Herbicide persistence and revegetation in controlled dense wilding stands

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SCION

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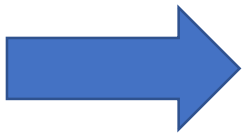
Why this study

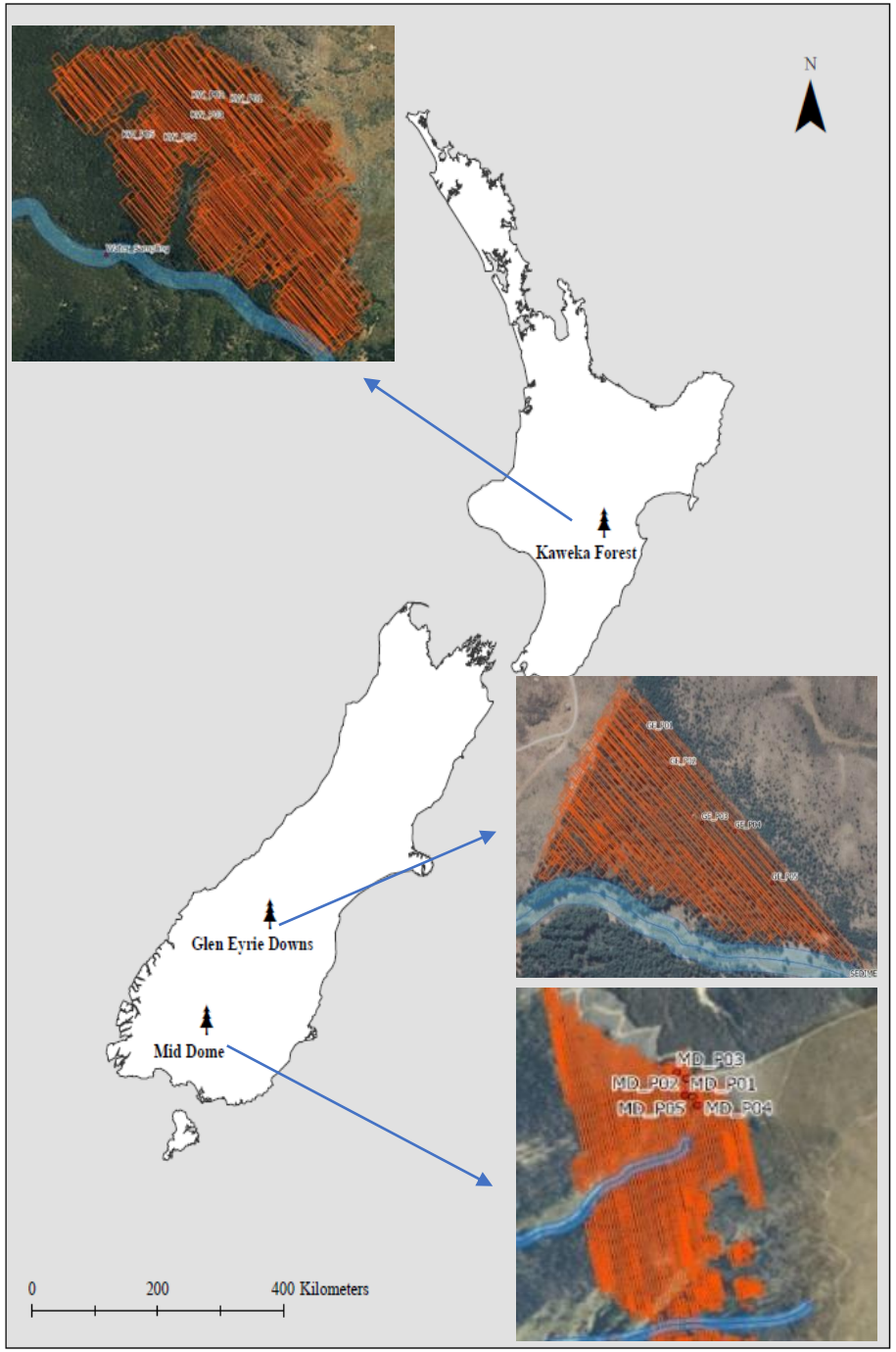
- Over 100tsd hectare of dense wilding conifers will possibly be treated with TDPA over the coming years.
- What will happen with those sites after the existing wildings have been killed?
- Claims that TDPA has long lasting effects as it kills mycorrhizae that wildings rely on.

Aims

- Understanding the fate of active ingredients (TDP) in the most used spray-mix to control dense wilding infestations
- Do herbicides have a “after control effect” e.g. do they limit regeneration of wildings (and in what way)?
- Will herbicides limit potential of natural occurring succession of native species?

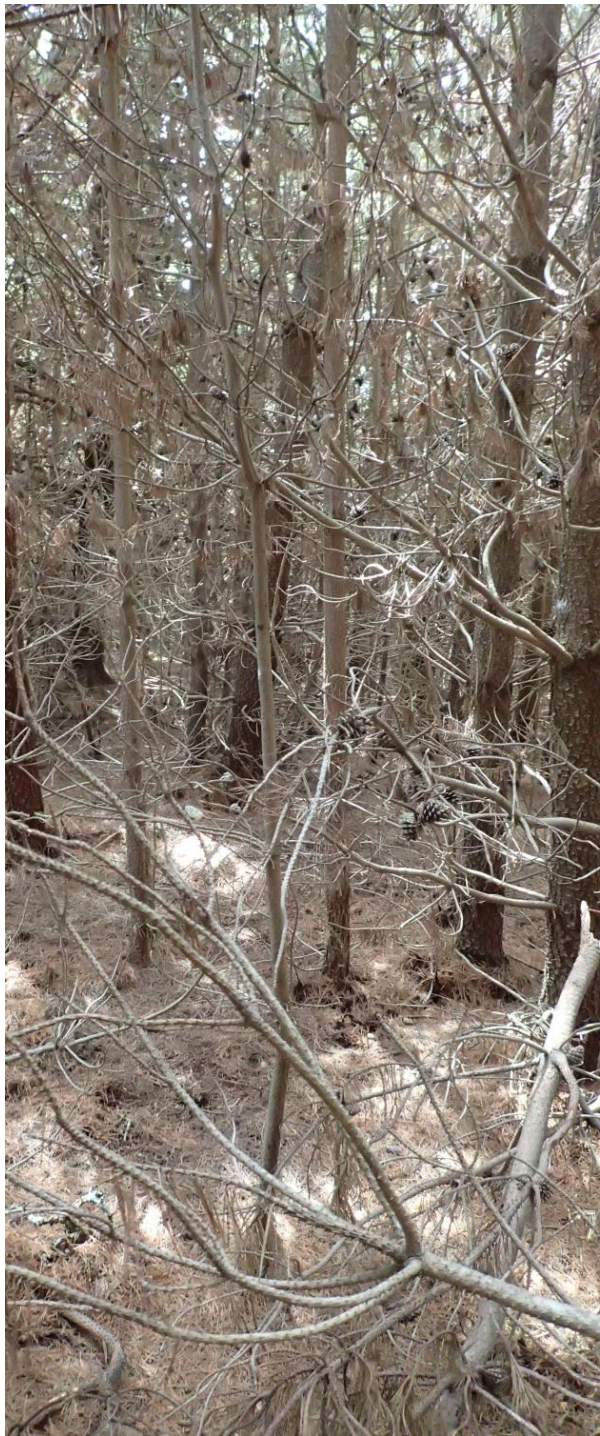


Are control operations achieve their long term goal of being invader free ?



Study sites and Methods

- Study sites represent areas where some of the largest areas of dense *Pinus contorta* stands are present.
- At each study site replicated random placed permanent sample plots (100m^2) were installed (before spraying)
- At each study sites stand structure, plant diversity, soil characteristics were recorded.



Sampling to determine herbicide fate

			Sampling intervals (months)				
Site	Pre-spray	Spray date	1	6	8	12	24
	Days before sampling		Days after sampling				
Kaweka Forest	-450	30/01/2019	29	119	230	356	-
Glen Eyrie Downs	-78	26/01/2018	27	112	271	390	782
Mid Dome	-52	08/02/2018	33	201	278	389	678

We sampled:

Needle fall
Litter and FH
Soil (0-10cm)
Soil (10-50cm)

Samples for each pool were send to Hill Lab for analysis to determine herbicide levels

Sampling and trial setup for herbicide effects

- Sampling of litter + soil cores from Glen Eyrie site plus from an un-sprayed control site close by in

  Feb 2018 (27 days after spray)

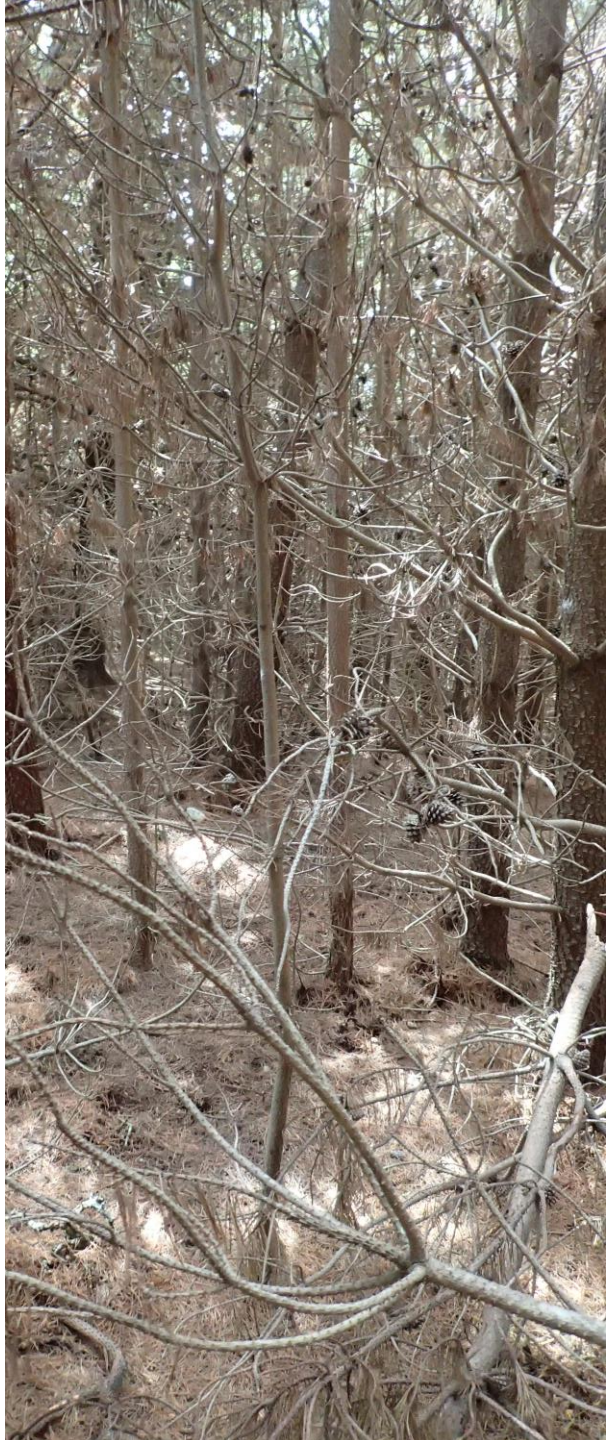
  May 2018 (119 days after spray)

  May 2019 (484 days after spray)
- 120 Cores placed in greenhouse and *P. contorta* and natives (mountain beech, coprosma, matipo, red tussock, manuka) seeded into cores
- Mineral soil collection for testing effects on pine associated mycorrhizae (soil 0-10cm)

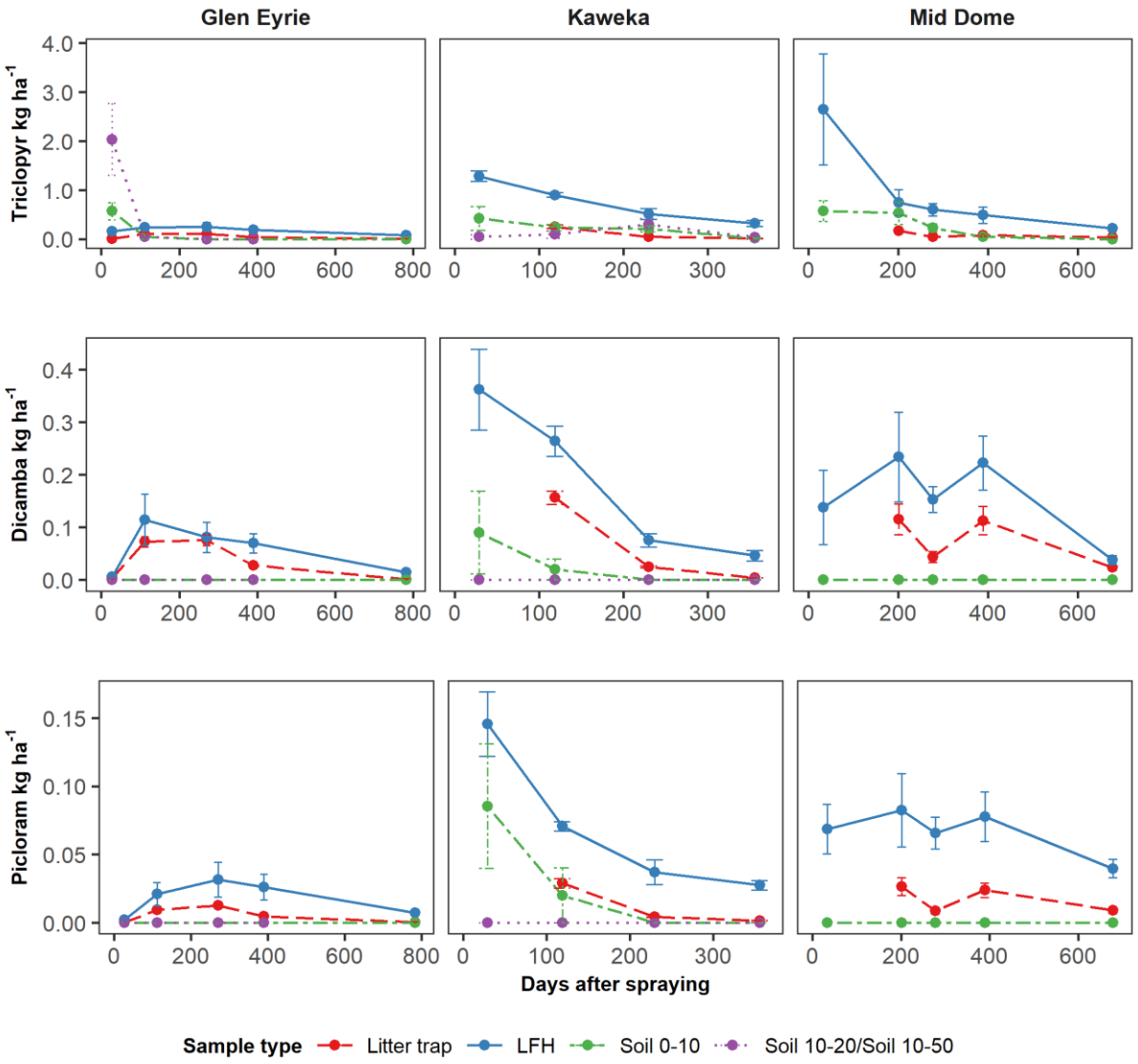
Results – stand characteristics

Site	Stand age*	Average height (m)	Stand density (stems per ha)	Canopy coverage (%)
Kaweka Forest	31 ± 1.5	15.2 ± 1.2	5880 ± 569	84 ± 17
Glen Eyrie Downs	17 ± 1.5	11.0 ± 0.9	8220 ± 839	71 ± 5
Mid Dome	28 ± 1.7	6.4 ± 0.4	7240 ± 1252	84 ± 2

- Stands have a high number of stems with a very high range of stem diameters
- Canopy cover is dense resulting in low plant diversity and lack of ground vegetation
- Tree heights are very low for age



Results – Herbicide Fate



Key points:

- Herbicides mostly retained in LFH layer with limited movement into the soil profile.
- Herbicides below detectable levels in soils at end of assessment at all sites
- Herbicides detectable in the LFH layer at low levels at all sites at end of the assessment.
- Triclopyr was present at the highest levels across all three sites in needle fall and LFH and soil (applied at 18 kg/ha).

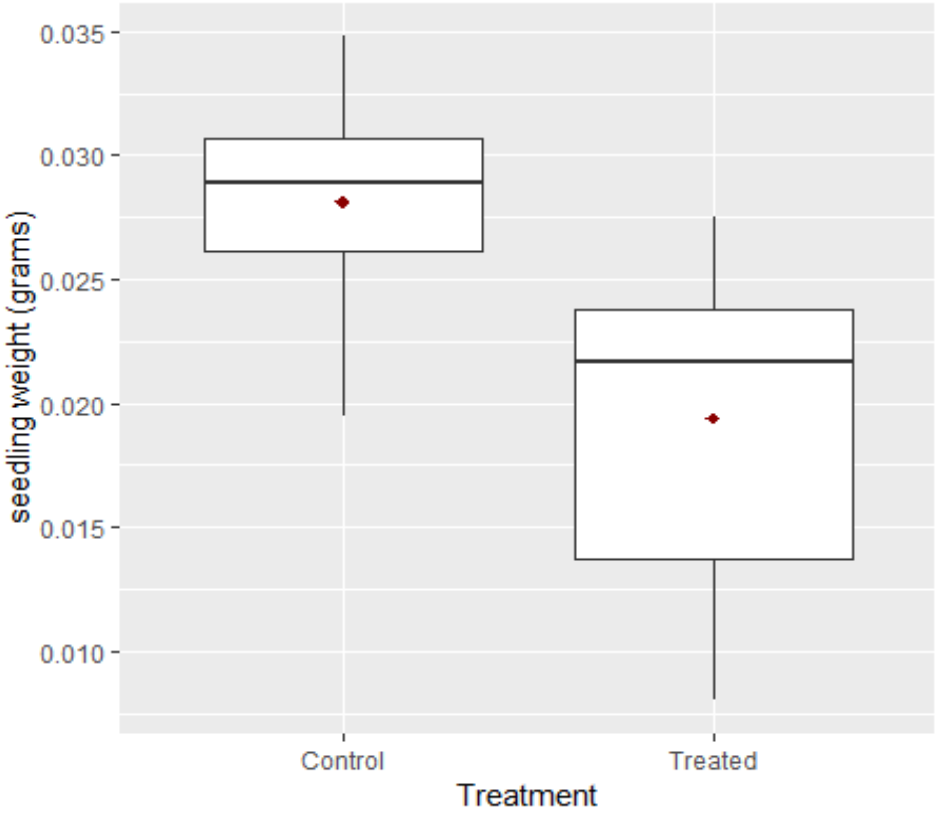
Dead needles were continuous source of input of herbicide into the site.

Results Herbicide effects on germination and seedling growth - *Pinus contorta*

Species	Mean % Germination		Mean % Mortality	
	Control	Treatment	Control	Treatment
Pinus contorta	90.3[1] (n = 204)	66.7* (n = 110)	0.8 (n = 2)	24.0* (n = 29)

Control - healthy

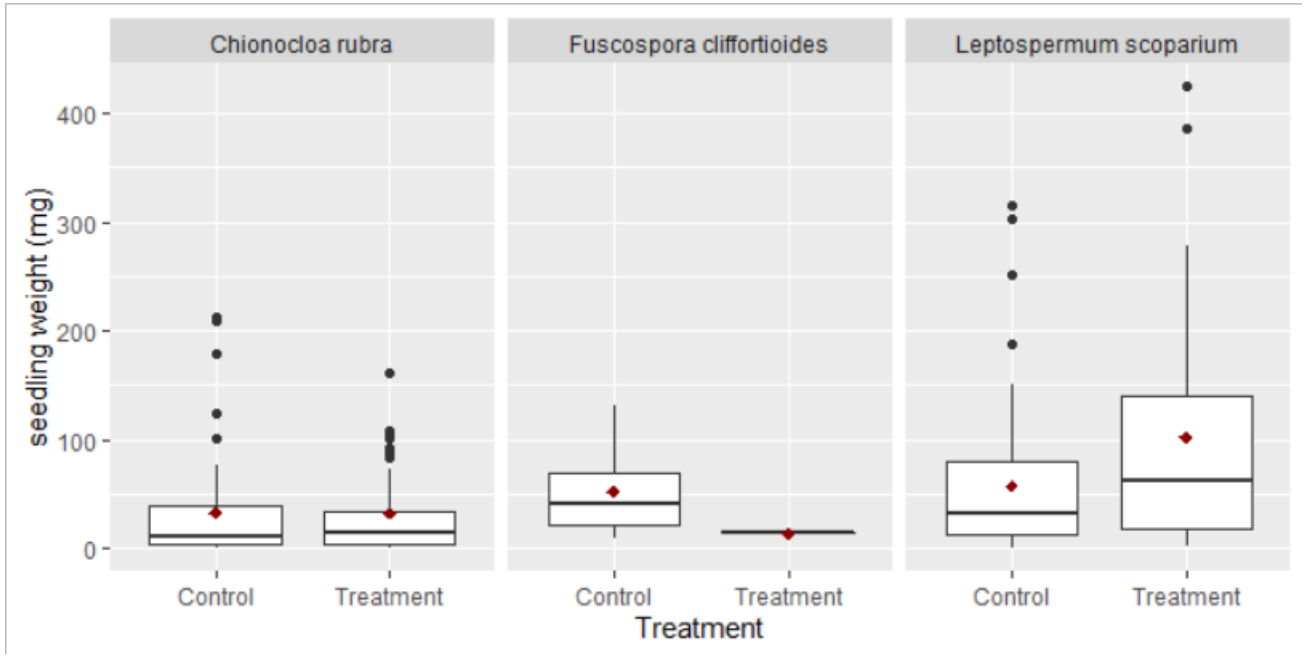
Sprayed – growth deformation



Significant reduction in germination and mortality & Growth and form relate to phytotoxicity caused by herbicide

Results Herbicide effects on native species

Species	Mean % germination		Mean % mortality	
	Control	Treatment	Control	Treatment
Chionochloa rubra	20.0 (n = 50)	20.3 (n = 45)	7.1 (n = 1)	30.9* (n = 13)
Fuscospora cliffortioides	6.7 (n = 20)	3.7 (n = 11)	45 (n = 7)	95* (n = 10)
Leptospermum scoparium	9.9 (n = 70)	5.5* (n = 40)	14.8 (n = 11)	48.0* (n = 15)



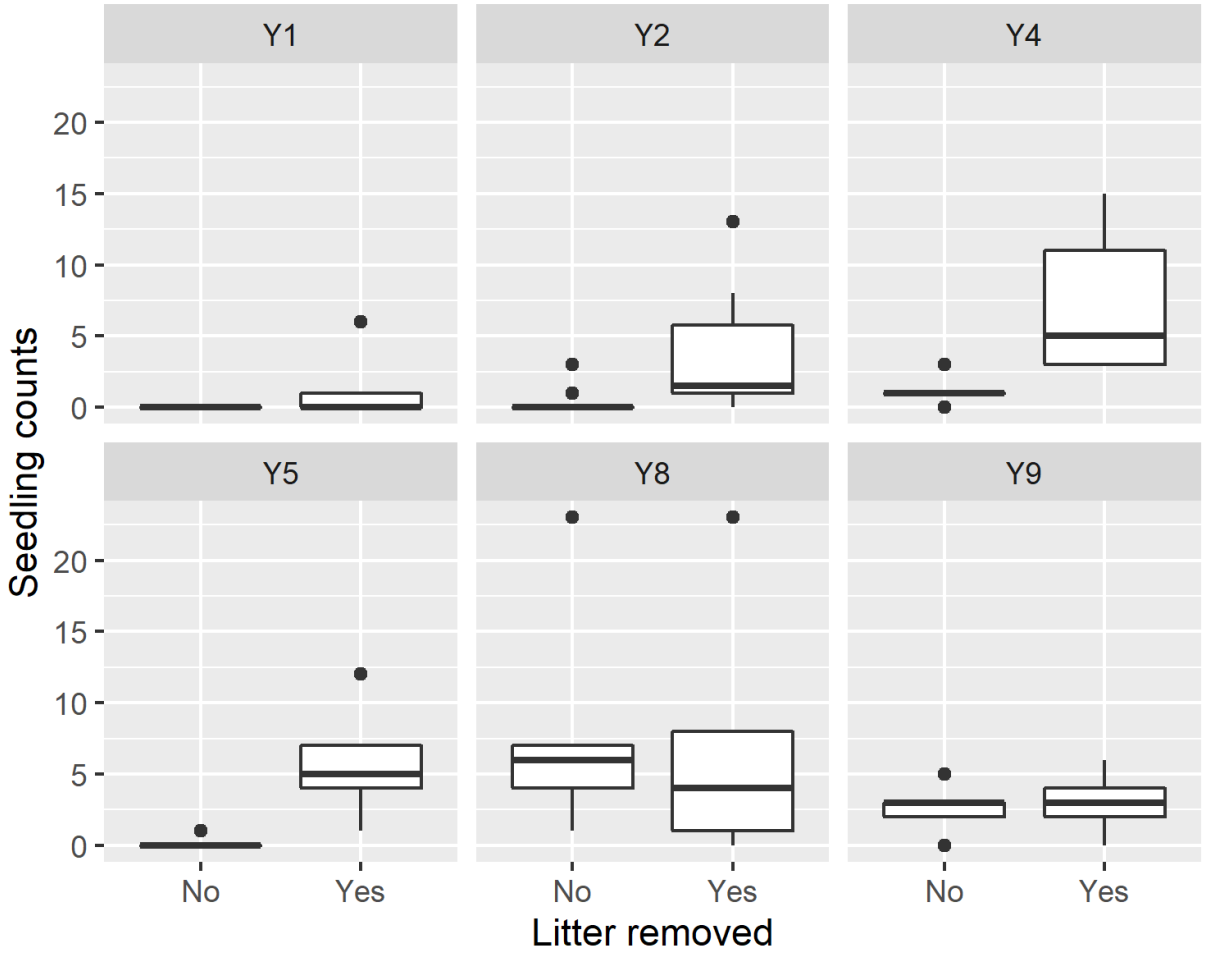
- Lower germination rates for most species except *Chionocloa rubra*
- Mortality higher in treatment for all natives
- Reduced growth / biomass in herbicide cores for mountain beech
- Manuka only species growing better in treatment than in control

From greenhouse to the field – a seeding study in controlled wilding stands

Sites	Altitudinal range (m a.s.l)	Time since control (years)	Median stem density (stems/ha)	Wilding conifer	Main vegetation cover surrounding wilding stands**
Kawekas (Comet)	800-1000	0 – 1	~ 4000	Lodgepole pine	Manuka/ Kanuka shrublands
Mackenzie (Glen Eyrie)	600-700	0 – 2	~ 5500	Lodgepole pine	Low producing grassland
Canterbury (Flock Hill)	800-1000	6 – 9	~ 1500*	Lodgepole pine	Low producing grassland
Southland (Mid Dome)	800-1200	0 – 4	~ 4500	Lodgepole pine	Tall Tussock grassland

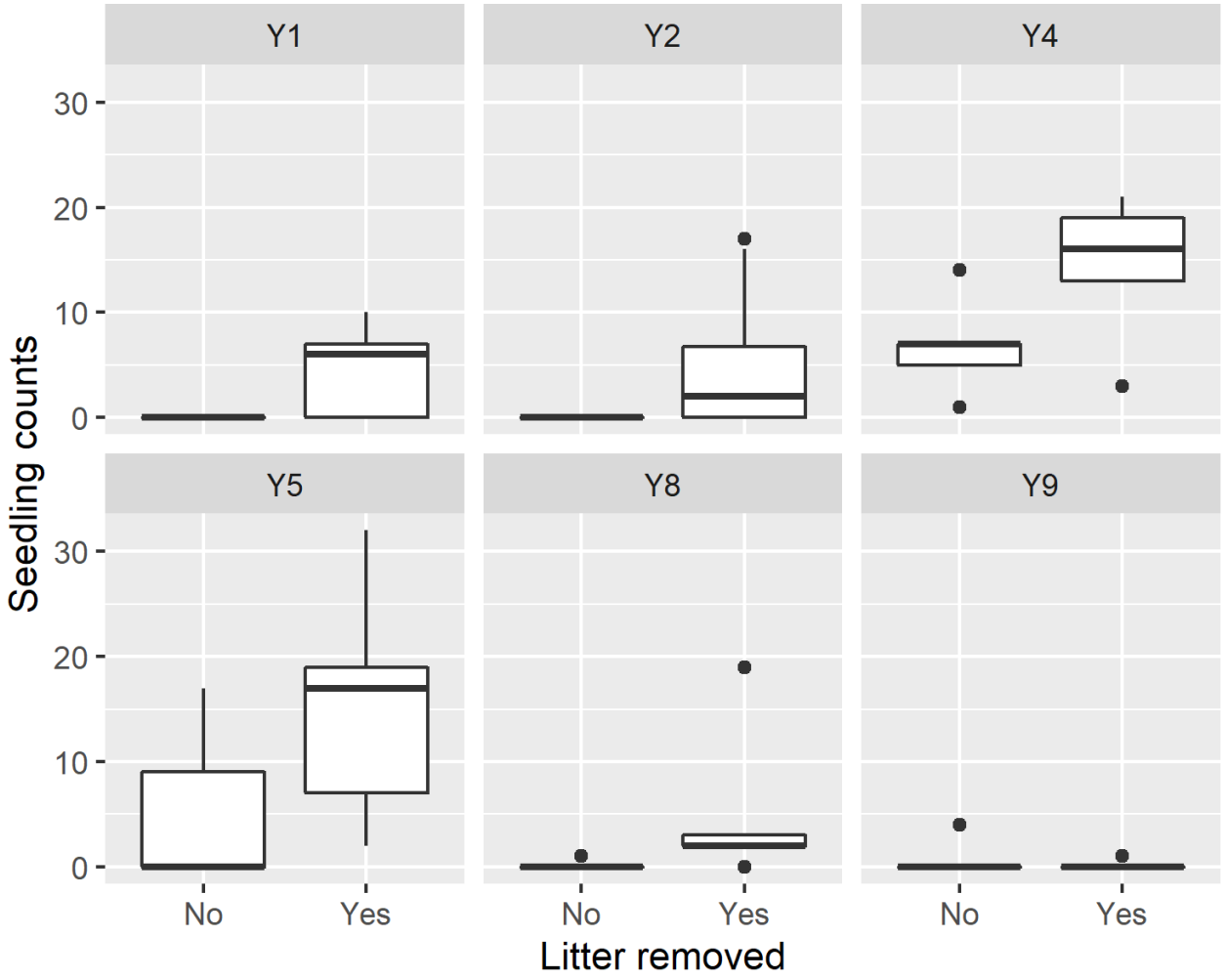
- 0.25 m^2 seeding plots in established tree level plots
- Litter removed yes/no
- Mountain Beech and Manuka seeded (fresh seed)

Mountain beech



- Germination rates are generally low (1% germinated)
- Indication that effect of litter removal (herbicide pool) weakens in the long term
- Other co-founding factors are environmental changes (stand opening up) and site differences.

Manuka



- General germination rates are higher (3.5%)
- Litter removal increased germination rate across all years
- germination rates low in first two years (herbicide litter) and in stands controlled early on

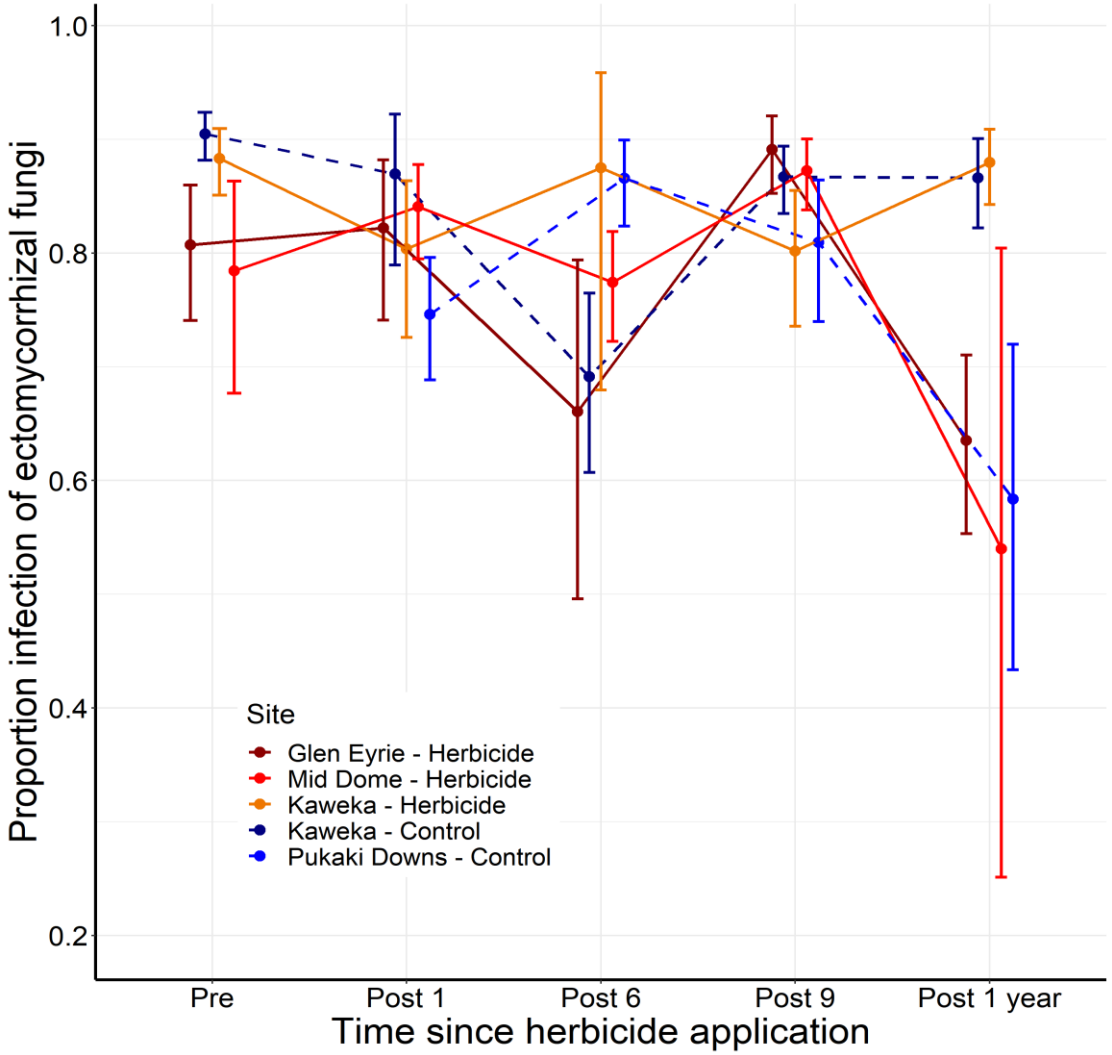
While herbicide residues in litter affect wildings and natives directly, what about the mycorrhiza claim?

Thanks to Sarah Sapsford and Ian Dickie (University of Canterbury) we have an answer!

Method

- Mineral soil was collected from all three sites plus the control area close to Glen Eyrie before spraying and at intervals afterwards
- Pre germinated non-inoculated Pinus contorta seedlings were planted into soil and grown for three months and then assessed for ectomycorrhizal infection
- Biomass was also assessed

Results



- Ectomycorrhizal infection not affected by herbicide across all sites (seedlings maintained 80% infection throughout the year)
- Abnormal root growth was found in soils collected 1 month and 6 month after spraying – confirms the observations in the glasshouse study
- Biomass (growth) was not affected

In Summary

- All herbicides move with needles to the forest floor; in very dense stands minimal amounts of herbicides reaches the floor at spraying and herbicide levels in the mineral soil are low.
- Triclopyr shows the highest levels and is present even after 2 years.
- Remaining levels of herbicides reduce germination and raises seedling mortality in *Pinus contorta* and natives.
- Abnormal growth through phytotoxicity was observed in *Pinus contorta* and tested natives (except Manuka).
- Ecto-mycorrhiza is still present on site and therefore not limiting *Pinus contorta* seedlings (the herbicides are!)
- Seeding or planting of natives should occur after two years. LFH could also be removed to minimise herbicide effect.

Thank you