and management prioritisation. Their composition, structure, and function are driven by a diverse array of factors, many of which are complexly interrelated. The imprint of disturbances is pervasive and it is necessary to understand disturbances to interpret human-related impacts. For example, understanding impacts of exotic browsing mammals is only possible within a context of forest ecosystem development and tree demographic processes. There are now extensive areas of shrublands successional to forest, often composed of mixtures of indigenous and exotic species. These shrublands expand the opportunities for ecosystem services from, for example, carbon sequestration to water quality. An increasing area of indigenous forests and shrublands are managed for distinctive Māori aspirations that include sustainable use.

TRANSCRIPT
I am not going to talk about wallabies specifically, but rather things relevant to wallabies. Some of the topics will be quite general and hopefully attractive to those who are not into forests. In some aspects I will get quite specific which will appeal to those who are interested in forests and may be of interest and more relevant to the wallaby.

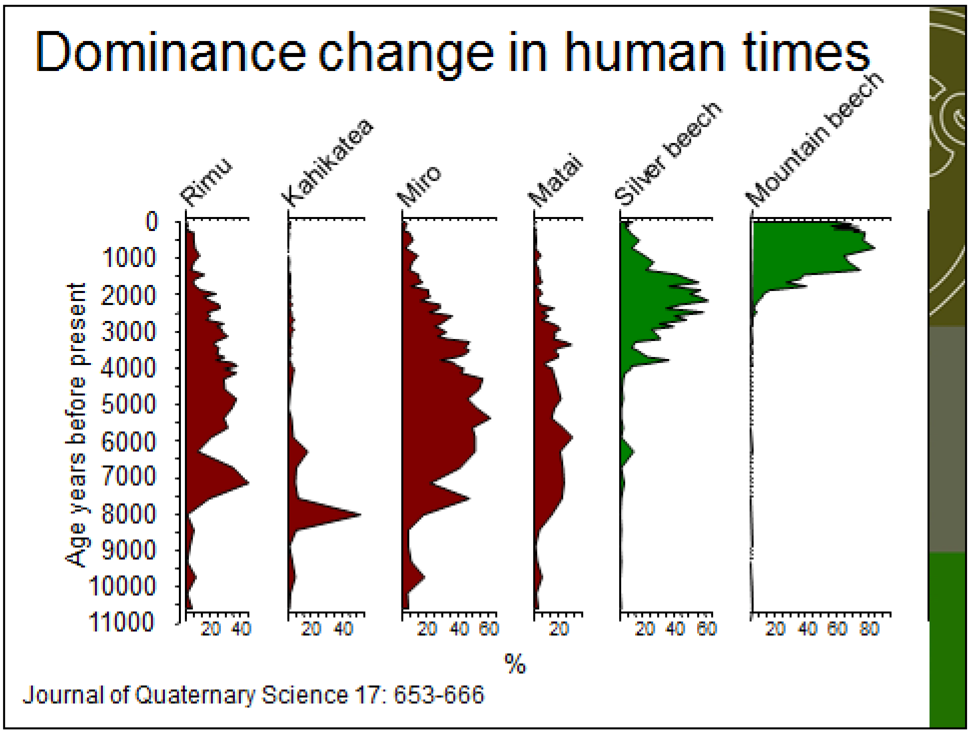
There are two parts to my talk - status and trends in indigenous forests and drivers of change. Probably the most profound change in the county's indigenous forests has been the loss of forest area. **(Slide 1)** In human times we have gone from 85% forested, marked in green, to 26% forested. We have lost the forest particularly in the drier eastern areas and at lower elevations.

Slide 1



People are interested in the changes taking place in deforested areas, but there is considerable change taking place in forested areas as well. One piece of evidence comes from pollen analysis. People who study pollen deposition in bogs can age the time it was deposited and build up a history of vegetation change. **Slide 2** is a pollen diagram from Southland showing time on the left and moving up to our present, and the percentage of pollen across a range of tree species.

Slide 2



In the last 1,000 years mountain beech has come to dominate this forest. In the 1,000 years before that they were dominated by silver beech and before that a range of podocarps. So in the last 3,000 years there have been dramatic changes in the composition of the forests unrelated to human impacts. Looking at matai, one of the podocarps, it is only 5 generations in 3000 years and so dramatic changes at short time scales in terms of the trees but of course not in human time scales. These background changes go on quite commonly when looking at history of the forests.

To summarise current forest and shrubland:

- 7.3 million ha (26% of area) of indigenous forest
  - 2.0 million ha of beech-broadleaf forest
  - 0.4 million ha of kānuka forest
- 1.5 million ha (6%) of shrubland
  - 0.5 million ha of bracken-gorse-exotic grass
- <0.001 million ha (< 0.004%) of planted indigenous forests[1]

We have been trying to plant indigenous forests for a long time. You will find in Roche's book on the History of New Zealand Forestry[2] large efforts to plant areas of indigenous forests were made in the 1880's and 1890's. Within the indigenous forest area are considerable beech forests, because they are left in mountainous, wetter areas. We also have large areas of kanuka, bracken, gorse and exotic grasses that are often successional back to forest. These are large areas naturally going back to forest and I will come back to that a bit later.

Slide 3

[1] Applied Vegetation Science 14: 505-523

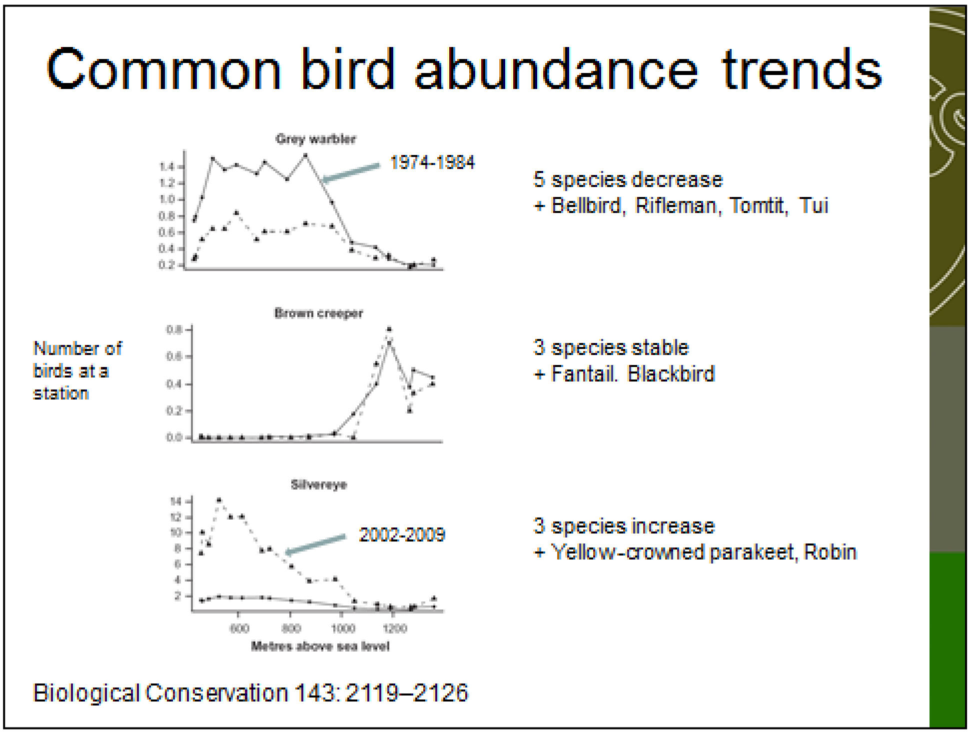
[2] Roche, Michael; (1990) *History of New Zealand Forestry,* GP Print Ltd, Wellington.

Slide 3 looks at bird extinctions. The first birds here; moa were a large herbivore abundant in our forests, up to 250 kilograms for an individual bird. We were faced with a 400 year period of no large herbivores in our forest before we introduce others. The Haast's Eagle was a 15 kilogram bird with a 3 metre wing span which ate moa and many of the other larger birds. There was a South Island goose, a 20 kilogram bird that was flightless. North Island also had a goose but it was somewhat smaller than the South Island one.

Around 40 bird species have become extinct in human times, which is 30% of 131 bird species. In pre-European times they were large birds and in European times they were flightless birds. There are many reasons for the decline in birds. The loss of 75% of the forest was largely through fire and the odd feather was singed. Not only did we have fire as a factor leading to extinction, but also disease, fragmentation of habitat, small populations and predators. With around 2,500 native plant species we have lost one; the point being the loss of a very few plant species in comparison with the birds.

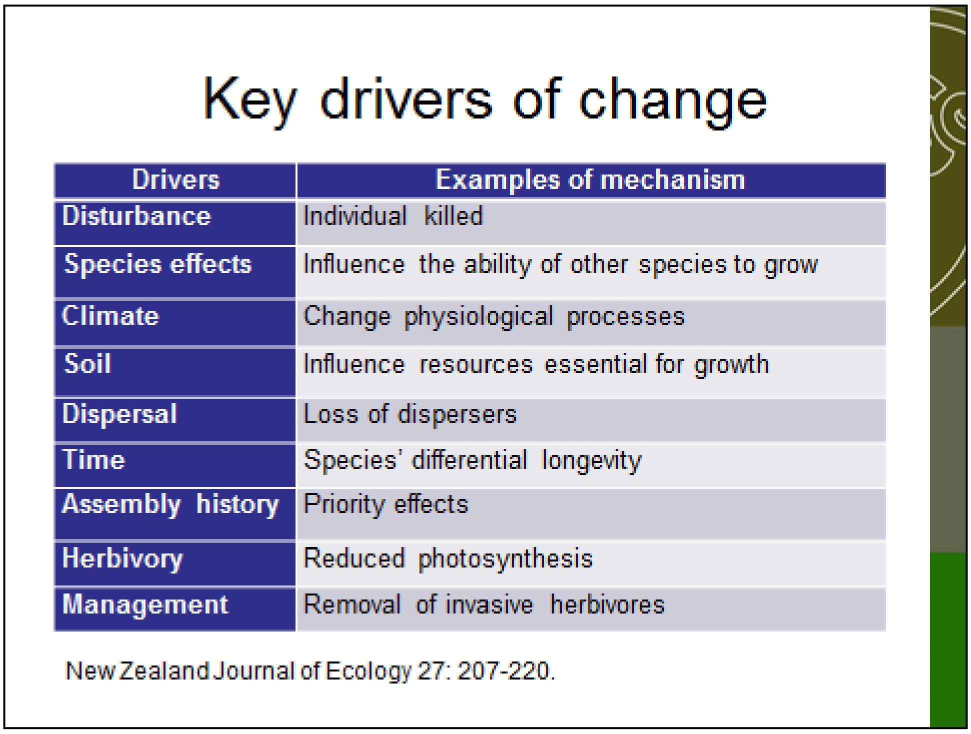
In European times we have lost 34 land bird species and 17 land bird species have arrived naturally, either flown or blown here. This emphasises that the role of the split up of Gondwana in New Zealand's isolation has been questioned. The New Zealand biota is quite new, often less than 5 million years since the arrival of the ancestors. Gondwana was 70 million years ago, so immigration has always been a feature on longer time scales.

Slide 4



On shorter time scales we have very little information about the trajectory of bird communities for any length of time. **Slide 4** is one of the few studies on community level changes in bird abundance. It is from a ridge in Nelson Lakes National Park and counts the number of birds at a recording station. It shows the elevation going up the ridge. In the 1970s the grey warbler was more abundant at low elevations than between 2002 to 2009 and the other line indicates that this bird species has declined at low elevations. The silver eye has become more abundant at low elevations than it was back in the 1970s. Some bird species like the brown creeper are high elevation species and have not changed in the last 30 years. Overall 5 species have declined, 3 have stayed the same and 3 have increased, one being the yellow crowned parakeet. We have different trajectories for species taking place in different parts of the landscape.

Slide 5



Key drivers of change

Drivers	Examples of mechanism
Disturbance	Individual killed
Species effects	Influence the ability of other species to grow
Climate	Change physiological processes
Soil	Influence resources essential for growth
Dispersal	Loss of dispersers
Time	Species' differential longevity
Assembly history	Priority effects
Herbivory	Reduced photosynthesis
Management	Removal of invasive herbivores

New Zealand Journal of Ecology 27: 207-220.

I have talked about status and trend but the topic that interests me most is key drivers of change and they are many and varied. **(Slide 5)** Many people study disturbance, an event that kills trees. Others have studied the effects of management. But few people have studied things like assembly history or species effects and yet they are as important in driving change as the more studied drivers of change. In sympathy with past work I am going to go with examples of disturbances as a driver of change and management but I do not want to belittle all those other factors, which to include would turn into a one day seminar.

Disturbances are pervasive and varied. In the South Island people are obsessed with glaciation as a remover of forests and landslides initiated by earthquakes. In the central North Island people are obsessed with volcanic eruptions in the long time scale in terms of dictating forest pattern and dynamics, and flood deposition. There are also climatic events like drought and wind, or fire, pest and diseases.

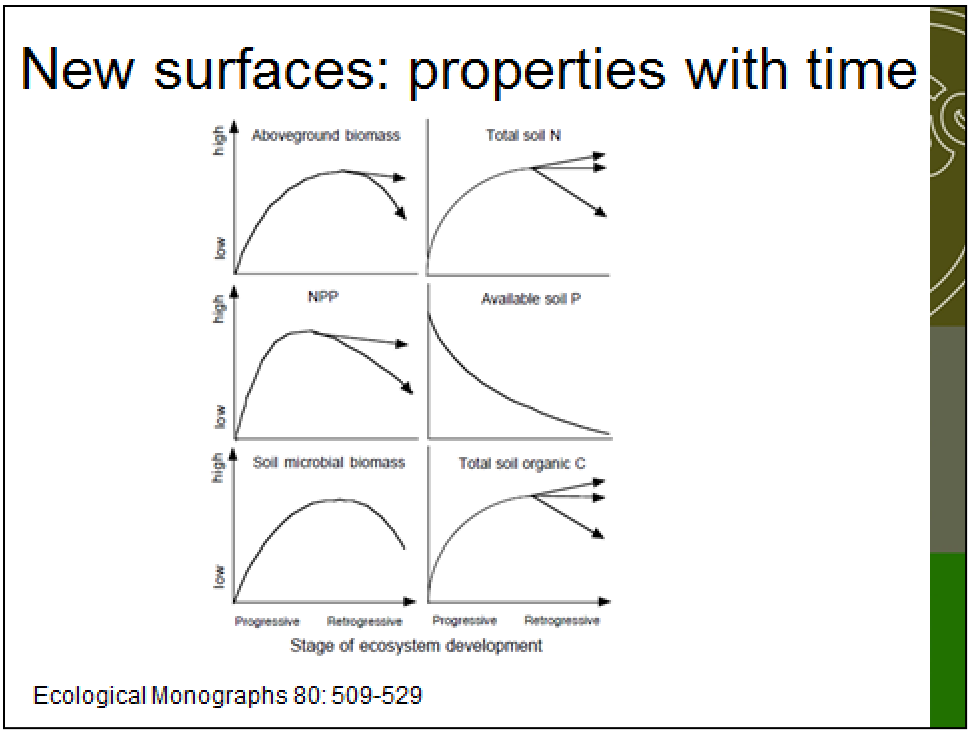
The impact that could be caused by these events is the creation of new mineral surfaces and the example in **Slide 6** is from a glacial recession in the South Island, leading to a fresh mineral surface with colonisation by plants.[3] There is an increase in biomass or a progression to a tall statured forest and in the final stage nutrients are lost from the system and the stature becomes less.

[3] Ecological Monographs 80: 509-529

Slide 6

This is also found on sand dune successions, volcanic eruption induced successions and has recently been summarised as a set of ecosystem properties through time (**Slide 7**). All else being equal these processes are occurring everywhere. There is a build-up in above ground biomass and in primary production. I want to focus on total soil nitrogen which accumulates and soil available phosphorus which declines. On a fresh mineral surface such as landslide surfaces or alluvial fans there is high available phosphorus and this creates opportunities for surface transport of phosphorus and movement in soil solution. This should be reflected in background patterns of stream chemistry to some degree but there are also other relevant processes.

Slide 7



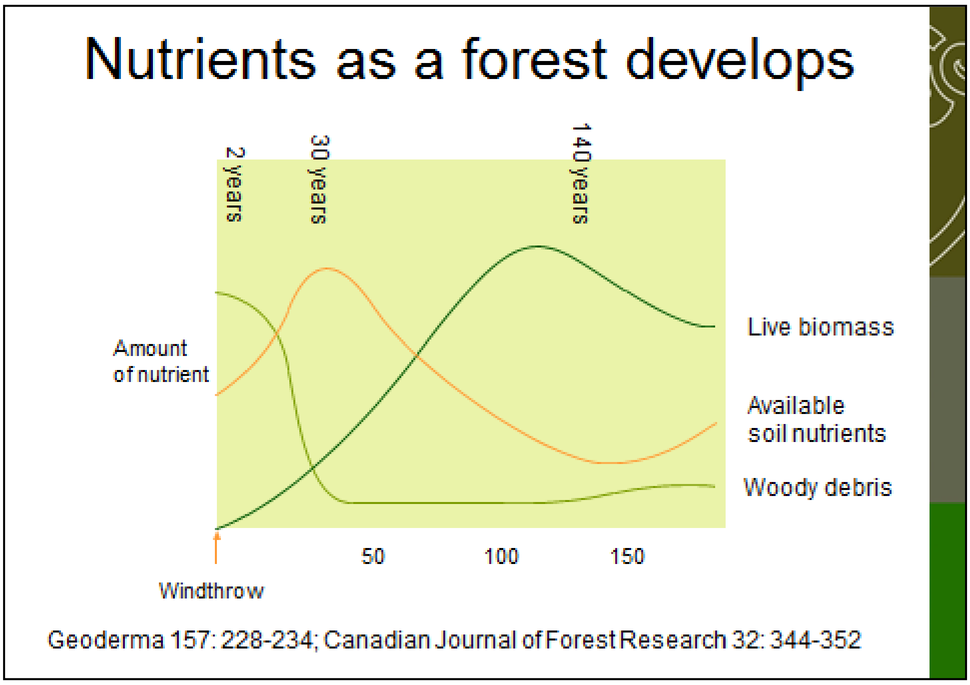
This is fundamentally altered where the disturbance leaves the organic material on the landscape, and **Slide 8** shows where a wind throw has put woody debris on the ground. The middle picture shows the woody debris quite decomposed at 30 years with young trees and then to the right more mature trees. This is a common sequence where you have wind throw. We have a set of soil nutrient availability trajectories taking place here.

Most of the nutrients are stored in the dead woody debris initially. As that woody debris decomposes those nutrients become available in the soil. Then as the biomass in the forest builds up, the nutrients move from the soil to the live biomass.

Slide 8

Slide 9 shows the amount of nutrients for each of these trajectories. Again we see declining available soil nutrients over much of this development sequence, suggesting that there will be patterns in soil solution chemistry consistent with this forest development pattern. In some of the forests around the lakes there will be even aged forests with soils developing in this way.

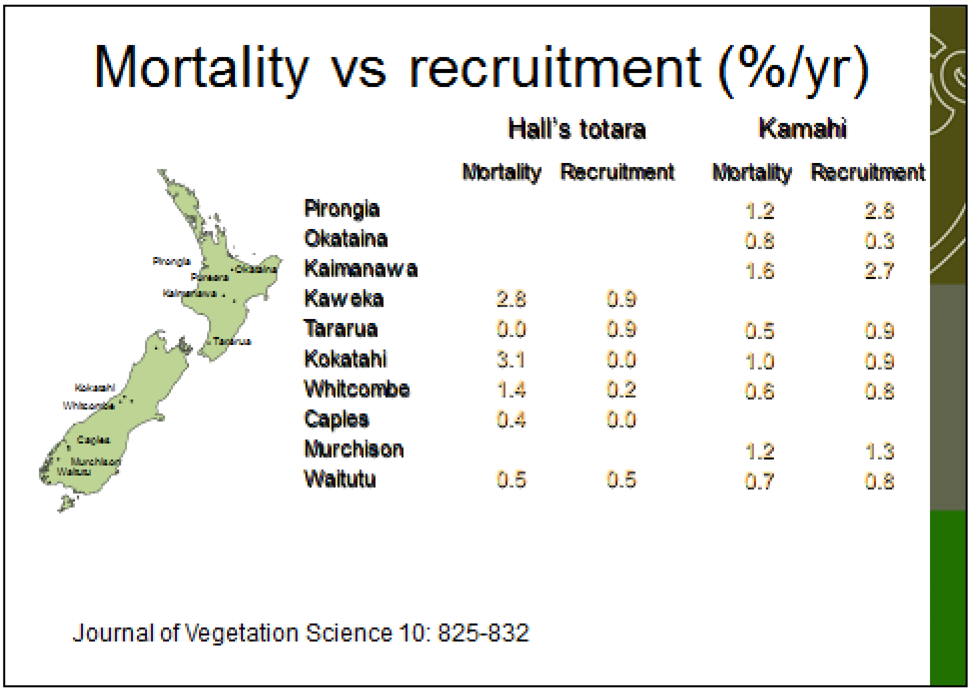
Slide 9



Slide 10 shows locations around the country where permanent forest plots have been established with tagged individuals to calculate mortality and recruitment. At each of these locations the sampling is representative, not biased. The mortality for Hall's totara in the

Kaweka Range exceeds recruitment. In the Tararua range the recruitment exceeds mortality. At Okataina kamahi mortality exceeds recruitment and in the Kaimanawa recruitment exceeds mortality. It indicates that the balance between mortality and recruitment in different locations around the country is varied, implying that the processes of nutrient and biomass dynamics are different in each location.

Slide 10



	Hall's totara		Kamahi	
	Mortality	Recruitment	Mortality	Recruitment
Pirongia			1.2	2.8
Okataina			0.8	0.3
Kaimanawa			1.6	2.7
Kaweka	2.8	0.9		
Tararua	0.0	0.9	0.5	0.9
Kokatahi	3.1	0.0	1.0	0.9
Whitcombe	1.4	0.2	0.6	0.8
Caples	0.4	0.0		
Murchison			1.2	1.3
Waitutu	0.5	0.5	0.7	0.8

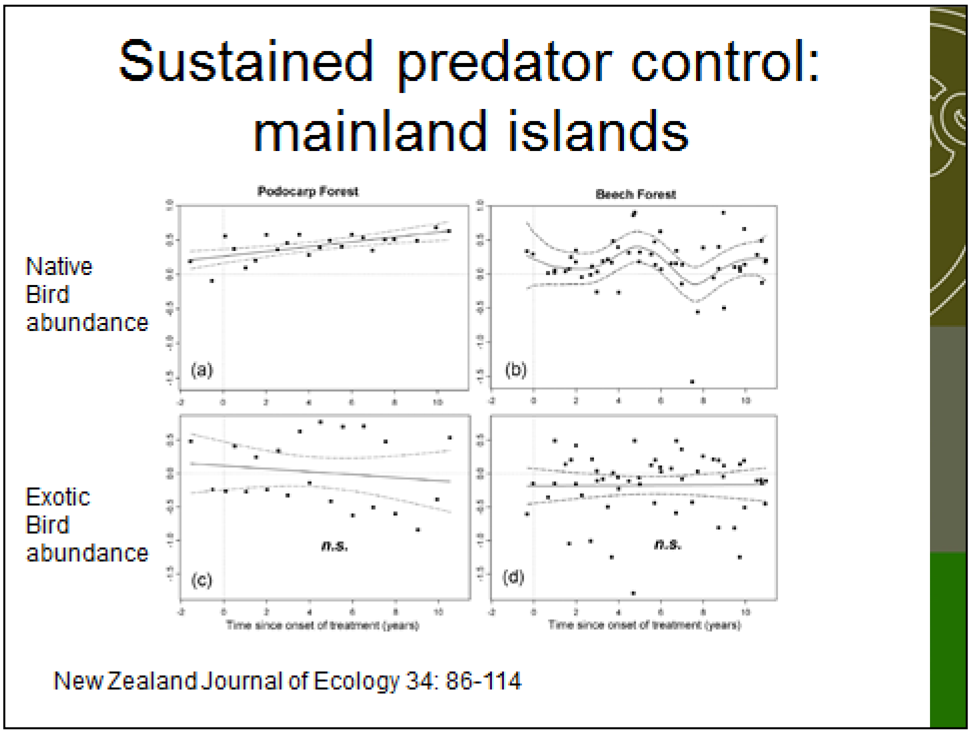
There are two ways that we manage our forests:

Threats
- Fire
- Invasive species
- Climate Change
- Fragmentation

Services
- Timber
- Water quantity and quality
- Carbon

Slide 11 is a study from mainland islands around the country looking at the impact of management of invasive species - as predators have been removed, as much as they can be. Two of the locations were in the podocarp forest of North Island mainland island sites, and two are beech forests in South Island sites. The graphs record the native bird abundance. In the North Island podocarps sites there is a slight increase in native bird abundance over the untreated area and no trend in the exotic bird abundance. Whereas in the South Island beech forests after 10 years of mainland island predator control there is no trajectory in native bird abundance over the whole period. We do have an oscillation in native bird abundance which is related to resource availability and no pattern in exotic bird abundance. So we have varying patterns around the country depending on the nature of the system.

Slide 11

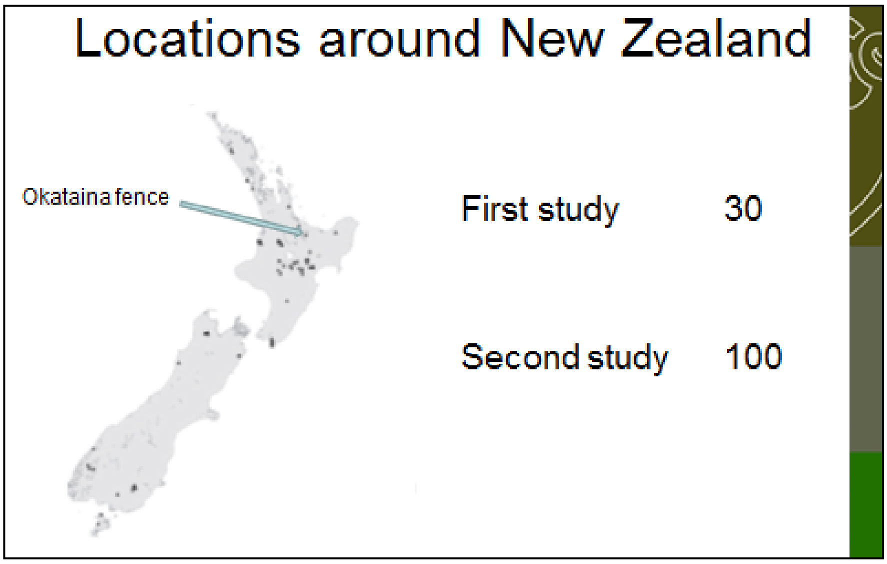


The second example of management is herbivore removal by fence plots, one is shown in **Slide 12** in Te Urewera. There are two studies I will talk about, one using around 30 exclosures throughout the country and one using around 100 exclosures throughout the country as shown on the map, including one Okataina site. **(Slide 13)**

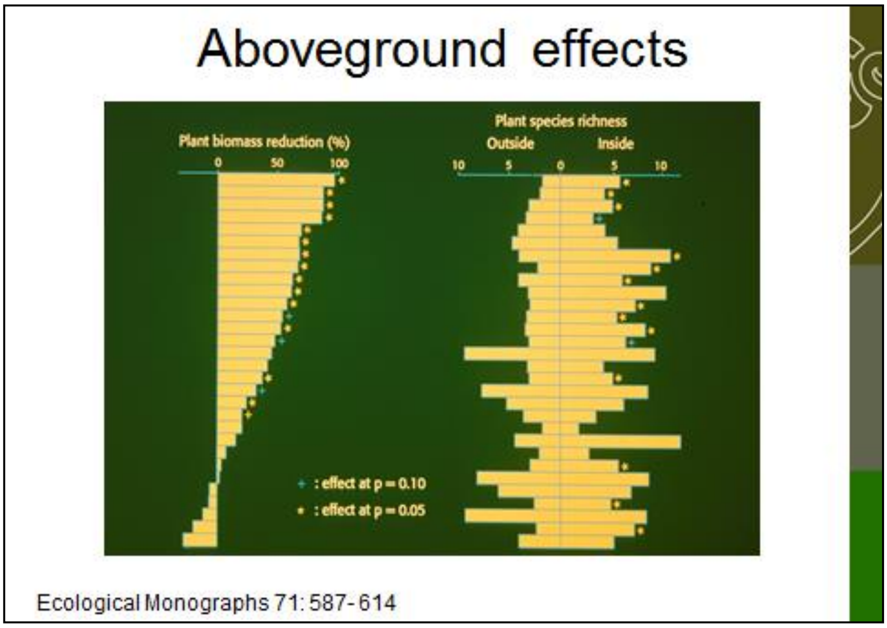
Slide 12

A comparison was made of forest ecosystem properties, both above and below ground, at one point in time after the exclosure had been established. **Slide 14** shows on the right hand side plant biomass reduction with a horizontal bar for each exclosure. Bars to the right show there is more plant biomass inside the exclosures, and the bars to the left, and at the bottom of that diagram, indicate more biomass outside the exclosures. The exclosures (horizontal bars) are ranked from the most biomass increase inside to the most

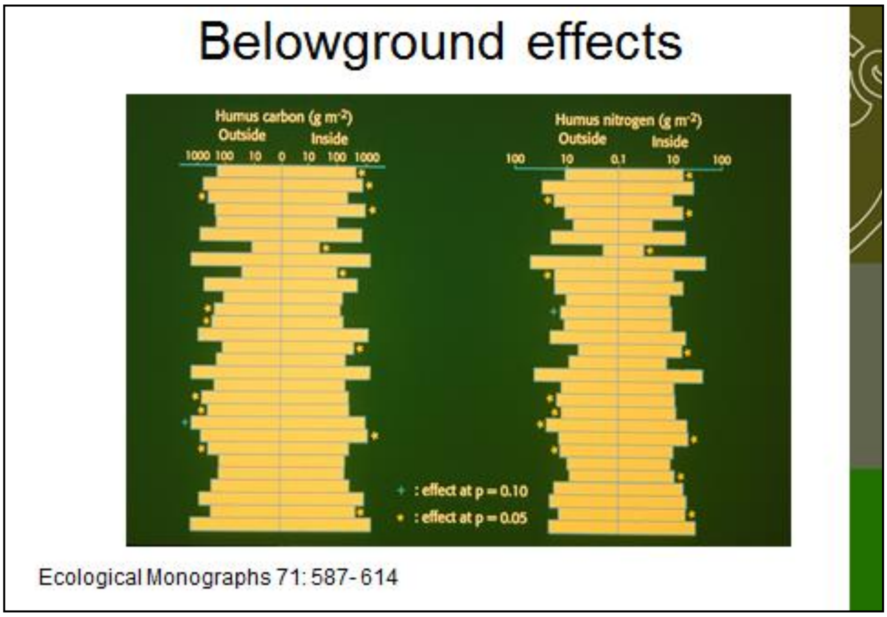
Slide 13



Slide 14



Slide 15

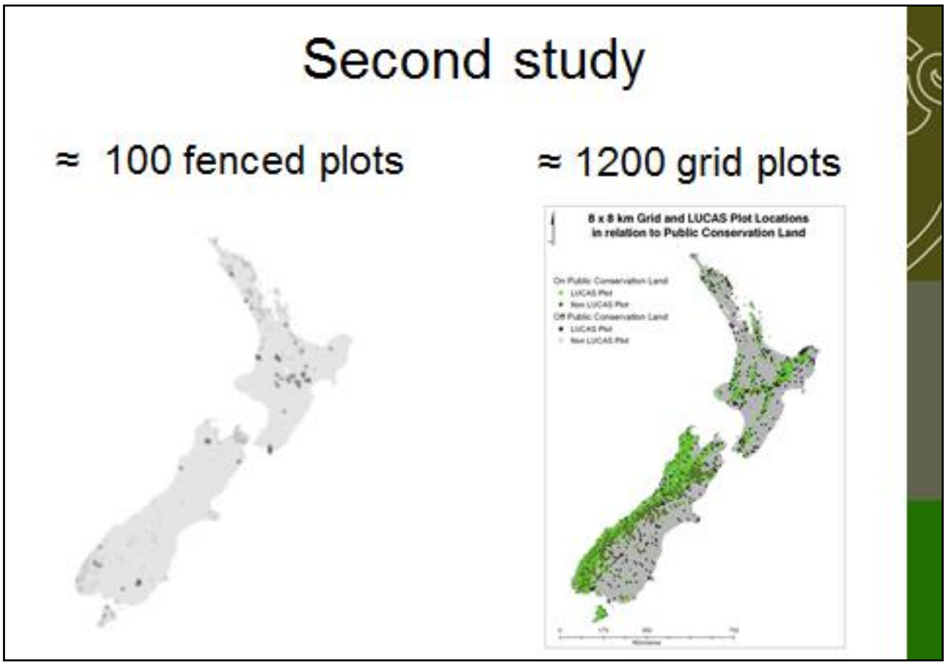


increase outside. Around 50% of the enclosures have statistically more biomass inside than outside. Looking at plant species richness on the left hand side, there is often statistically more species inside than outside the exclosures (That is the asterisk against the bar), but the order is unrelated to the biomass change effect. So where there is little above ground biomass effect you can have a significant species richness effect.

Slide 15 shows the below ground effect of exclosures on humus carbon inside versus outside. Some exclosures have more humus carbon inside and others more outside. There is no pattern related to the above ground response suggesting that it is not ordered by the above ground biomass pattern in the previous slide. So below ground is decoupled from above ground. Similarly, the pattern with humus nitrogen, sometimes has an increase outside, sometimes inside. It is important to recognise that below ground responses to herbivore removal do not always mirror above ground responses.

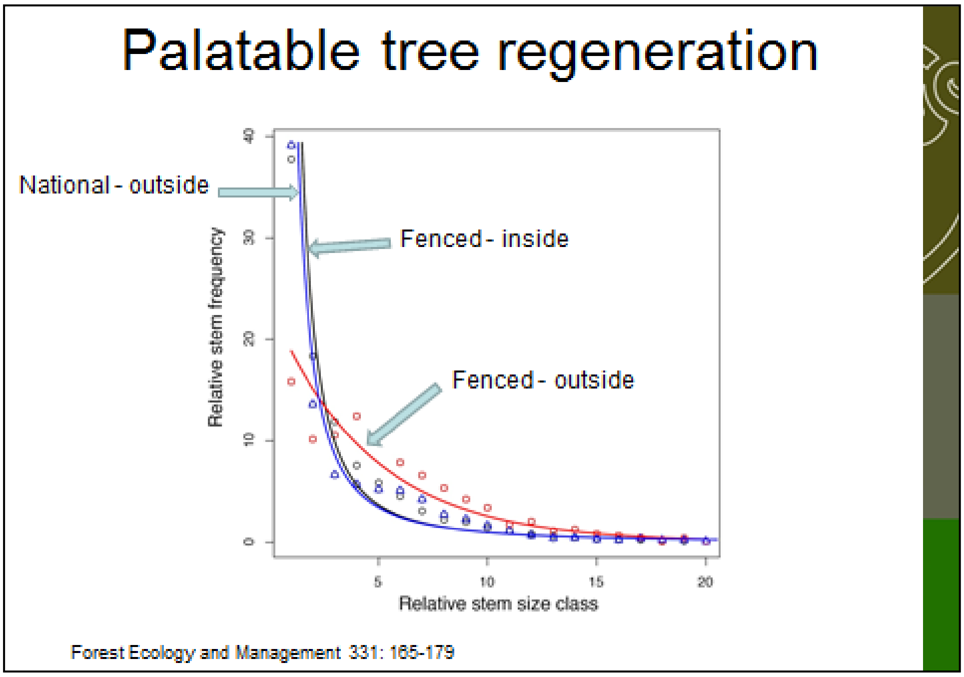
Slide 16 is the second study which used 100 fenced exclosures and compared the size-structure of palatable tree species inside and outside exclosures around the country with their size structure on a grid of plots initially established by the Ministry for the Environment but taken up by the Department of Conservation. The important point here is that they are a representative sample of the country's forests, unfenced, and on a fixed grid.

Slide 16



(Slide 17) Inside the fenced exclosures the blue line shows there were many small trees and a few large individuals. The red line is for trees outside the exclosure where there were a similar number of large individuals to inside the exclosures, but much fewer small individuals, just as we expected from looking at the photo in **Slide 12**. But when you go to the national grid sample of plots the size structure of palatable trees is similar to inside the exclosure. This suggests that the subjectively located exclosures are a biased sample of the country's forests. What has happened is that people go out and where they see intense impacts they put in exclosures, but they are strongly biased for what is happening in the country's forests.

Slide 17



But I have not talked about many species. In this country 31% of land birds are exotic. We have no idea about that for insects or moulds because we do not know our indigenous species.

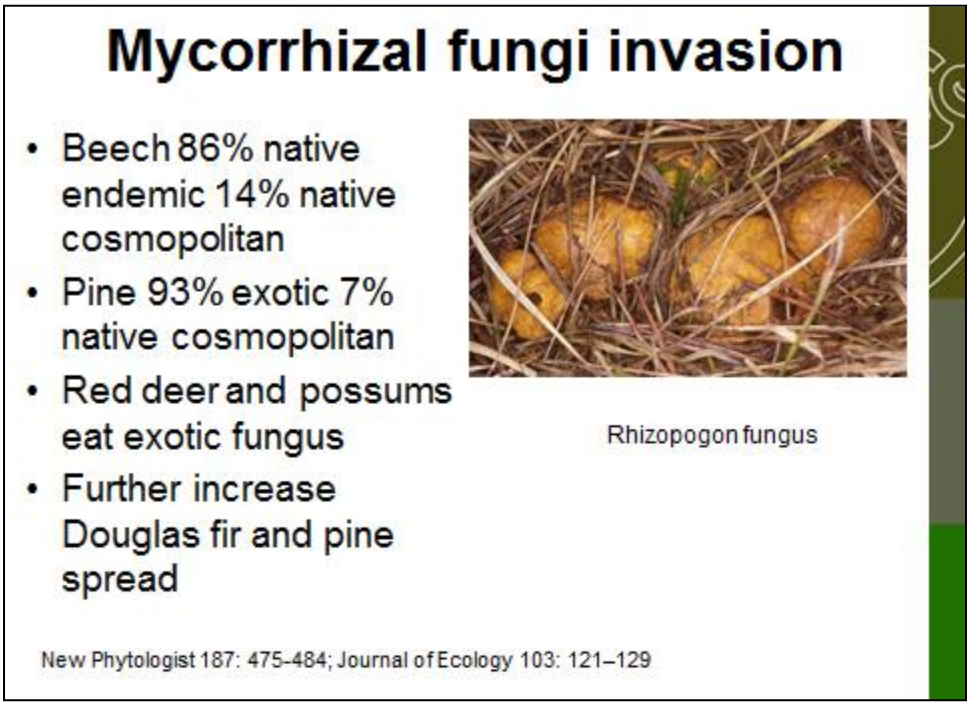
Forgotten Invasives - Diversity of introductions

• Land birds	31% exotic
• Insects	??% exotic
• Moulds	??% exotic
– Phytophthora taxon agathis	exotic?
• Bacteria	??% exotic
– Phytoplasma /cabbage tree	native?
• Fungi	??% exotic

When it comes to kauri die back we do not know whether the implied agent phytophthora taxon agathis is native or an exotic. We have similar problems with bacteria. Phytoplasma was thought to lead to the cabbage tree decline 15 years ago we cannot be sure whether that agent was native or exotic. Not knowing means we are hard pressed to understand the effect of invasive species.

However, some of the invasives that are quite cryptic can have profound impacts. A recent study of native beech and exotic pine trees growing in mixture where both had mycorrhizal communities on the roots (**Slide 18**).These tree species have ectomycorrhizal fungi on the roots, one type of mycorrhiza. They are a fungus on the root of trees that help them establish and grow. In the beech trees 86% of the fungi were native endemics, a native species only found in New Zealand, and 14% were native cosmopolitan, a native species here but which also occurs in other parts of the world. The pines had 93% exotic and 7% native cosmopolitan. We are talking about the tree species growing in a mixture together; yet they do not share mycorrhizal species even though they are the same type of ectomycorrhiza in a broad sense. In addition, people are also looking at the dispersal of all these mycorrhizal fungi. Red deer and possums eat the exotic fungus but, not the native fungus, and disperse these fungi in the same way they do in their home countries.

Slide 18



This will allow the exotic tree species to better establish, spread and compete with native species. So as these processes take place we will be further shifting the balance and competitiveness of exotic and native tree species.

Talking about indigenous forests providing services, carbon has gone out of fashion but it remains important because there are ways that it might come back on the agenda. The amount of carbon stored in indigenous forests and shrublands has been estimated at around 5,600 megatonnes of CO_2 equivalents. If we were to remove the human effect on successions back to native forest, caused by clearing and grazing, it has been estimated that around 1,800 megatonnes would be added. That is without human disturbance stopping those successions. This is estimated at between 6 and 12 megatonnes of CO_2 equivalent per year for the period 2010/2022. New Zealand's gross emissions of CO_2 are expected to go from 74.7 to 83.5 mega tonnes a year between 2008 and 2020. What you can see is that one year of sequestration in these successional communities absorbs our anticipated increase in gross submissions for a 12 year period.

In conclusion I want to leave the impression that change is ubiquitous in our indigenous forests. Often these changes are driven by natural processes and can be the dominant force in driving change. To manage threats effectively and efficiently means picking battles that are valid and can be won, and there are plenty of examples of where we have not in the last 60 years in New Zealand. We need to understand that context matters and how systems change. Are changes that are undesirable reversible? Is it economically, socially and biologically feasible to reverse them and do we have a robust evidence-base for our actions? Too often we have subjective data that is biased and does not have the longevity to ensure it is robust for actions.

(Much of what I have talked about is summarised in a publication that can be found at http://www.manaakiwhenua.com/__data/assets/pdf_file/0017/77030/1_2_Allen.pdf).