Sanctuaries in a changing climate. What are the known unknowns?

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School of Biological Sciences
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the kauri drought experiment

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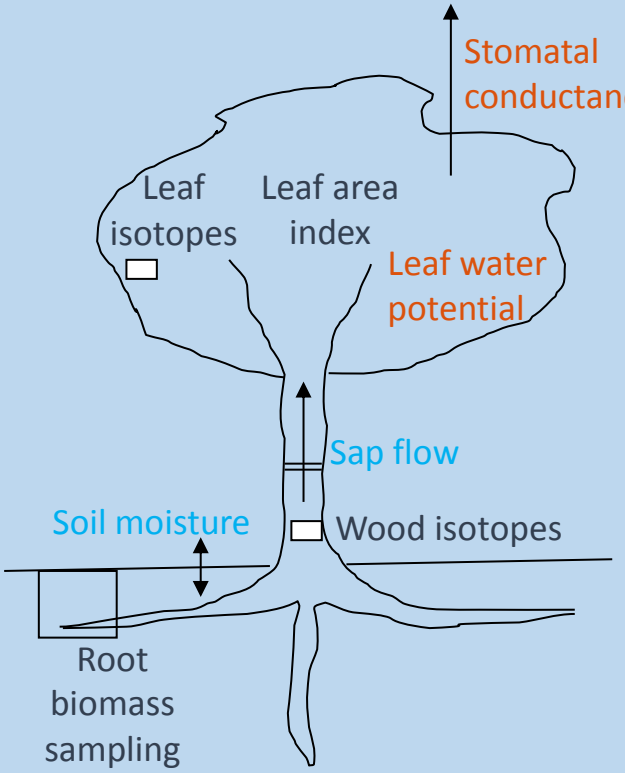
Te Pūnaha Matatini
Data ▪ Knowledge ▪ Insight

Water fluxes in kauri forest

the kauri drought experiment

What we measure



Schematic diagram of water flux measurements. Arrows represent fluxes of water

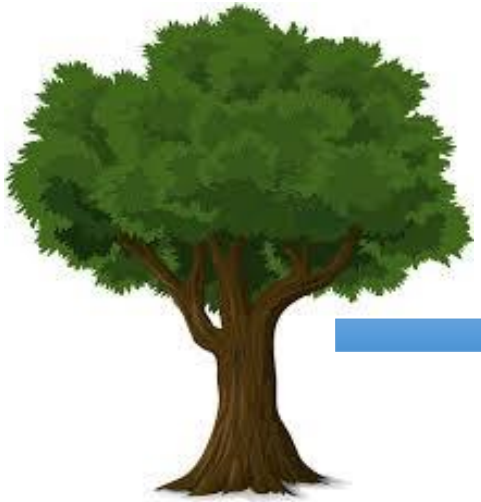
How we measure


Leaf processes


Climbing trees


Sap flow sensors

Scales of measurement/approximation



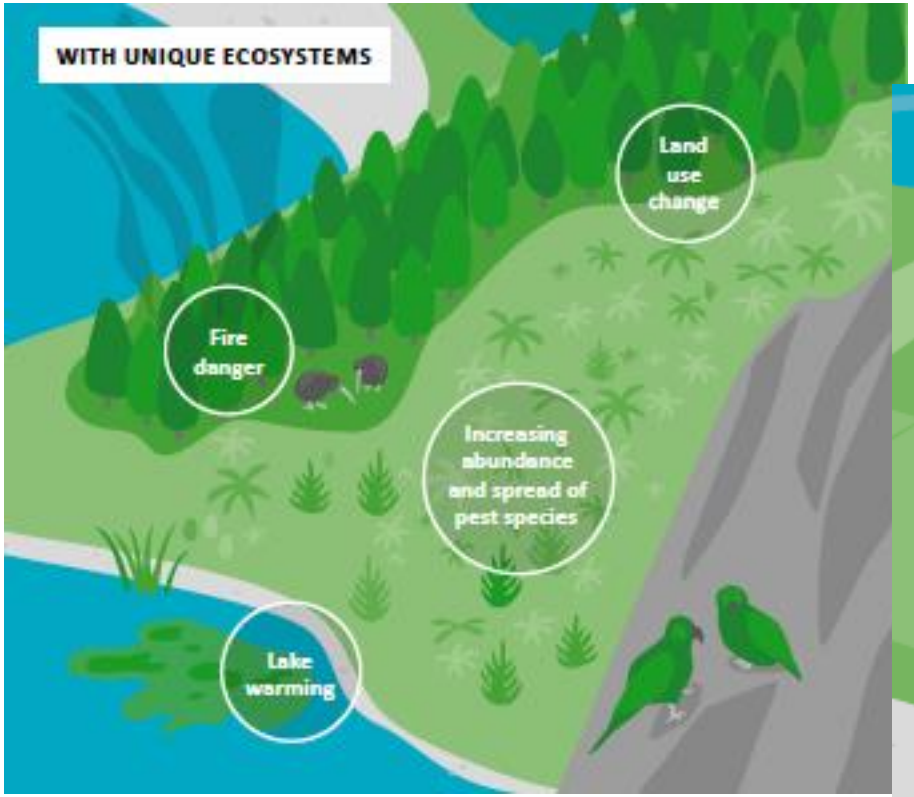
Evidence of climate change impacts in NZ

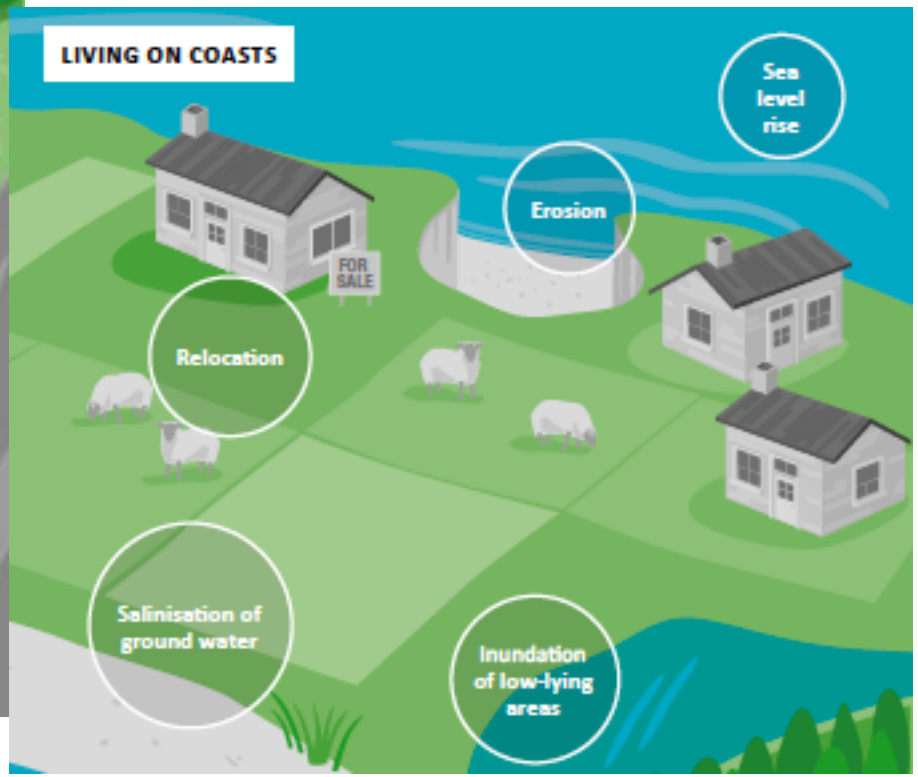
- 'Predicted impacts of climate change on New Zealand's Biodiversity' Lundquist et al. (2011) *Pacific Conservation Biology*
  - 7 of 67 references were actual climate change impacts in NZ
- 'Climate change, natural systems & their conservation in New Zealand' McGlone et al. (2010)
  - listed 10 clear examples of climate change impacts, half of which were seabirds

  In: New Zealand Climate Change Centre 2010. Climate change adaptation in New Zealand: Future scenarios and some sectoral perspectives. Nottage et al. (eds), Wellington, 136 p.

2016 Royal Society Te Apārangi Climate Change implications for NZ

http://royalsociety.org.nz/assets/documents/Climate-change-implications-for-NZ-2016-report-web3.pdf





Beyond mild, maritime climate

- In Environment Aotearoa 2015, Dr Jan Wright identified CC and rapid growth in dairying as twin threats to NZ's environment
- Prof Lesley Huges – regional IPCC lead author 4th and 5th assessment reports – poor research record in NZ
- NZ is largest emitter of GHGs in OECD yet has no long-term plan for Environment - March 2017 OECD report on Evironmental Performance

Changing climate in NZ

http://www.mfe.govt.nz/sites/default/files/climate-change-impact-map-a4.pdf

Biggest climate-related threats to biota in NZ

- Rising sea levels
- Freshwater availability
- Ocean acidification
- Extreme events
  - Droughts
  - Floods
  - Storms
  - Heat waves
  - Fires
  - Predictability, variability, magnitude

How might species and ecosystems respond to climate change?

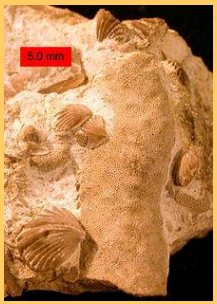
Modes of response to environmental change
(Dawson et al. (2011) Science 332: 53-58)

Toleration	Habitat shift	Migration	Extinction
Persistence at a site despite change	Moving short distances (1-10 km)	Moving 100 to 1000 km	Can involve population bottlenecks first
	Species adjust geographic location to track suitable environment	Species adjust geographic location to track suitable environment	

A species can respond in multiple modes

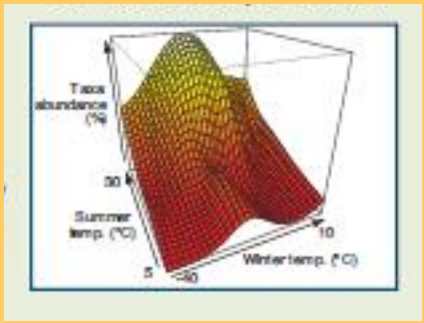
Empirical and observational

Paleoecological records



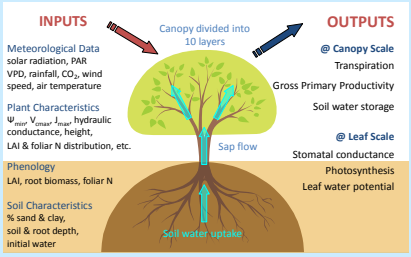
Direct observations

Climate envelope models

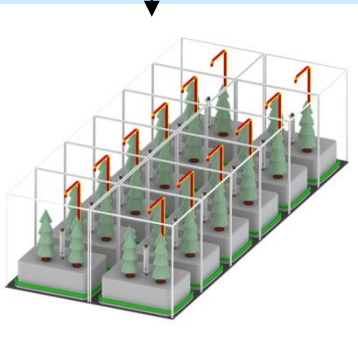


Integrated science of climate change biodiversity assessment

Mechanistic



Ecophysiological models



Experimental manipulations

Population models

Fig. 1, Dawson et al. 2011 Science 332: 53-58

Images: Wikimedia commons and https://www.bgc-jena.mpg.de/bgp/index.php/Main/JenaDroughtExperiment

Clear examples of CC threat

Tuatara produce only male eggs in higher temperatures

Shrinking alpine ecosystems

Rising sea levels squeeze coastal habitats

Increased frequency of mega masts -> increase of predator impacts

Images: http://www.forestandbird.org.nz/saving-our-environment/climate-change and http://www.landcareresearch.co.nz/publications/innovation-stories/2015-stories/mega-masts

Less clear examples

Fragmentation of rare populations

- Reshuffling of ecosystems
- Declines in ecosystem productivity and other ecosystem services
- Responses of plants to rising CO_2
- Shifts in ecological processes like pollination
- Interactions between CC and invasive species

Strategies identified in Christie (2014) DOC report

(Adapting to Climate Change: a proposed framework for the conservation of terrestrial native biodiversity in NZ)

1. Improve knowledge and understanding
2. Develop decision support tools and adaptation techniques
3. Incorporate adaptation strategies into existing management
4. Improve management and restoration of existing biodiversity
5. Raise awareness and understanding

Biological Heritage NSC

The team – December 2016

Tim Curran, Sarah Richardson, Kath Dickinson, Cathy Rufuat, Angus McIntosh, Helen Warburton, Richard White, James Renwick, Nicky Nelson, Charlie Clark, Jo Monks, Mike Clearwater, George Perry (not pictured), Margaret Stanley, Duane Peltzer, Souyad Boudjelas, Nick Waipara, (not pictured).

Our findings

- We identified 45 pressing research topics

Examples

  - Physiological limits of organisms
  - Impacts of cliamte change on kaitiakitanga
  - Can threatened coastal ecosystems migrate inland fast enough and still be connected?
  - How will species interactions change?
  - Identify vulnerable species and ecosystems
  - Additive effects of weather events – drought + fire, drought then flood

- Long-term datasets
  - Where are the long term data? Who is responsible for data

Unique biota and environment of Aotearoa

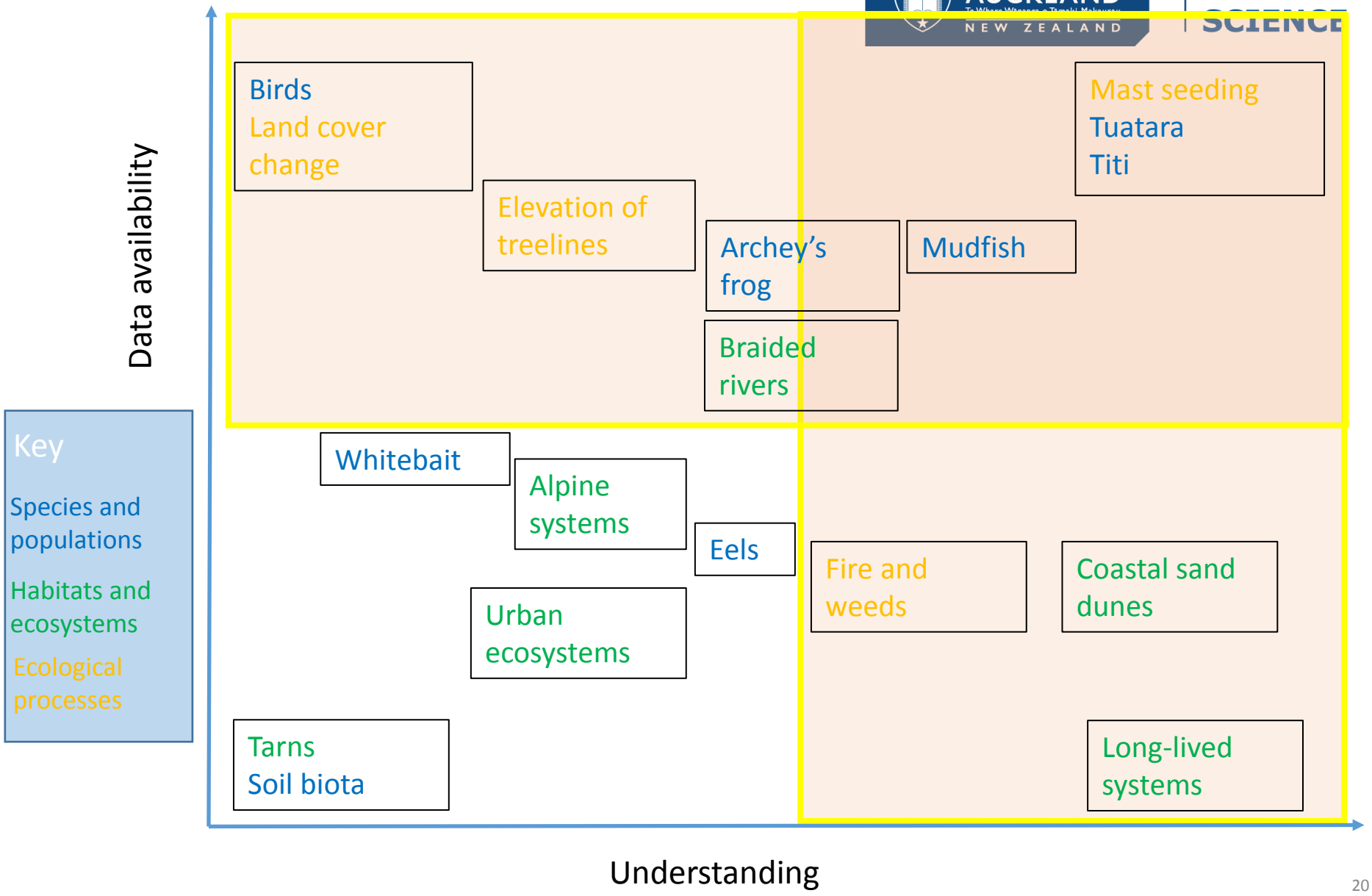
- Large proportion of endemic species
- Large proportion of fragmented populations

- Greatest conservation threat is invasive species
- Highly variable climate, highly coastal

- Interactive effects likely to be main climatic influence – some are known but others unknown

Vulnerabilities

Species and populations	Habitats and ecosystems	Ecological processes
Tuatara	Braided rivers	Mast seeding
Titi	Alpine systems	Land cover change
Mudfish	Urban ecosystems	Elevation of tree lines
Archey's Frog	Tarns	Fire and weeds
Fragmented bird populations	Coastal sand dunes	
Whitebait	Long-lived systems	
Eels		
Soil biota		


Data availability
Understanding
Key
Species and populations
Habitats and ecosystems
Ecological processes
Birds
Land cover change
Elevation of treelines
Archey's frog
Mudfish
Braided rivers
Mast seeding
Tuatara
Titi
Whitebait
Alpine systems
Eels
Urban ecosystems
Fire and weeds
Coastal sand dunes
Tarns
Soil biota
Long-lived systems

Current threat to biodiversity	Exacerbation due to climate change
Invasive mammals	More favourable conditions for reproduction
Invasive plants	New exotic weeds from Pacific region
Invasive insects	Increased chance of overwintering
Invasive pathogens	More pathogens arriving and interacting with other stressors
Freshwater degradation	Warming of lakes and streams boosts algal blooms
Habitat fragmentation	Increased incidence of fire and rising sea levels cause further fragmentation
Small, isolated populations	Exposed to extreme events
Rare ecosystems	Specific niche – may have nowhere to move

Exacerbation of existing environmental problems

- Freshwater quality and quantity
- Arrival and survival of new pathogens and other introduced species (e.g. myrtle rust)
- Further fragmentation and habitat degradation

Extensive fires where vegetation is not adapted to fire (e.g. Port Hills fire) and extensive drought likely to cause huge shifts in ecosystems

Conclusions

- Exacerbation of existing environmental problems
  - freshwater quality and quantity
  - Arrival and survival of new pathogens and other introduced species (e.g. myrtle rust)
  - Further fragmentation and habitat degradation
- Extensive fires where vegetation is not adapted to fire (e.g. Port Hills fire) and extensive drought likely to cause huge shifts in ecosystems
- Need to find ecological and cultural solutions
- Watch this space

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What might we expect?

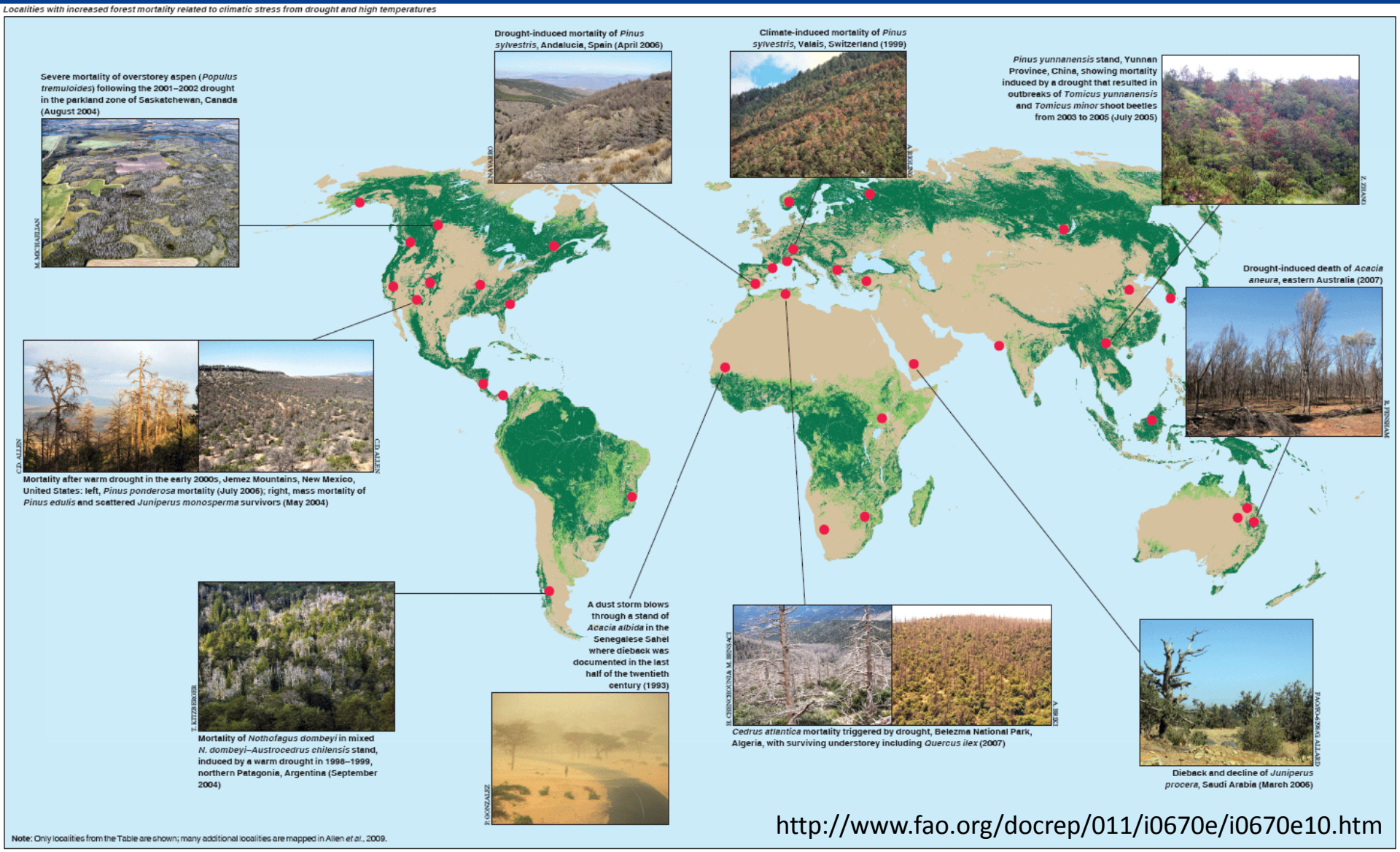
Biggest climate-related threats to biota in NZ

- Rising sea levels
- Freshwater availability
- Ocean acidification
- Extreme events
  - Droughts
  - Floods
  - Storms
  - Heat waves
  - Fires
  - Predictability, variability, magnitude

NZ's terrestrial ecosystems

- 2 degrees warming
  - Tripling number of hot days
- 5-10% less rain
  - Tripling drought occurence
  - 4-6 months extreme fire danger in eastern NZ

Climate-induced forest dieback



http://www.fao.org/docrep/011/i0670e/i0670e10.htm

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A big drink for Tane Mahuta

By Lindy Laird

6:00 AM Saturday Apr 13, 2013

1 comment

One of the world's most famous trees is dying for a drink but Waipoua iwi say quenching Tane Mahuta's thirst could hasten rather than hold off the giant's demise.

New Zealand's biggest tree is visited by thousands of tourists a year and is an icon of the county's largest remaining kauri forest.

Waipoua Forest Trust conservator Stephen King plans to dump 40,000 litres of water around the tree, with half of that task already carried out.

Mr King said the tree is shedding abnormal amounts of foliage and showing other signs of stress caused by the 70-year record drought. The forest has had only a tenth of its normal rainfall so far this year.

"Once the tree is very stressed then [disease] can take a hold," Mr King said.

Trust members have trucked the water from nearby Wairau Stream tributaries. The water would simulate an autumn dousing and prevent shock when the region's normal heavy winter rainfall arrived, he said.

But while the novel thirst quencher has raised international awareness about kauri vulnerability and the drought's far reaching effects, the forest's ancestral guardians

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Kauri icons threatened by inaction

By Kathryn Powley

5:30 AM Sunday Apr 14, 2013

Environment

126 3 0 4

A veteran conservationist and resident of Waipoua Forest says a lack of government funding is jeopardising iconic kauri forests.

Waipoua Forest Trust conservator Stephen King was "very frustrated" with the slow progress and lack of funds to stop kauri dieback disease.

Dieback-affected Kauri at Albany. Photo / Doug Sherring

As reported in the *Herald on Sunday* last week, a fungus-like kauri-killing disease called phytophthora taxon agathis has been detected on tracks in the 12,000ha rainforest, prompting Te Roroa iwi to consider a ban.

Dieback spreads along tracks in dirt on people's shoes, in rain run-off and by pigs. It kills kauri by entering the root system and ringbarking the tree.

"One of the big faults of the response is it has been Wellington driven. It's very frustrating."

King wanted a laboratory set up at Waipoua to speed up testing. So far only a third of sites had been tested, due to a lack of funding. King said tracks in Waipoua needed improving or closing.

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Iconic Tane Mahuta thrown a lifeline after drought

By Helen Castles

Published: 2:43PM Thursday April 11, 2013 Source: ONE News

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New Zealand's oldest Kauri tree has been thrown a lifeline after suffering through the long, dry summer.

Around forty thousand litres of water will be pumped into the Waipoua Forest in Northland over the next three days in an effort to restore Tane Mahuta - the 2,400-year-old Kauri tree.

iWitness ct of the drought has seen the tree form excessive foliage in the past few months and is layer is drying up.

has had ep heal

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Tane Mahuta earns a drink

Friday 12 Apr 2013 5:56 a.m. Join the discussion

The drought is affecting manuka, kanuka and kauri

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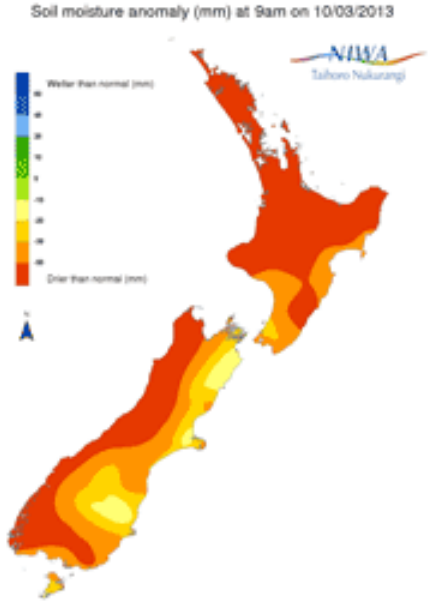
Reviving the garden after the summer drought? Spare a thought for those trying to refresh the country's largest kauri, it's taken them about two weeks' work with a hose.



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Gardening with giants

Amid urgent calls for more Government funding to stop the deaths of our iconic trees, there are steps you can take to help halt the spread of "the HIV of kauri".

By Xanthe White In Ecologic, Gardens

Print Share

16th May, 2013 Kauri Dieback Leave a Comment

A mature kauri in Auckland's Waitakere Ranges. Photo/David White

Although the recent drought was worrying for many gardeners, ironically when it came to kauri dieback disease, the conditions favoured the trees. The small chromista, or slime mould, that has been attacking these giants is water-dependent. In its reproductive stage, it forms a small tail that propels it through water in the soil, enabling it to spread from tree to tree. Closely related to algae, each organism is 1⁄30th of a millimetre wide. Hundreds of these micro-organisms may exist in a single grain of soil, and like many phytophthora, they are part of the unnoticed pulse of life at work underground. This particular branch – although identified as a chromista – is so far unnamed.

You are unlikely to notice much change to the kauri until it's badly affected. This is because the chromista first invades the roots, then enters the tree through its vascular system, eventually taking over the whole tree and causing it to die.

Chromista is an effective organism, says Auckland Botanical Gardens education officer Rebecca Stanley, a trained botanist who spent six years studying kauri dieback with the Auckland Regional Council.

Ministry for the Environment
Manatū Mō Te Taiao

Climate change impacts on New Zealand

Temperature

Temperature is expected to increase throughout the country. This will mean:

- Decreased frequency and severity of frosts
- More days above 25°C
- Longer growing seasons
- Increased rural fire risk
- Increased demand for water
- Increased occurrence of food and water-borne diseases

Towns and cities

- Increased stormwater flooding
- Warmer winters
  → less cold-related illnesses
- Warmer summers
  → increased heat stress
- Decreased electricity use in winter (less heating)
- Increased electricity use in summer (more air-conditioning)

This map provides an indication of potential impacts of climate change on New Zealand.

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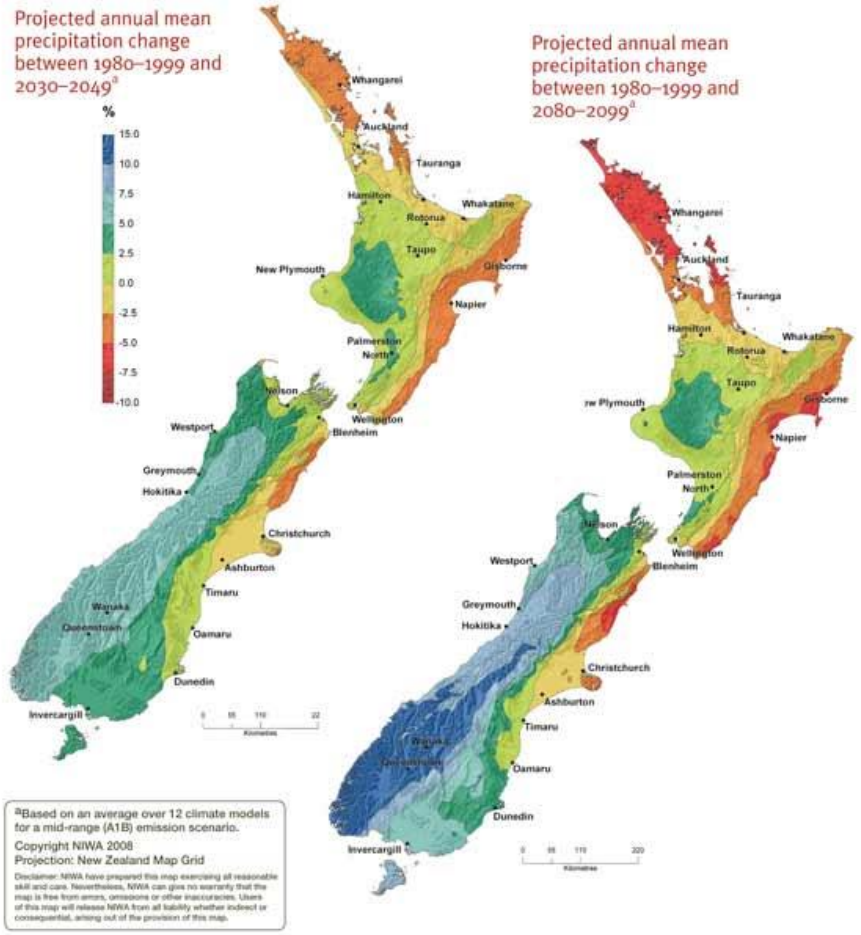
Figure 2: **Projected mid-range changes in annual mean rainfall (in %) relative to 1990.**

The changes shown are an average of the results of 12 climate models for a mid-range IPCC emissions scenario.



[a]Based on an average over 12 climate models for a mid-range (A1B) emission scenario.

Projection: New Zealand Map Grid

Reports of dead trees from across country

Cover story

What's killing the swamp forest?

Drone image from February 2017 showing dead and dying trees in a rare remnant swamp forest near Pirinoa, Wairarapa. Photo: Anthony Griffin

The sudden collapse of a rare forest remnant in the Wairarapa illustrates the fragility of our wetlands in the face of New Zealand's current water crisis.

Worried landowners are investigating the cause of a sudden die-off in a rare remnant of swamp forest in South Wairarapa.

A total of 249 trees died in one sudden burst in a protected forest area of only 1.9ha. The dead trees include 24 kahikatea with girths at chest height up to 1.4m, likely to be 300 years old or more.

The swamp forest remnant is protected under a Queen Elizabeth Trust (QE2) covenant and was formerly recognised by the Greater Wellington Regional Council as a Key Native Ecosystem (KNE).

The concerned owners of the land, Barrie Cook and Sarah Barton, have been trying to work out the source of the problem so the remaining trees can be saved.

The swamp forest is in the Whakatomotomo Valley, in the southern Wairarapa, next to the small Turanganui River that drains the western slopes of the Aorangi Range. It's one of only two forest remnants of its kind in the lower Whakatomotomo Valley.

The first signs the trees were in serious trouble came in 2015, when considerable kiekie vine die-off along with supplejack at the southern end was noticed. During the 2015 summer, some rimu outside of the covenant showed signs of stress. One is now dead, and the others are struggling.

In June 2016, a Google Earth image showed for the first time an area of dead and dying trees, mainly pukatea, at the southern end, but no obvious signs of damage to the big kahikatea.

But the die-back continued, and the kahikatea were next to succumb, with drone footage taken in February 2017 showing the once magnificent trees dead at canopy level.

Alarmed at what was happening, the owners contacted the QE2 Trust's Wairarapa representative and plant expert Trevor Thompson, who, suggested carrying out a full tree survey, which was done in November 2016. Apart from the kahikatea, most of the affected trees are pukatea and swamp maire.

Trevor and the owners believe one or more factors are causing the collapse:

Climate factors: Eastern Wairarapa experiences regular droughts, including the one that extended from the summer of 2014/15 through the following winter to the summer of 2015/16. Was this sufficiently prolonged and severe to kill the trees? Overall, is it a consequence of climate change? But if the trees had survived previous droughts throughout their long life, why would they be dying now?

Historical factors: Much effort over the years has been made to make the land in the valley more suitable for farming, including some channelling of the river and drainage of paddocks. A local man pointed out that, 30 years ago, he had dug ditches to drain the once swampy paddocks off the southern corner of the forest. Back then, he proposed that his ditch network should feed into a natural channel in the forest to continue to channel water to the forest. This did not happen. Was this enough in itself to start pushing the forest towards the brink?

Water take: The groundwater in the narrow valley is contained within what Greater Wellington District Council calls Turanganui Aquifer 1. It is fed by water moving down the valley in the Turanganui River and through the gravels and by rainwater. From this comes water for domestic use, general farm use, and specific consented use for irrigation. Could excessive water take be causing the problem?

There are four water consents in the valley. Two are for irrigating crops on two sheep and beef farms, although one of these consents has not been enacted. A third is for a small lifestyle farm's irrigation system. The fourth is for a dairy farm located just down the valley from the forest.

The regional council advises the current allocation of water from the river gravels in the valley is 960,240m³/year from the four consents.

On the books is an allowed allocation limit of 1.1 million m³/year. The council says this limit was set in the 1990s, and it no longer considers it a safe yield. Unfortunately, the council doesn't have much hydrogeological information for the area and there is no long-term monitoring of river levels or groundwater levels.

Regional council staff visited in May to see the problems first hand. They have undertaken to monitor water levels in the aquifer and take into account the needs of the swamp forest remnant.

With a bit of luck, the prompt action by QE2 and its lobbying of the council will result in a proper diagnosis of the problem.

If the result is agreement that it is just natural processes at work, then the forest will be left to adapt as best it can. If it is agreed that man-made factors may be at play, then any mitigation procedures available must be urgently considered.

More action needed

The fragility of our swamp forests is amply demonstrated in this case. Here we have a swift and devastating response to a much-reduced water level, when irrigation and drought likely combined to cause a major number of tree deaths.

Clearly, the regulatory authorities have little current ability to monitor the environmental effects of irrigation. In instances such as this, a much more robust system of picking up negative impacts in a timely manner in times of drought needs to be in place.

The regional council's rules say people must stop taking water when the river ceases flowing at a bridge downstream of this sensitive area. Surely, none of our rivers should cease flowing before irrigation is stopped?

Trevor Thompson, QE2's Wairarapa representative.

Swamp forests – wetland giants

Kahikatea is the dominant swamp forest species and our tallest native tree growing to heights of 60m or more, with trunks measuring up to 2m across. Dating back to the Jurassic Period, they are able to live for 500 years or more. Today, only 2% of kahikatea forest is thought to remain, says DOC.

Healthy swamp forest is home to secretive birds such as the Australasian bittern, marsh crake, spotless crake, and banded rail, and may support native eels and various species of kokopu and mudfish.

Pictured is one of the huge kahikatea in the 4.5ha White Pine Bush Scenic Reserve, once part of an extensive kahikatea-dominated forest and swamp between Awakeri and Taneatua, in the Bay of Plenty. Much of the original forest was cut down because of historical demand for kahikatea boxes to export butter and, more recently, because of agricultural demand for the fertile soils in which the trees grow. Photo: Caroline Wood

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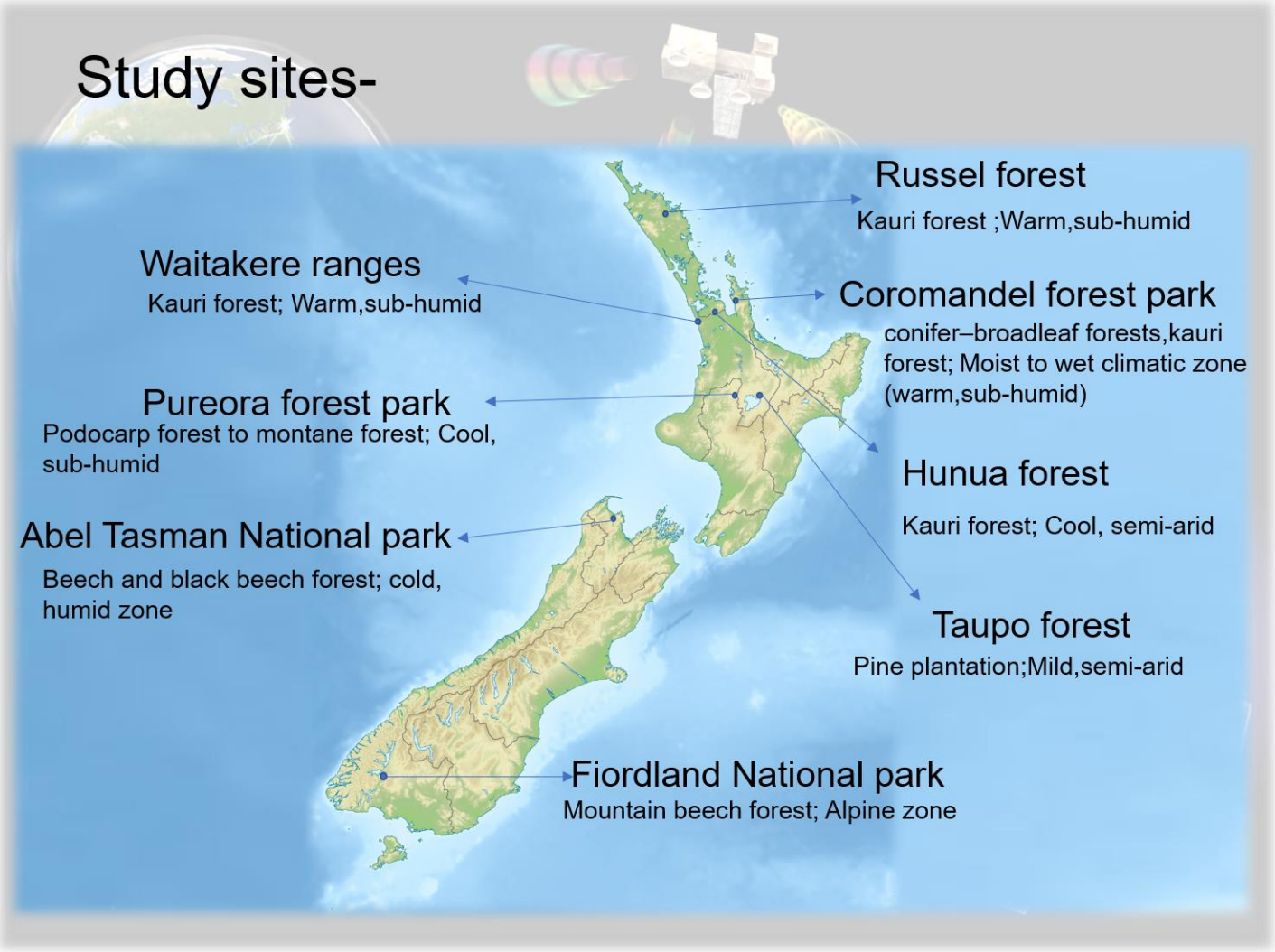
Can we detect drought impacts on native forests?

MSc student
Kshama
Awasthi

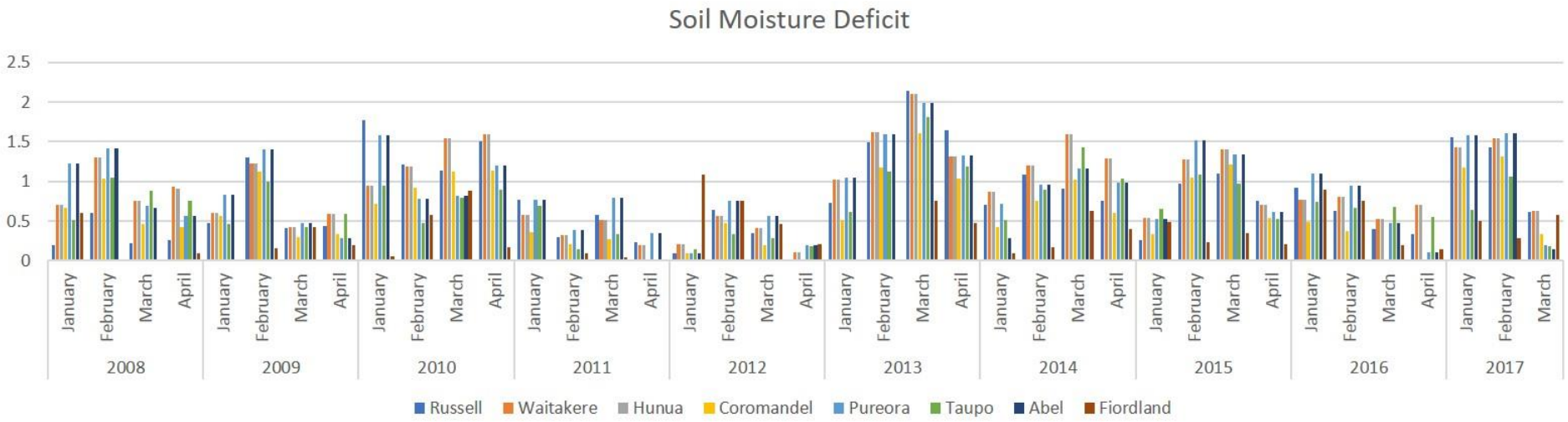
Assoc Prof
Jay Gao

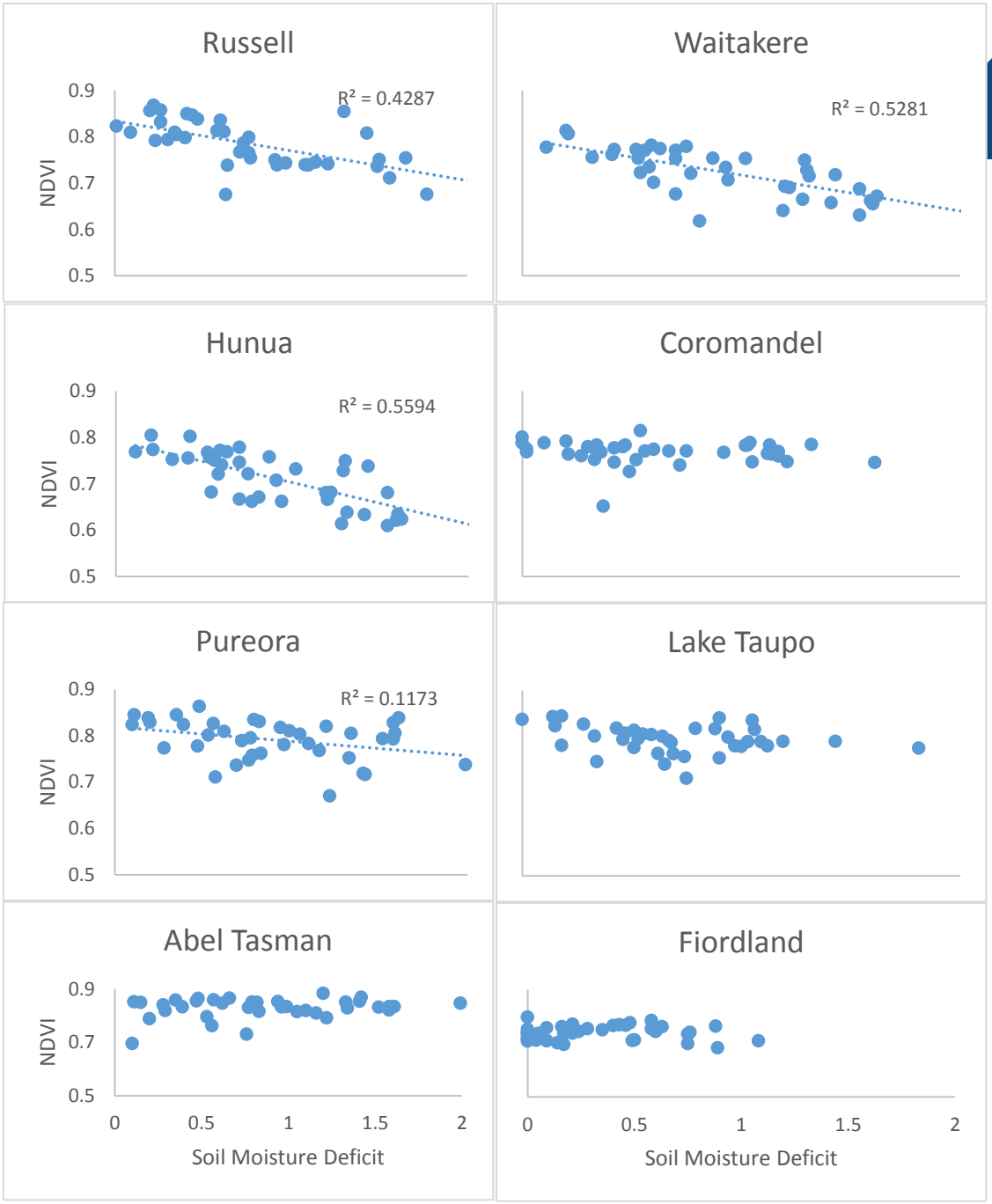
- Remote sensing approach
- MODIS NDVI and EVI products from USGS
- Soil moisture deficit data from NIWA

Study sites-


Russel forest
Kauri forest ;Warm,sub-humid
Waitakere ranges
Kauri forest; Warm,sub-humid
Coromandel forest park
conifer–broadleaf forests,kauri forest; Moist to wet climatic zone (warm,sub-humid)
Pureora forest park
Podocarp forest to montane forest; Cool, sub-humid
Hunua forest
Kauri forest; Cool, semi-arid
Abel Tasman National park
Beech and black beech forest; cold, humid zone
Taupo forest
Pine plantation;Mild,semi-arid
Fiordland National park
Mountain beech forest; Alpine zone

NIWA's soil moisture deficit





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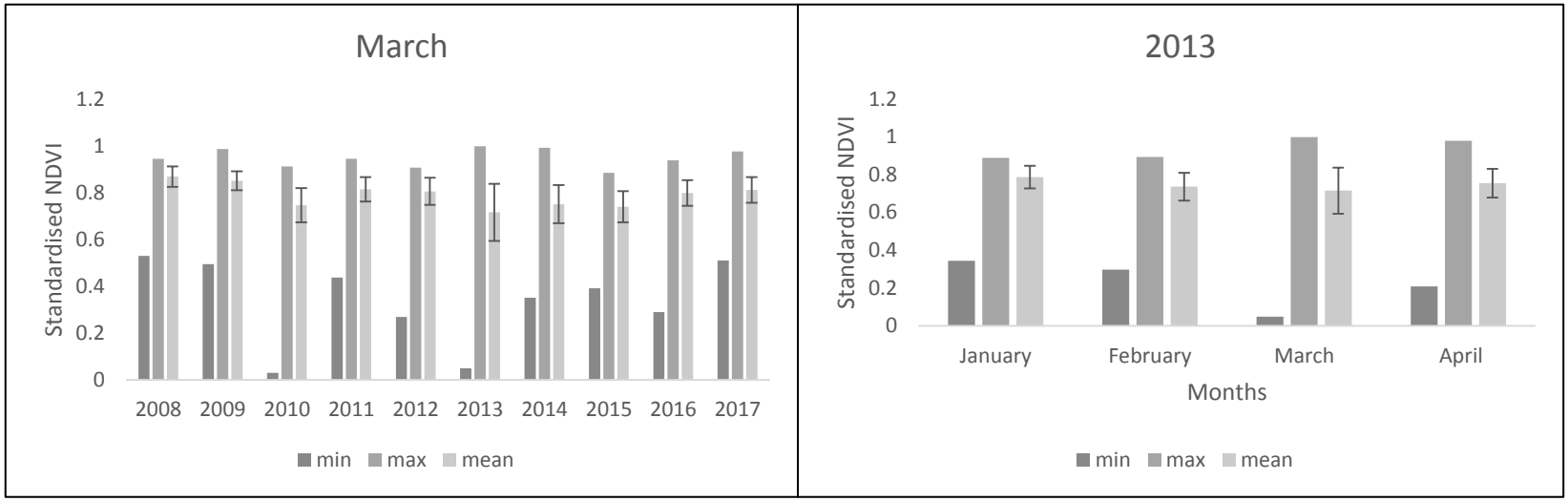
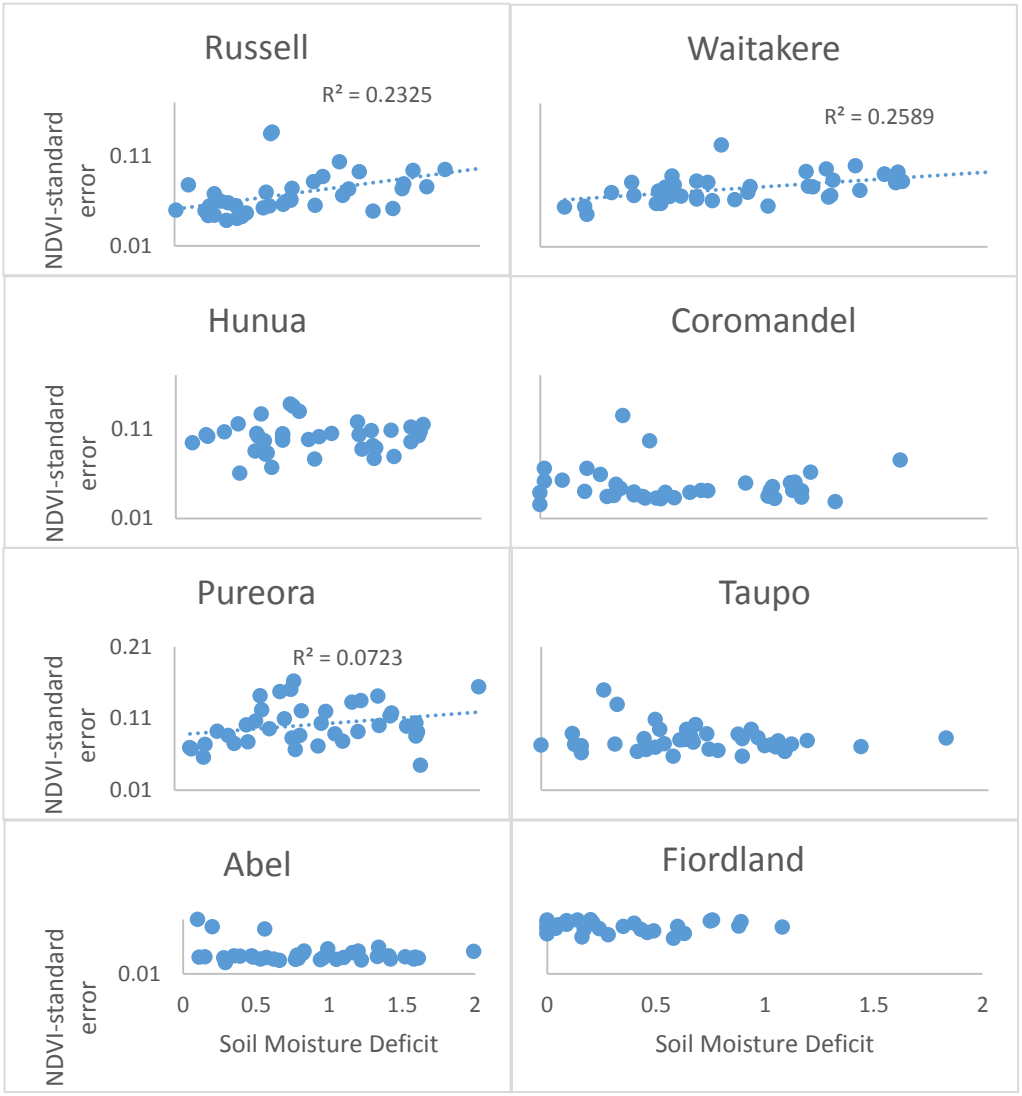
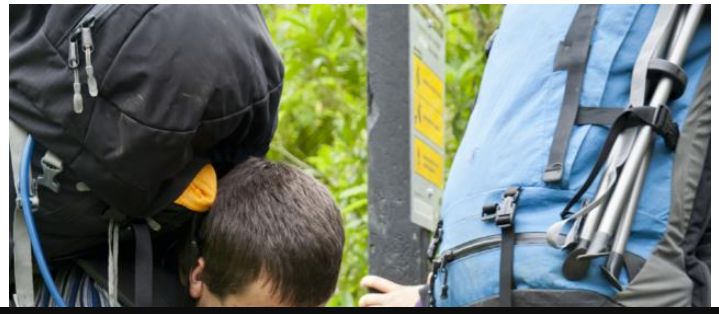
Russell forest NDVI values

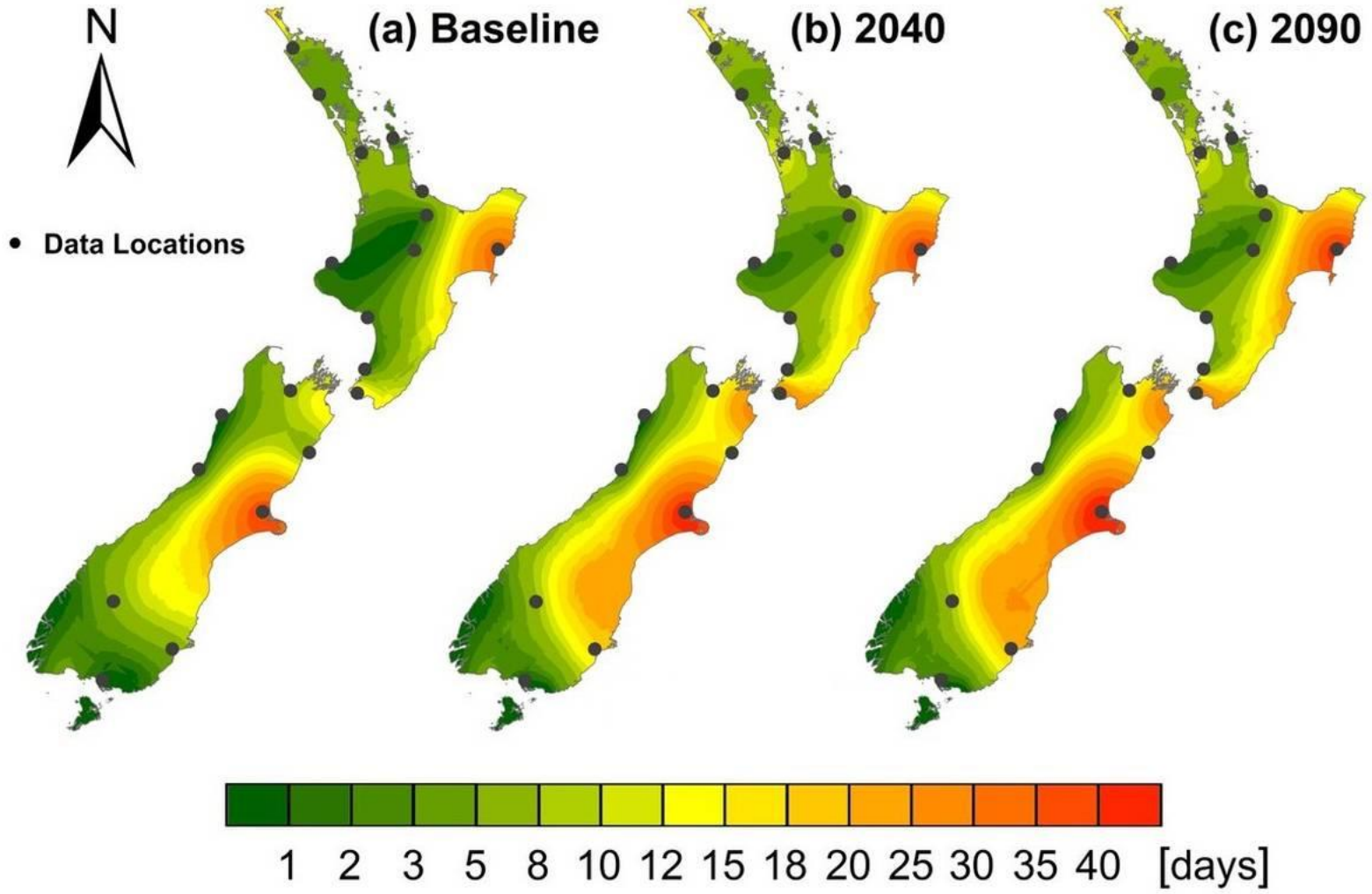



Russell
R² = 0.2325
NDVI-standard error
0.11
0.01
Waitakere
R² = 0.2589
Hunua
0.11
0.01
Coromandel
Pureora
0.21
0.11
0.01
R² = 0.0723
Taupo
Abel
0.01
0
0.5
1
1.5
2
Soil Moisture Deficit
Fiordland
0
0.5
1
1.5
2
Soil Moisture Deficit

Tree survivorship



http://ourauckland.aucklandcouncil.govt.nz/articles/news/2016/12/clean-your-shoes-auckland-and-save-our-kauri/



Annual frequency of extreme and very high forest fire danger under future climate. Source: Scion

Combatting increased fire danger

https://theconversation.com/low-flammability-plants-could-help-our-homes-survive-bushfires-53870

http://www.sanctuariesnz.org/projects.asp

In summary

- Need to consider CC in all conservation activities
- Have contingency plans for extreme events
- Drought, fire, rising sea levels are biggest threats

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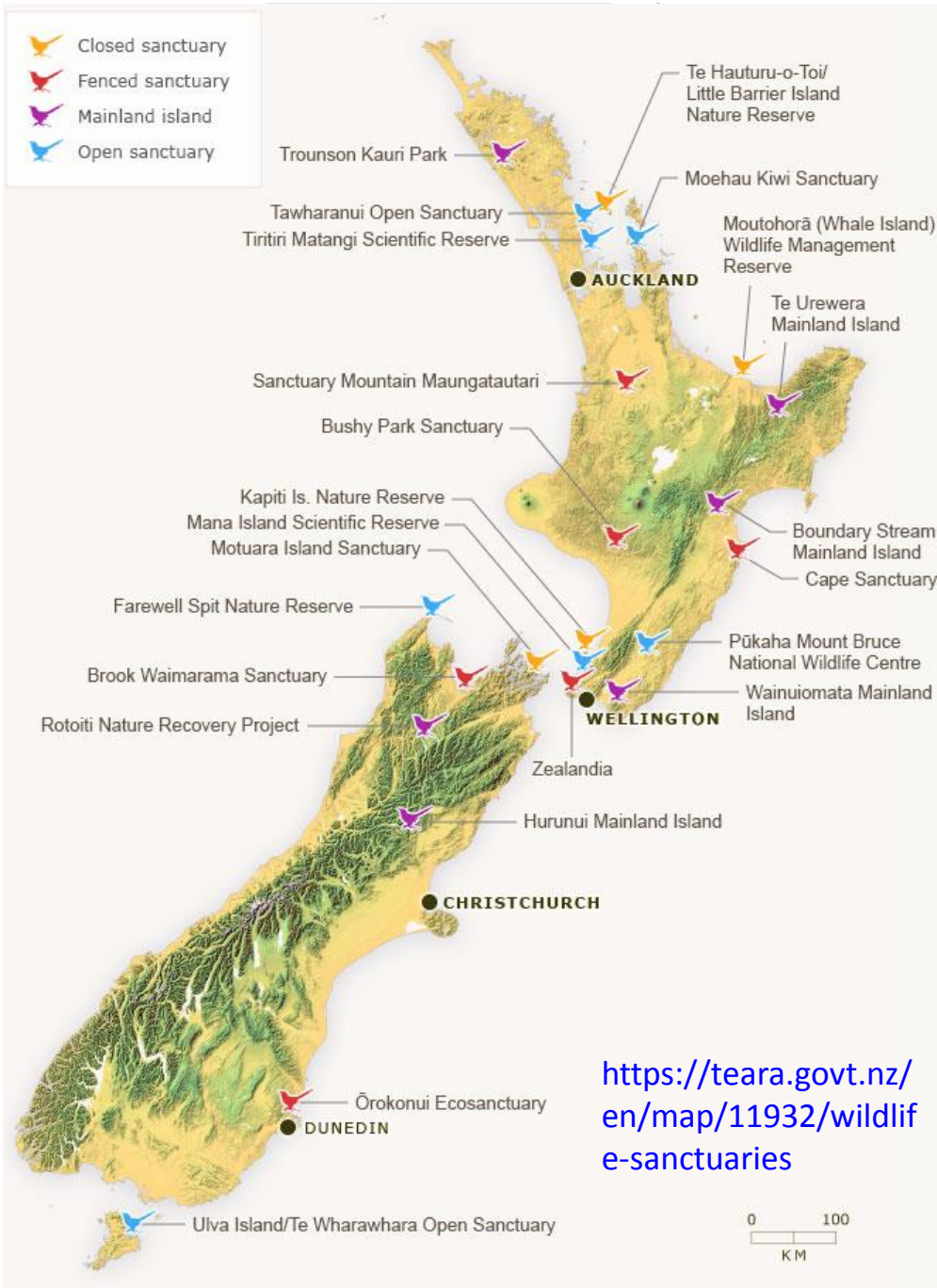
Thank you
@LoraxCate

Further reading:
New Zealand's Disappearing Forests
New Zealand Geographic, August 2014
https://www.nzgeo.com/stories/the-future-of-our-forests/



https://teara.govt.nz/en/map/11932/wildlife-sanctuaries

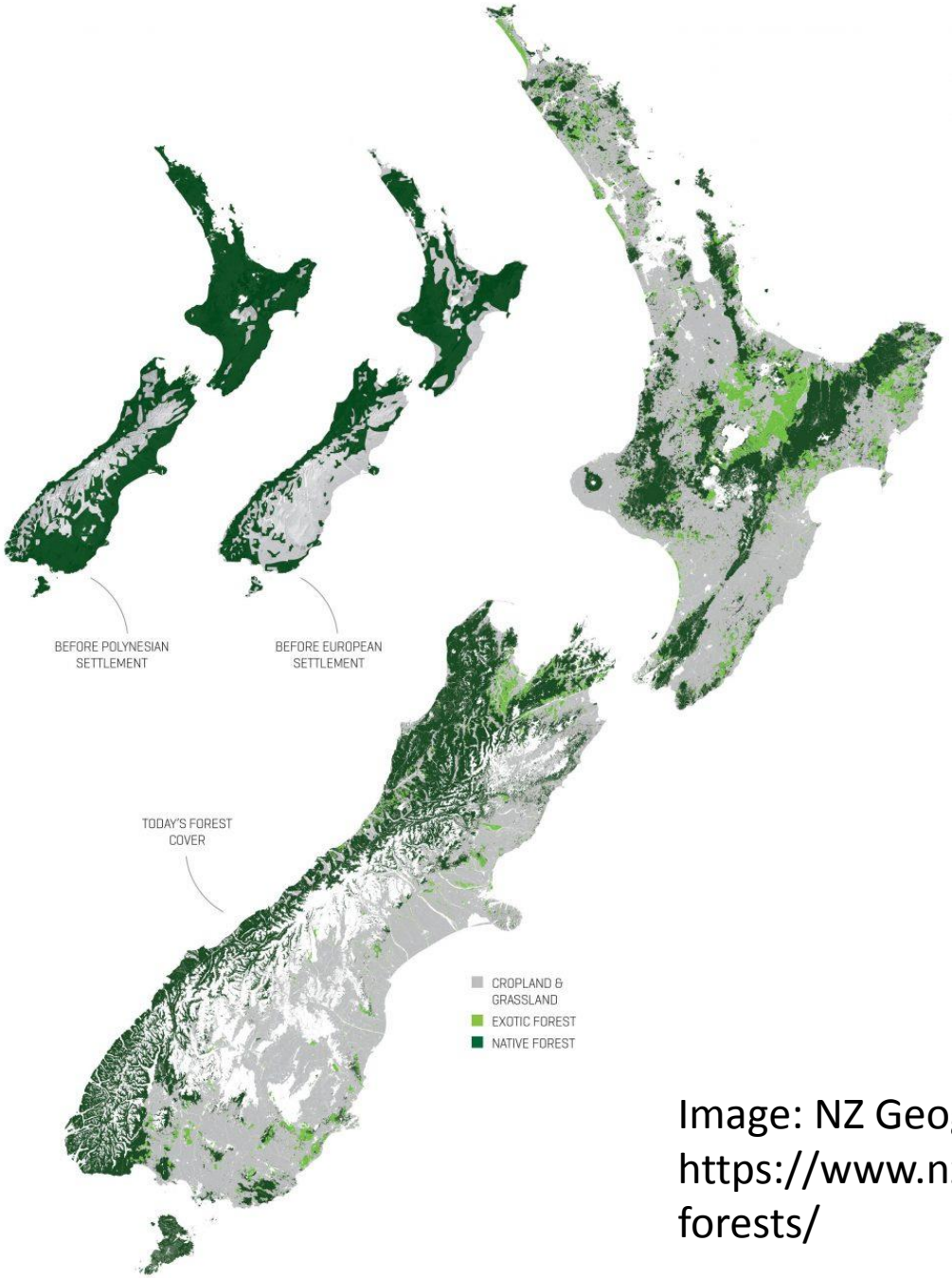


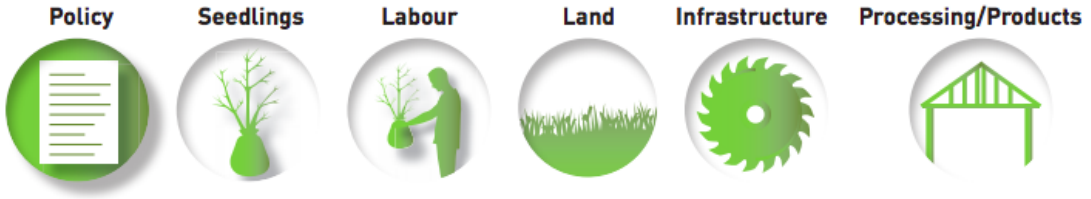
Image: NZ Geographic
https://www.nzgeo.com/stories/the-future-of-our-forests/

2018 - 2027

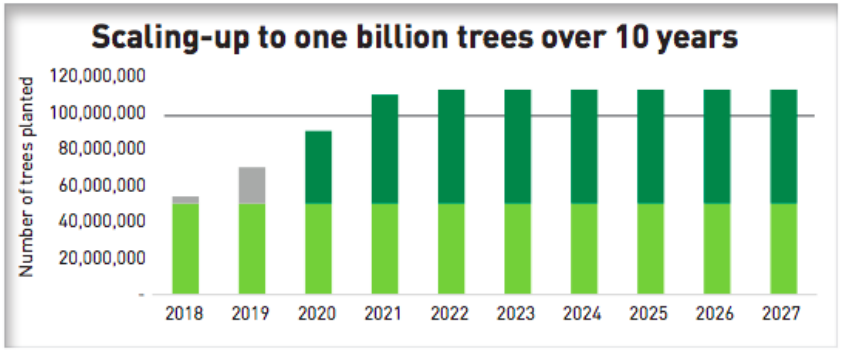
One billion trees – Reclaiming our forest heritage together

It's about:

It requires:



It's a 10 year programme:



https://www.mpi.govt.nz/funding-and-programmes/forestry/planting-one-billion-trees/

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One billion trees = 0.03% of global total

Down from 6 trillion since start of human civilisation

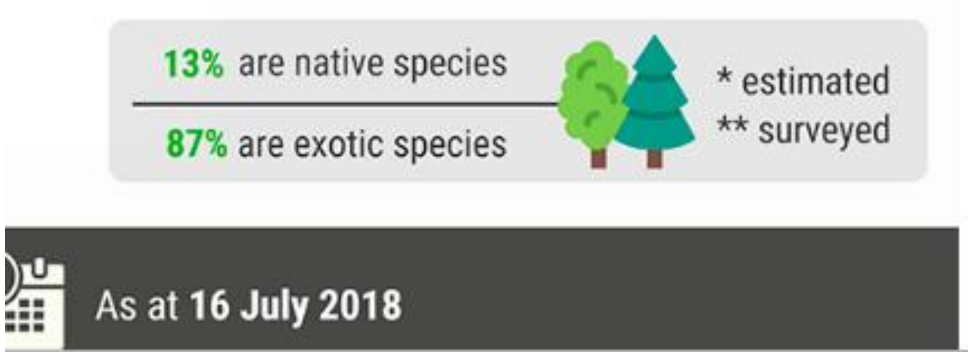
15 billion trees lost each year globally

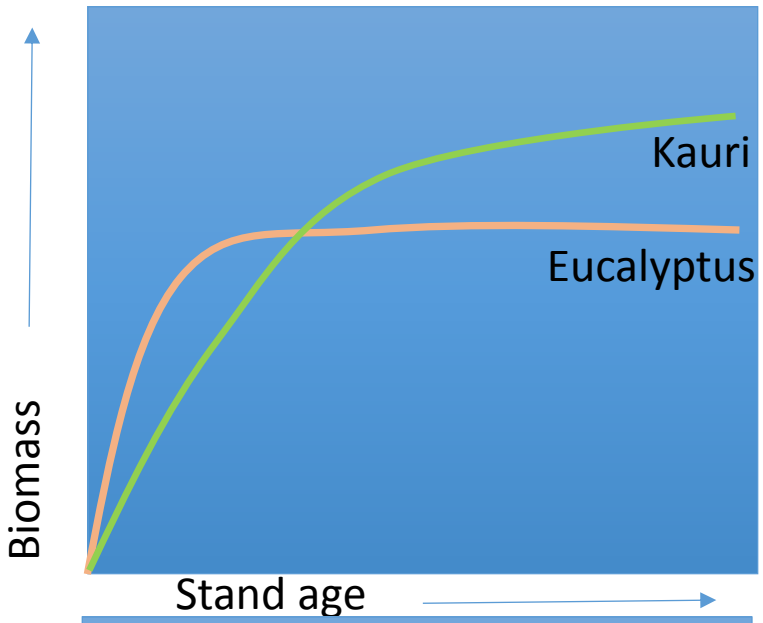
What type of trees?

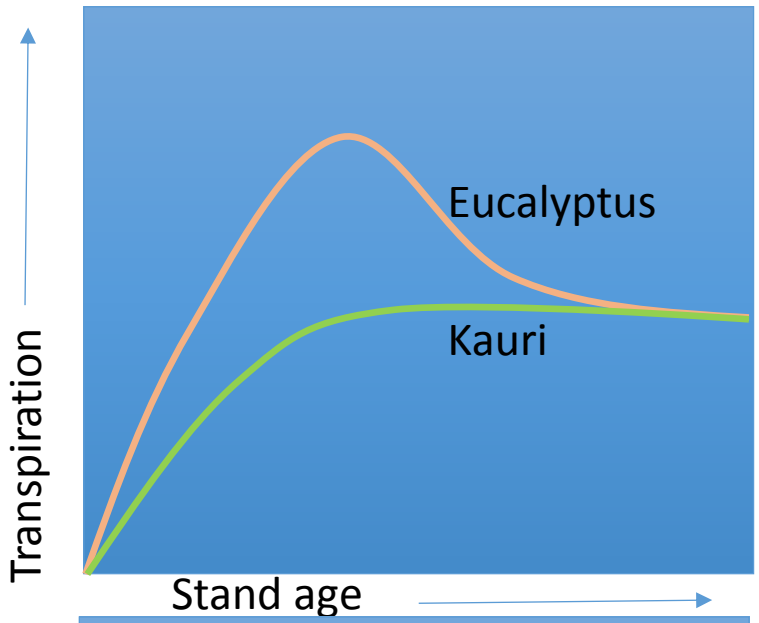
Appropriate trees listed on MPI website -

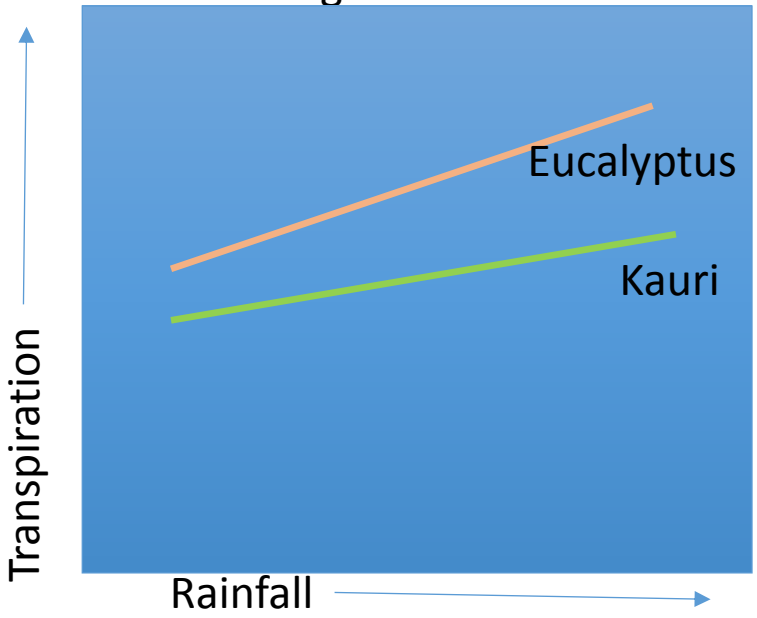
- 121 native species
- 26 introduced forestry species

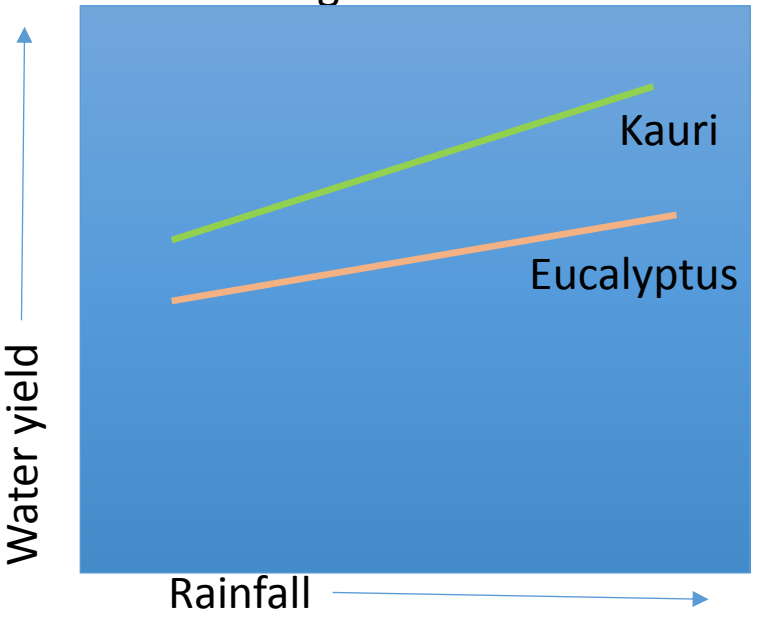
https://www.mpi.govt.nz/funding-and-programmes/forestry/planting-one-billion-trees/

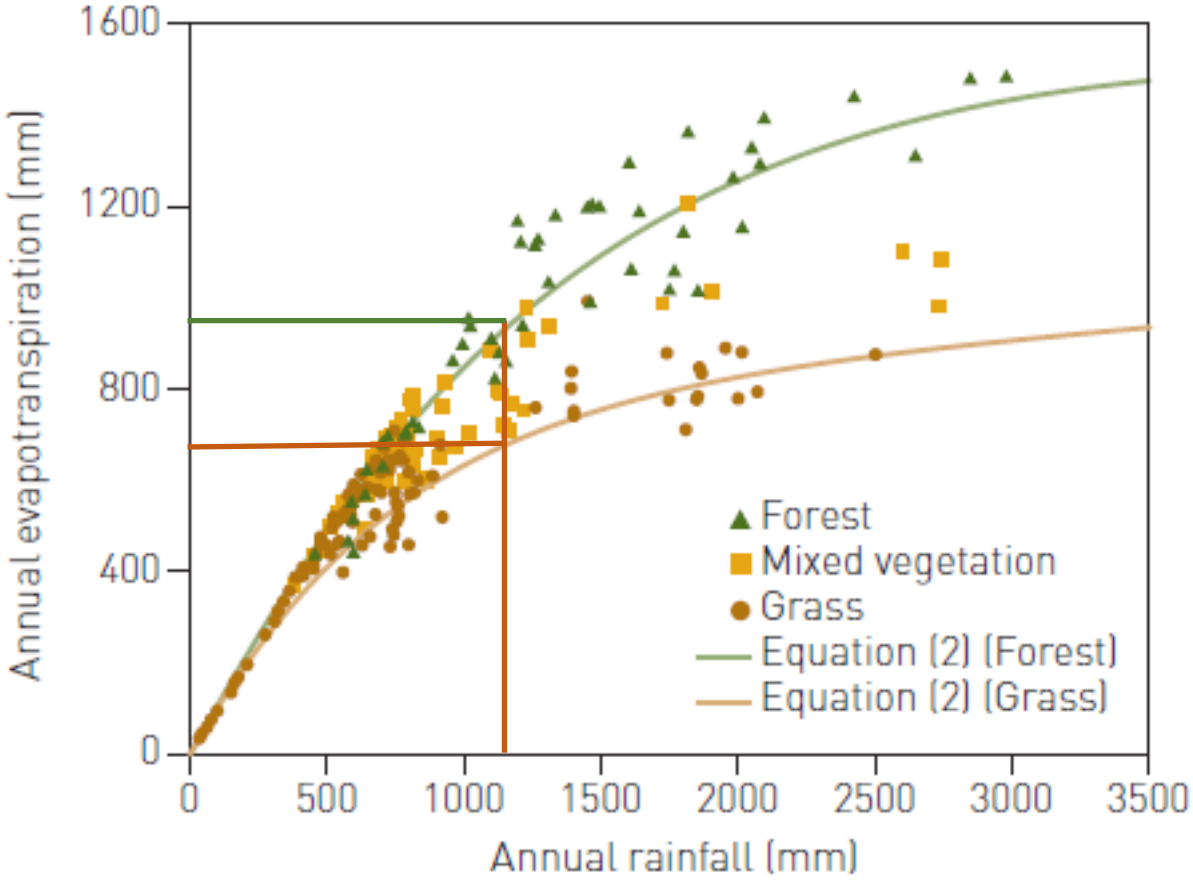



Biomass
Kauri
Eucalyptus
Stand age


Transpiration
Eucalyptus
Kauri
Stand age


Transpiration
Eucalyptus
Kauri
Rainfall


Water yield
Kauri
Eucalyptus
Rainfall



Relationship between annual evapotranspiration and rainfall for different vegetation types. After Zhang et al. (1999).

In summary

1. One billion trees programme has potential to enhance landscapes and economy in many parts of Aotearoa
2. Important to put the right tree in the right place – fill data deficiencies for best choices
3. Consider multiple services of trees – water cyce modulation, carbon uptake and storage, biodiversity provision
4. Include indigenous values, kaupapa Māori
5. Essential to address threats