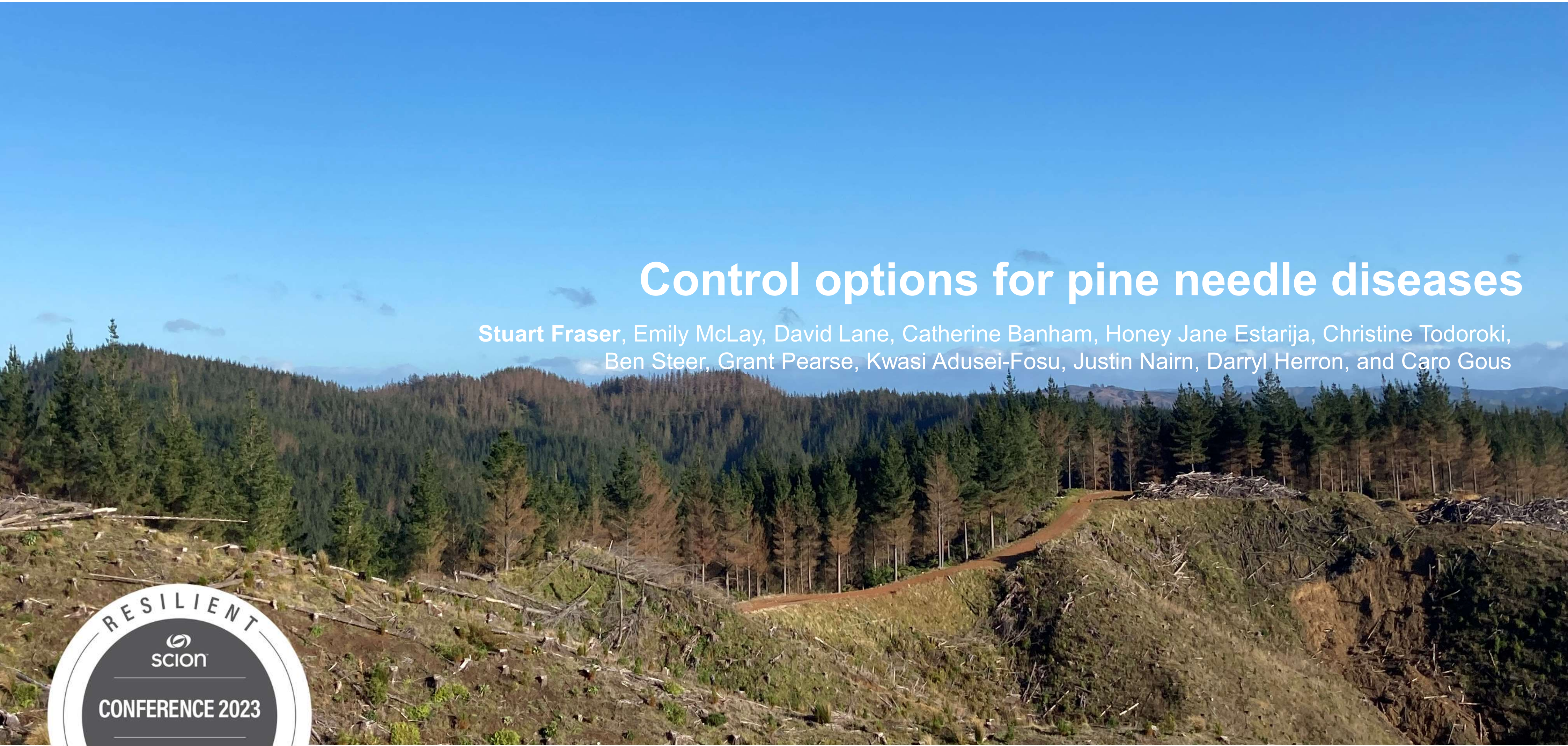
# Control options for pine needle diseases

**Stuart Fraser**, Emily McLay, David Lane, Catherine Banham, Honey Jane Estarija, Christine Todoroki, Ben Steer, Grant Pearse, Kwasi Adusei-Fosu, Justin Nairn, Darryl Herron, and Caro Gous



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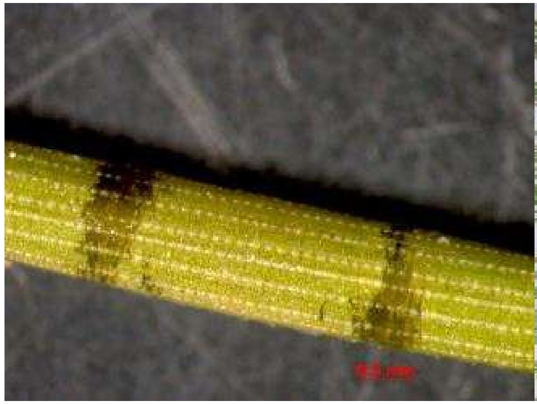
# Overview

- Fundamentals for control
- Background and aims of Resilient Forests
- Operational-scale RNC copper trials
- Alternative control options for Dothistroma needle blight

# Fundamentals for control

- Effective fungicide and dosage
- Knowledge of pathogen biology
  - Optimal seasonal spray timing
  - To spray or not – will disease develop?
- Growth impacts – cost benefit analysis

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# Fundamentals for control

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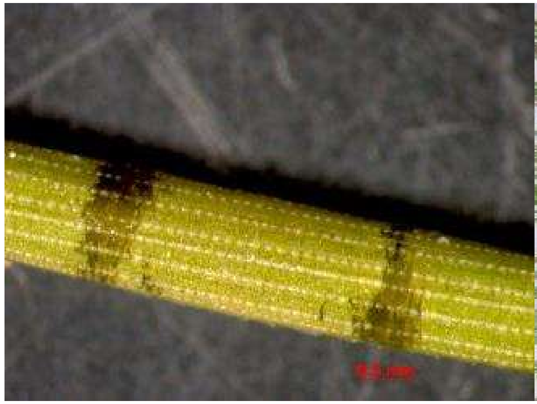


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# Copper effective in lab and pot trials

Plant Disease • 2019 • 103:1828-1834 • https://doi.org/10.1094/PDIS-07-18-1247-RE

Research

## Can Copper Be Used to Treat Foliar *Phytophthora* Infections in *Pinus radiata*?

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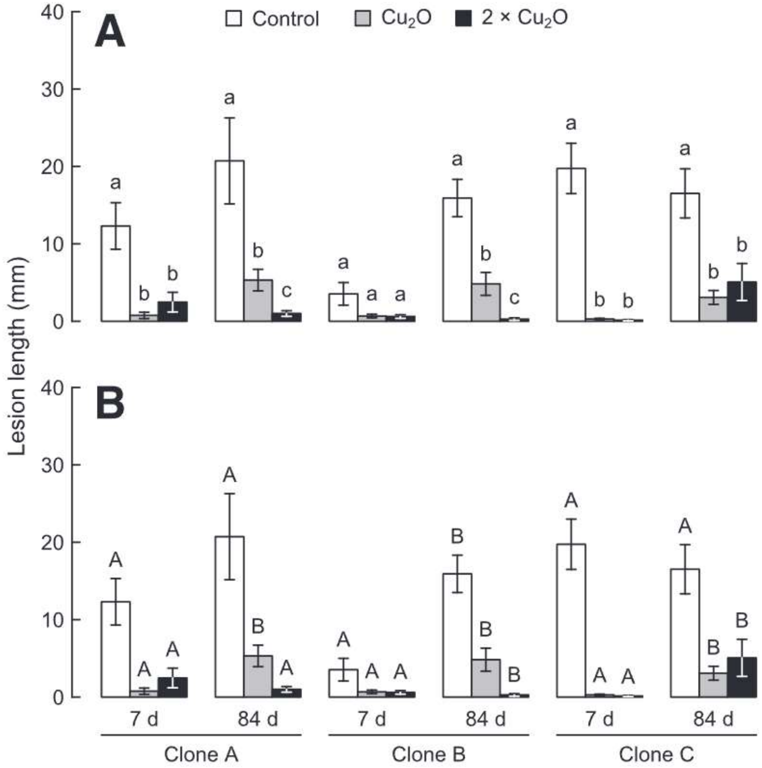
**Abstract**

Red needle cast is a significant foliar disease of commercial stands of *Pinus radiata* caused by *Phytophthora pluvialis* in New Zealand. The effect of copper, applied as a foliar spray of cuprous oxide at a range of doses between 0 and 1.72 kg $ha^{-1}$, was investigated in two controlled trials with potted plants and in an operational trial with mature *P. radiata*. In all trials, lesions formed on needles after artificial exposure to the infecting propagules (zoospores) of *P. pluvialis* were used to determine treatment efficacy, with the number and/or length of lesions as the dependent variable. Results across all trials indicated that cuprous oxide was highly effective at reducing infection of *P. radiata* with *P. pluvialis*. Application rates equivalent to $\geq$0.65 kg $ha^{-1}$ significantly reduced infection levels relative to a control treatment, with foliar surface copper levels as low as 13 to 26 mg $kg^{-1}$ of needle tissue preventing infection. Greater copper content was associated with a reduction in the proportion of needles with *P. pluvialis* lesions, with the probability of lesions developing decreasing approximately 1% for every 1 unit (in milligrams per kilogram) increase in copper content. Over a 90-day period, surface copper content declined to 30% of that originally applied, indicating an approximate period of treatment efficacy of 3 months. Our findings highlight the potential of cuprous oxide for the control of red needle cast in *P. radiata* stands. Further information about the optimal field dose, timing, and the frequency of foliar cuprous oxide application is key to prevent infection and also reduce the build up of inoculum during severe outbreaks of this pathogen.

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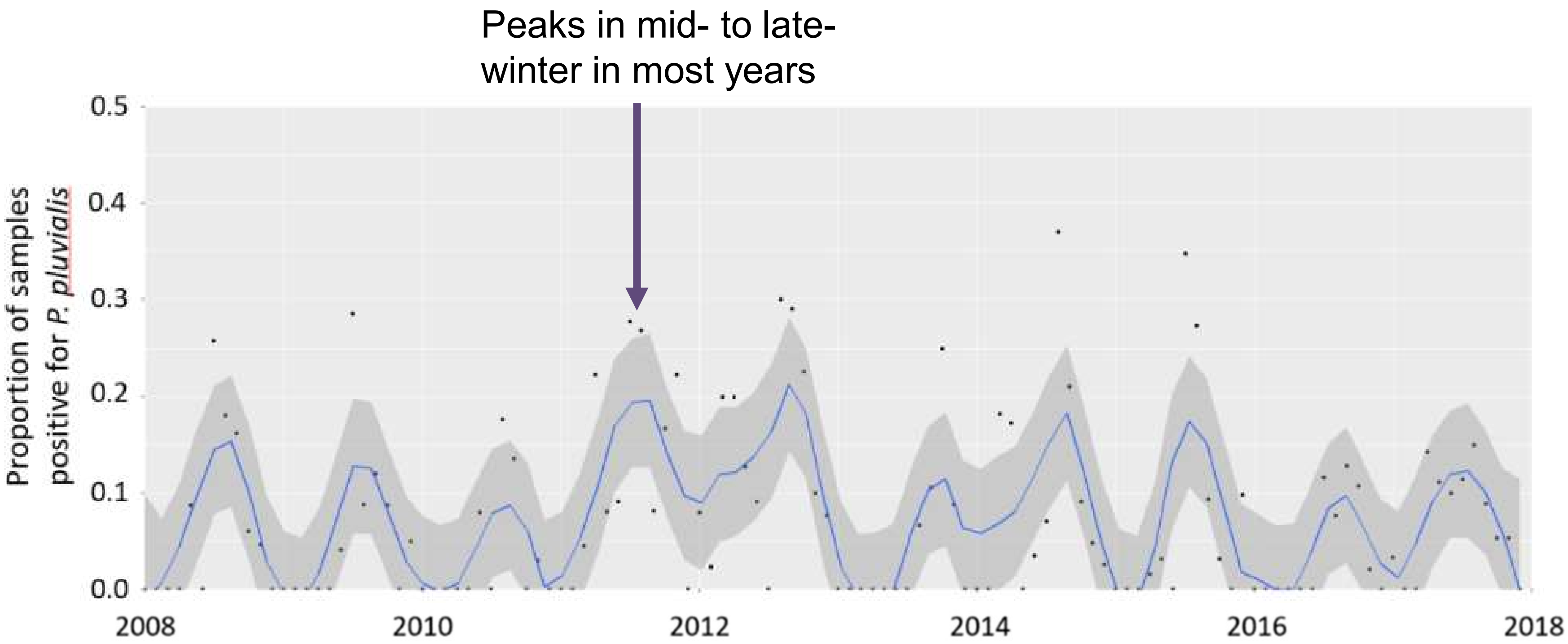
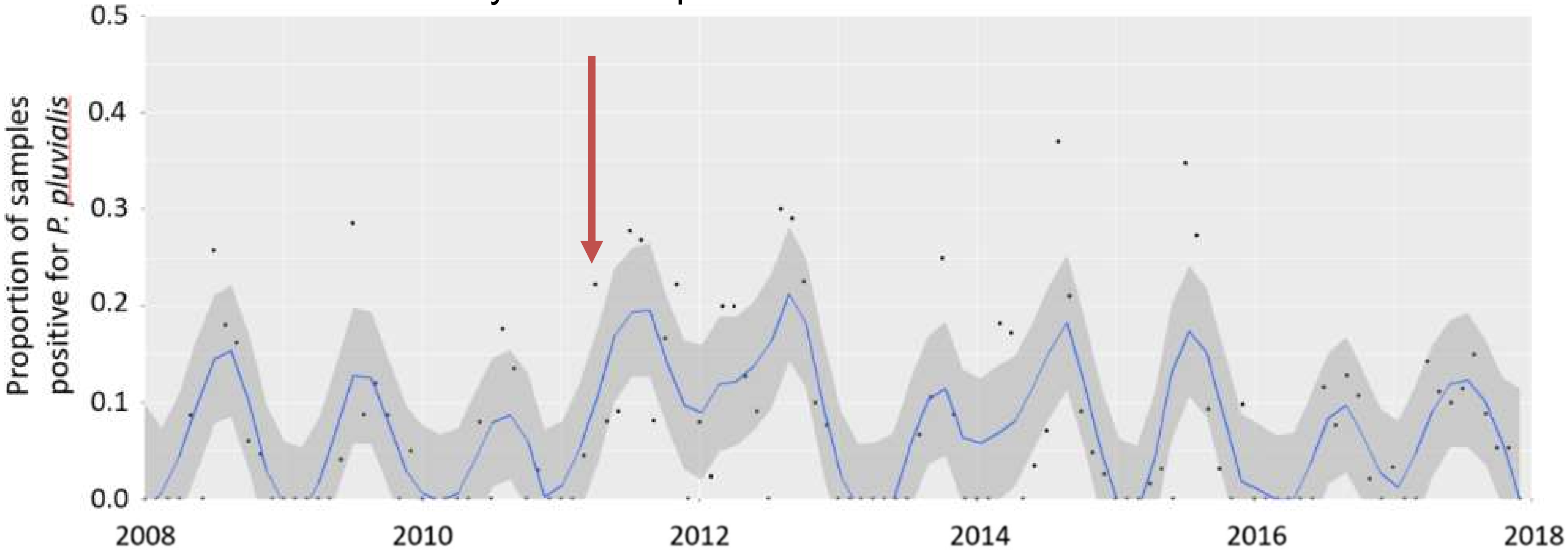
# Disease expressed over winter most years




Fraser et al 2020 *Forest Pathology*

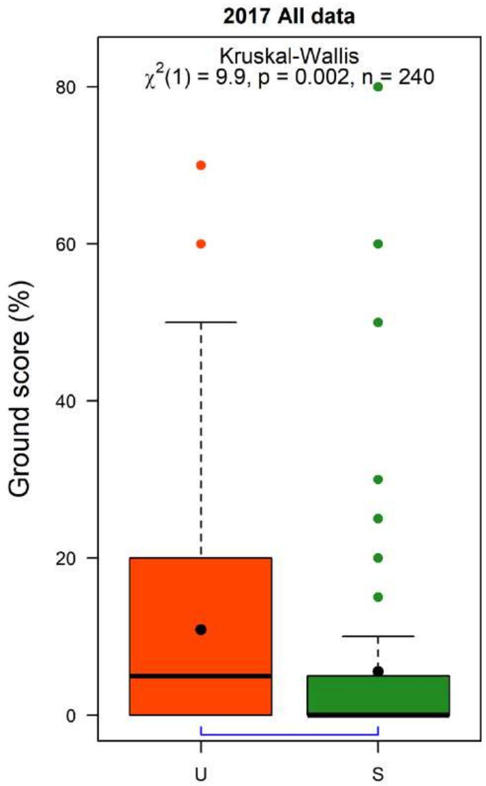
# Control applications in autumn best?

Applications in late summer
to early autumn optimal?

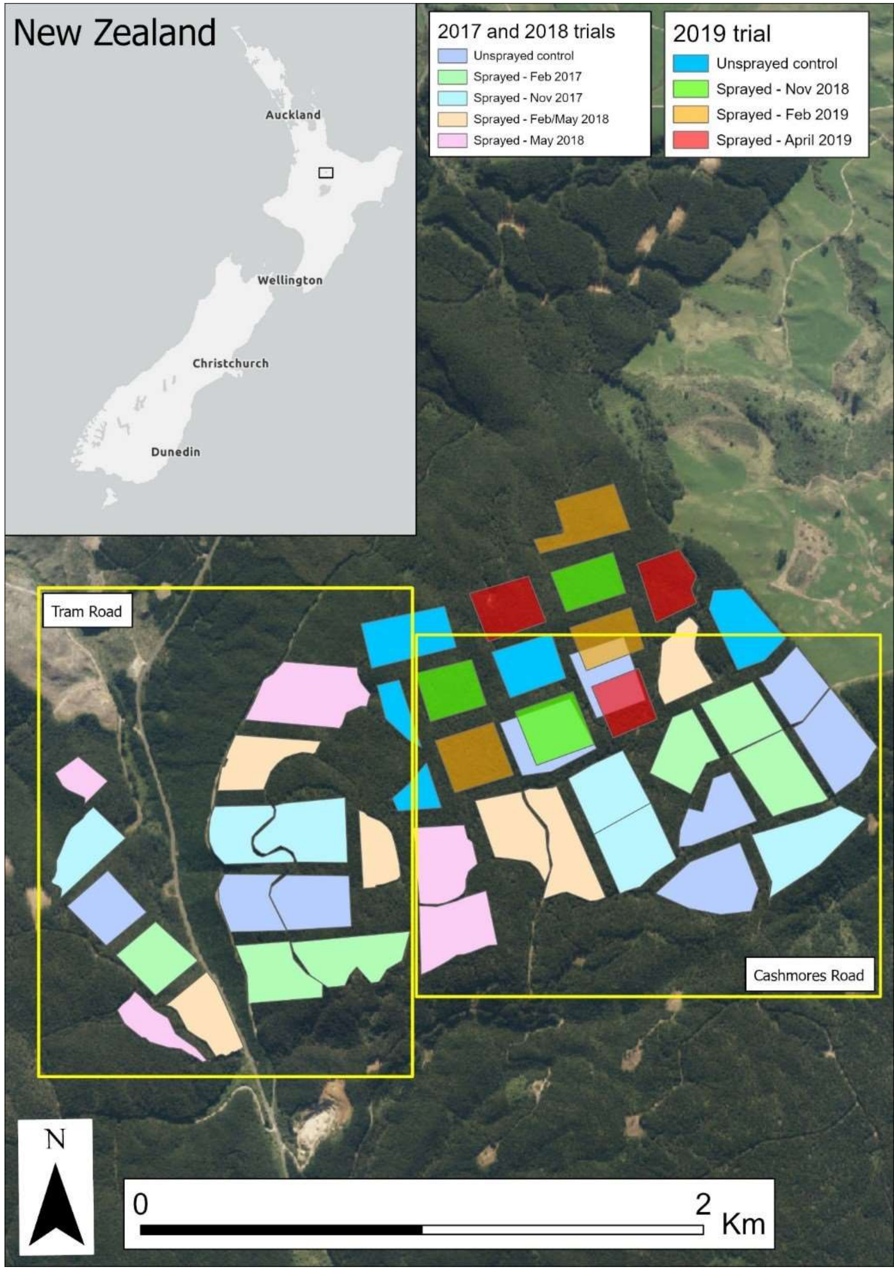



Fraser et al 2020 *Forest Pathology*

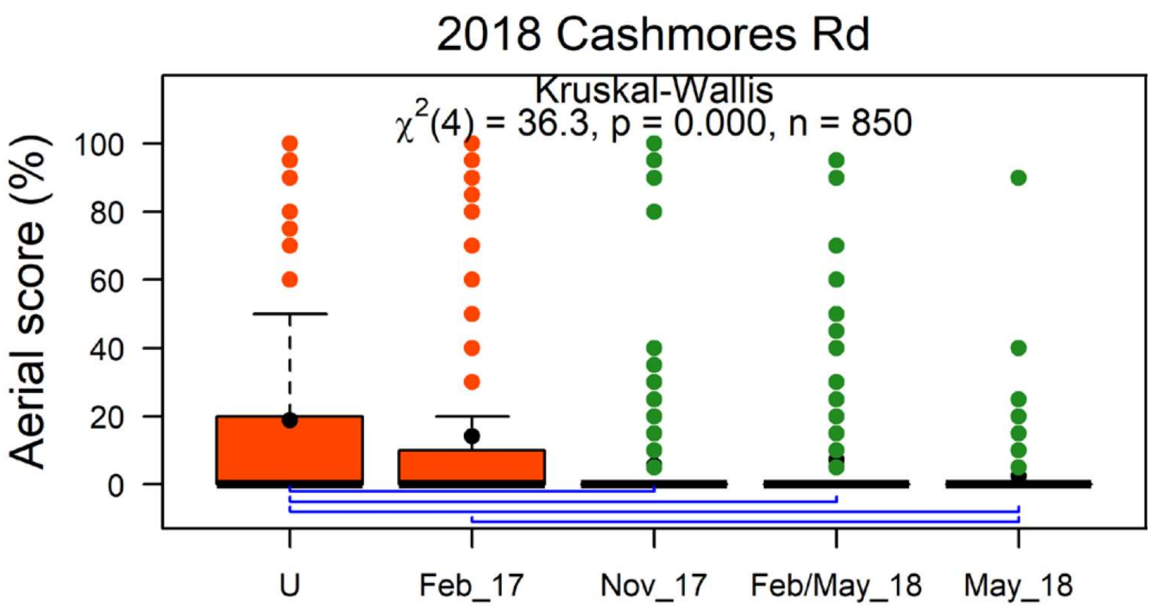
# Copper at Dothi rate showed promise in first operational-scale field trials

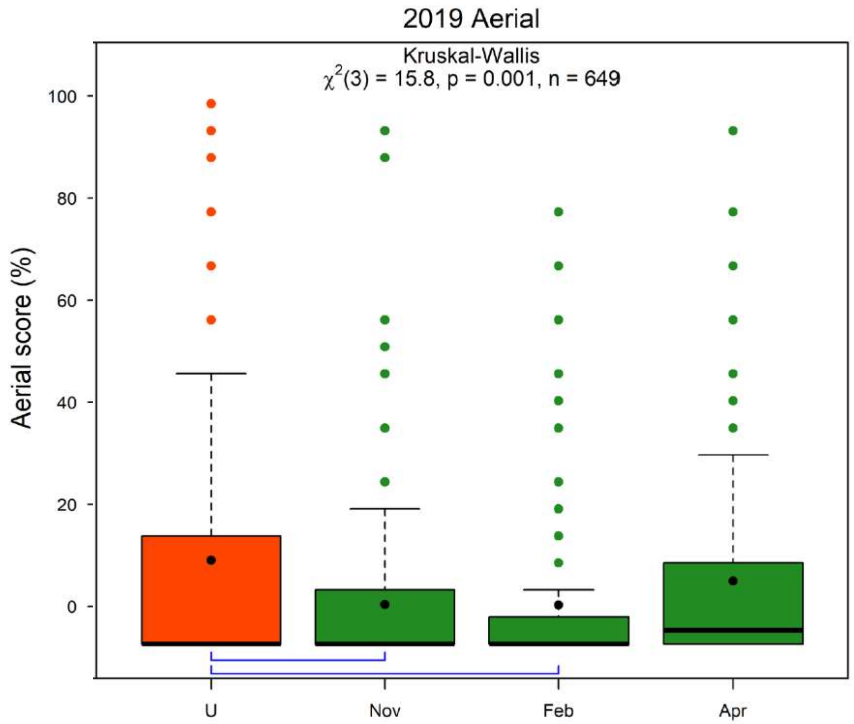



Fraser et al 2022 *NZJFS*



# No consistent impact of spray timing, but not tested under severe disease

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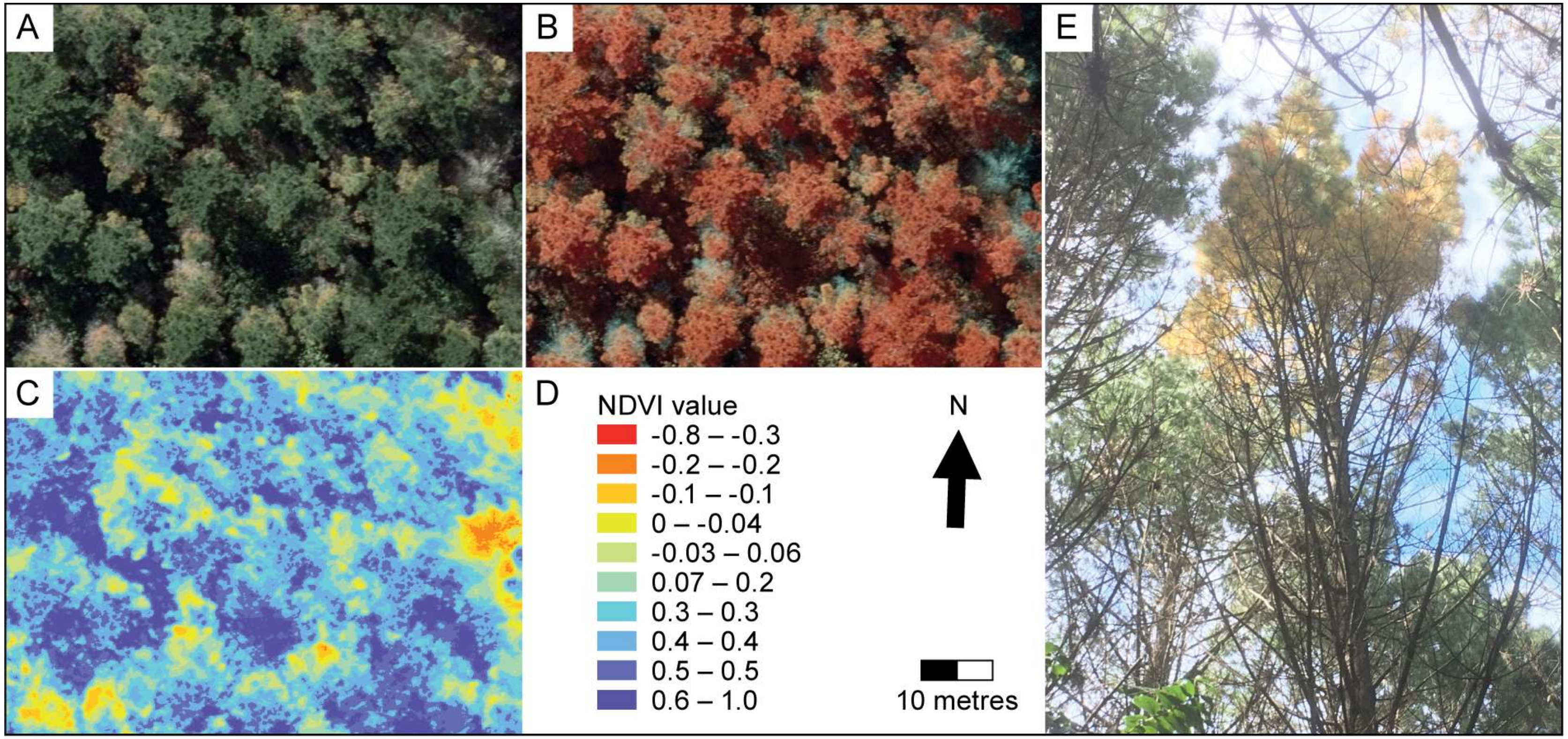
# Methodology developed for aerial disease assessments

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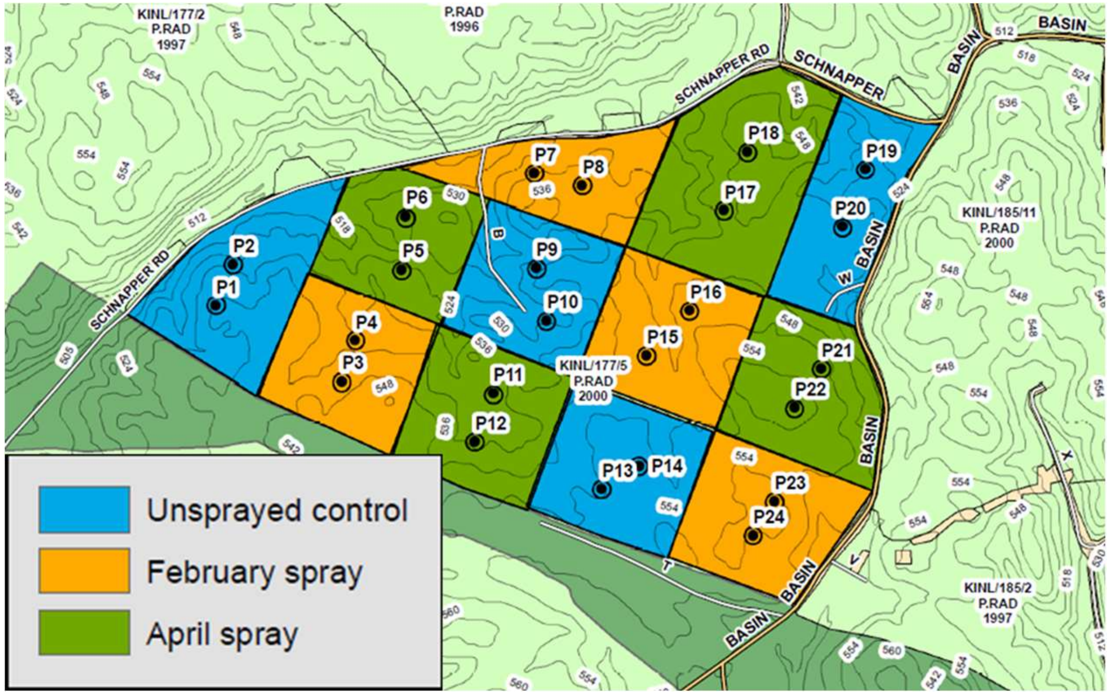
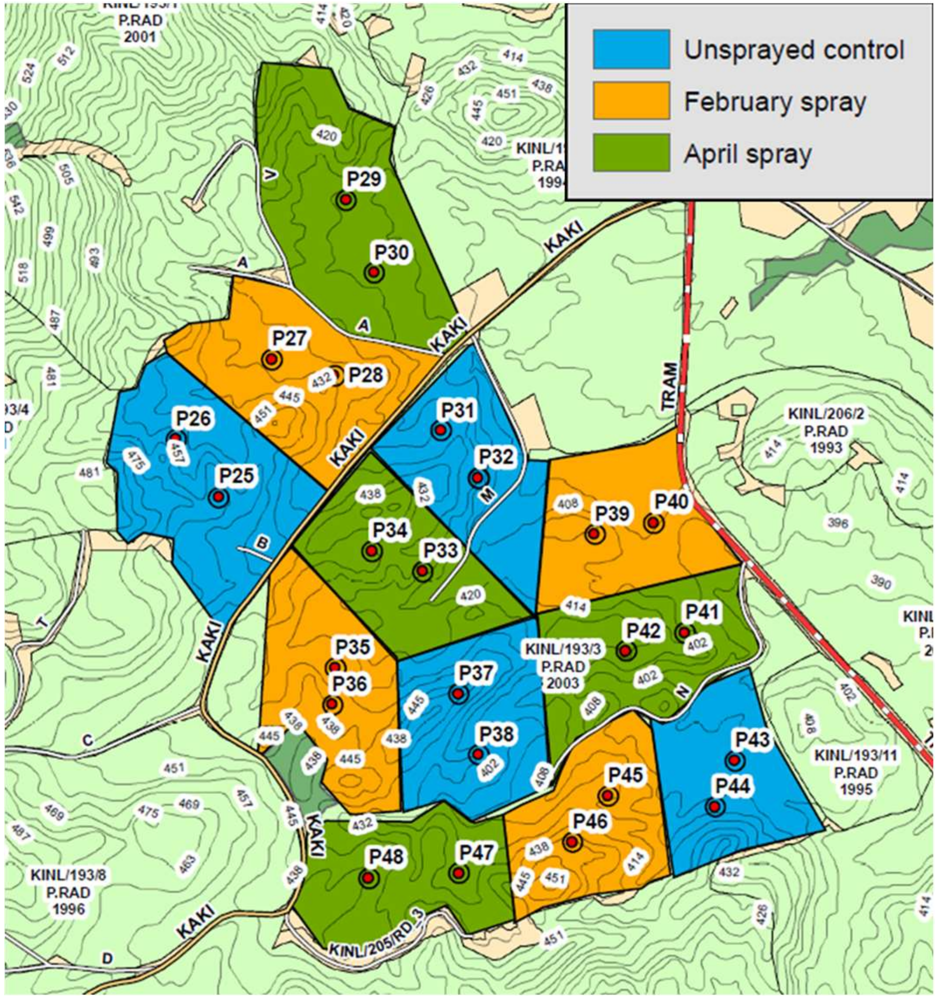
# Kinleith 2019-2024 trials

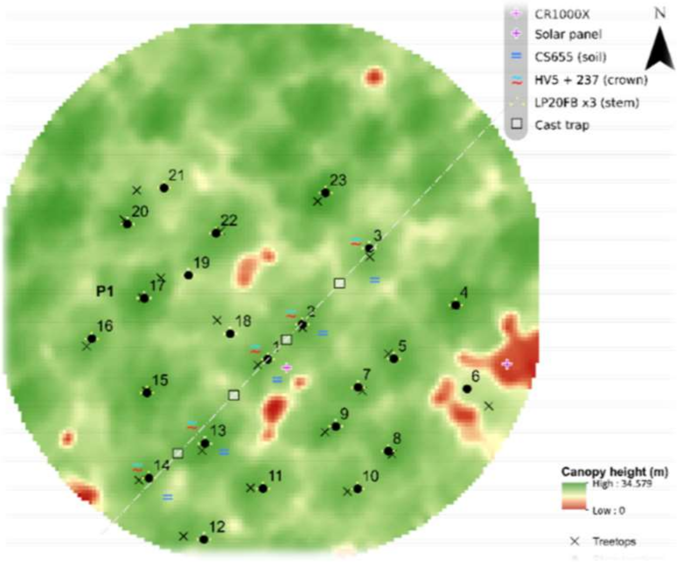
- Spray timing important? February vs April.
- Quantification of growth impacts to support cost/benefit analysis.

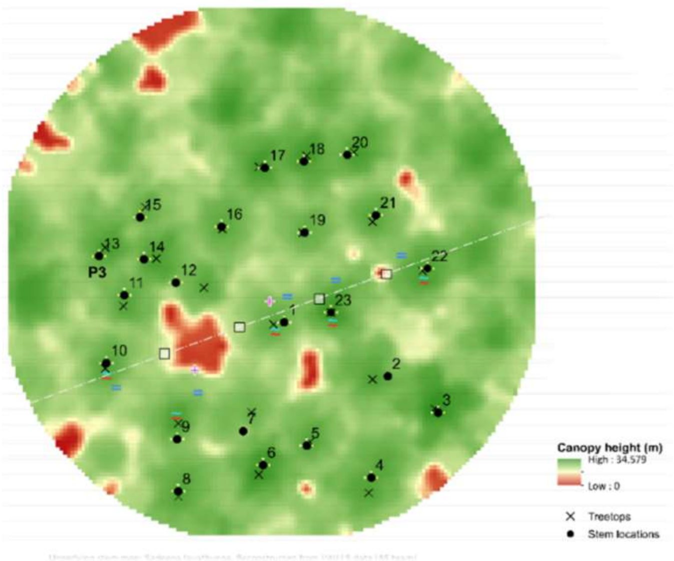


# Kinleith 2019-2024 trials

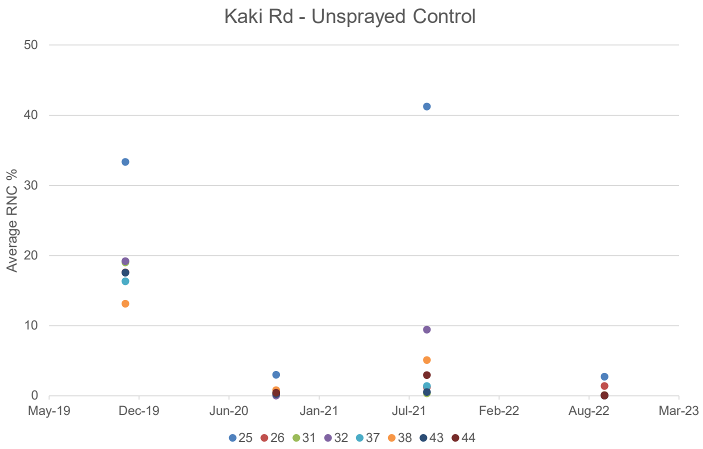
- Spray timing important? February vs April.
- Quantification of growth impacts to support cost/benefit analysis.
- **Canopy microclimate, disease epidemiology and fine scale growth patterns.**

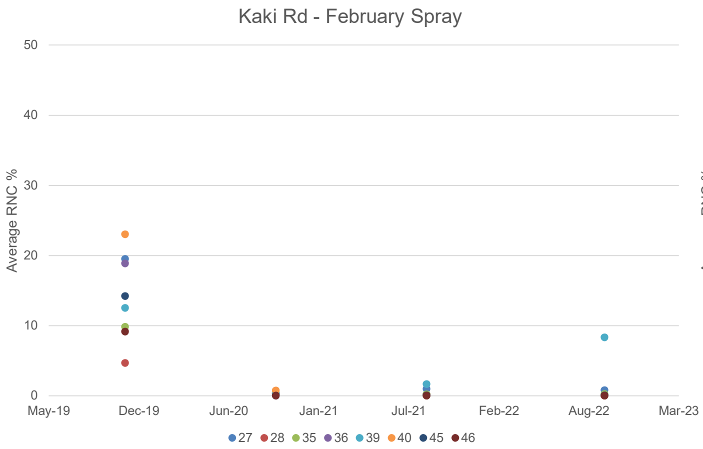


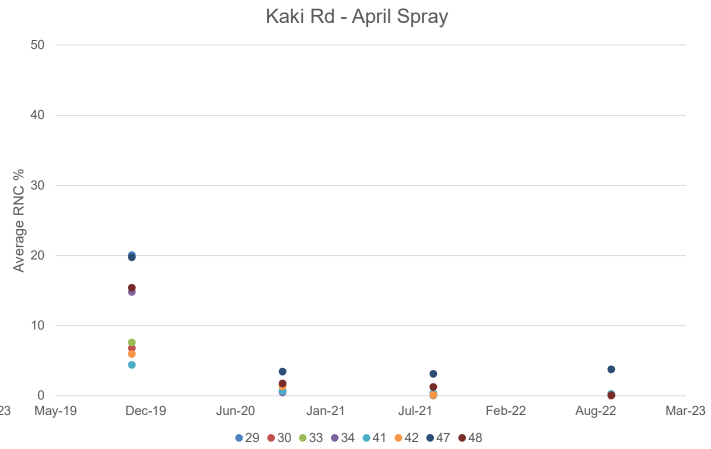



# Kinleith 2019-2024 trials

Disease levels are generally low

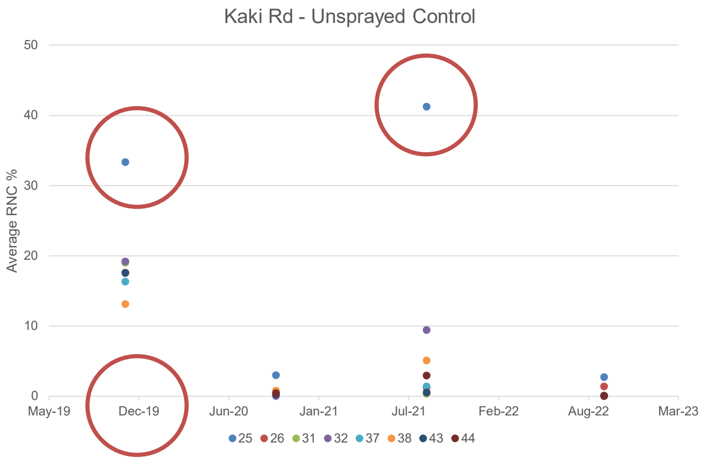


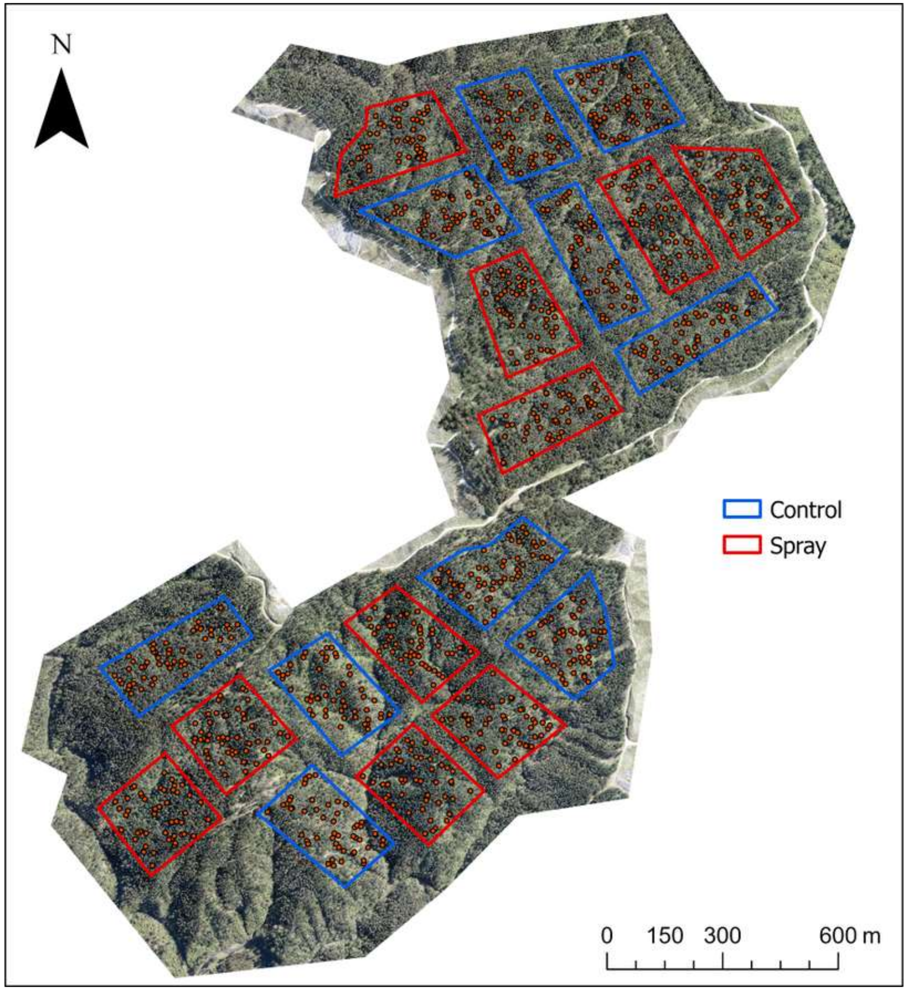
# Kinleith 2019-2024 trials

But disease in some unsprayed PSPs



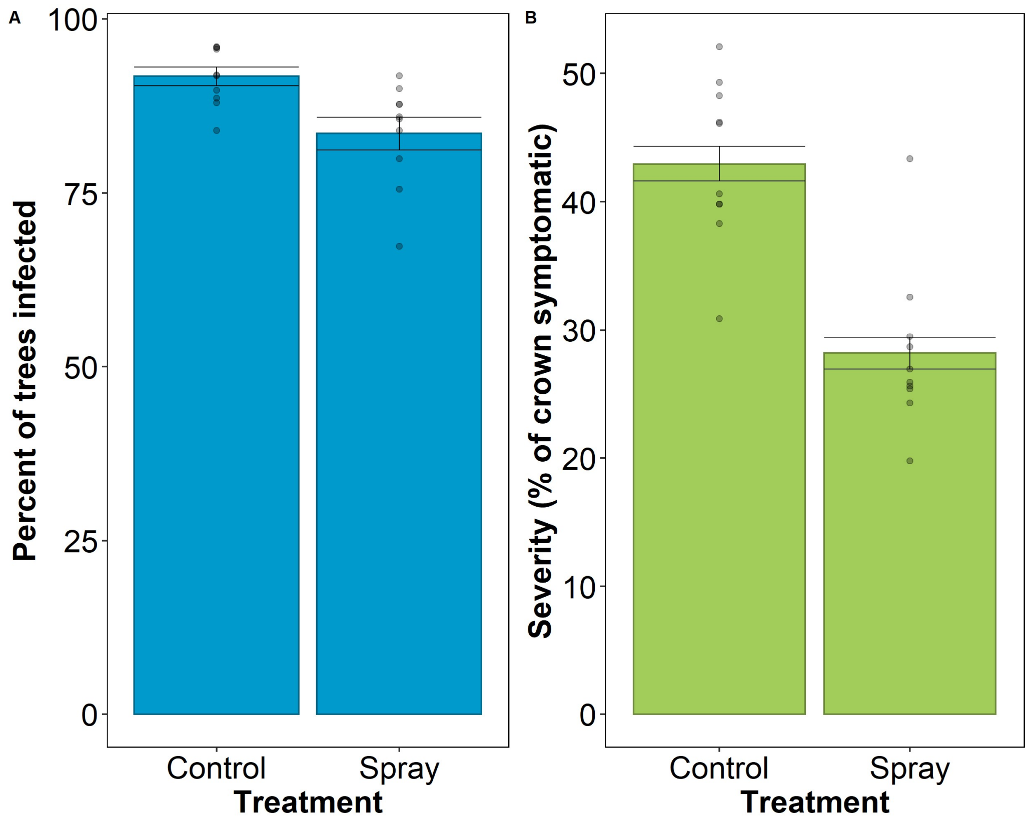

# Wharerata 2022 trial

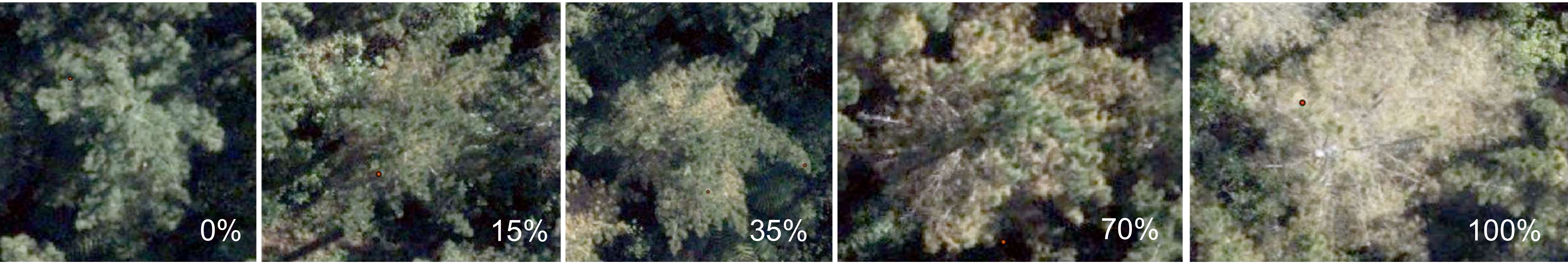
- Testing efficacy under greater disease.
- *Phytophthora pluvialis* the dominant pathogen.
- Copper applied 5 April 2022 (Dothi standard).
- Aerial multispectral imagery captured 28 Nov 2022.



# Wharerata 2022 trial

- Copper reduces RNC severity
- Would an earlier spray have been more effective?



# Conclusions – RNC control

- Copper (Dothi standard) consistently reduces RNC severity
- Impact of spray timing still to be tested under severe disease

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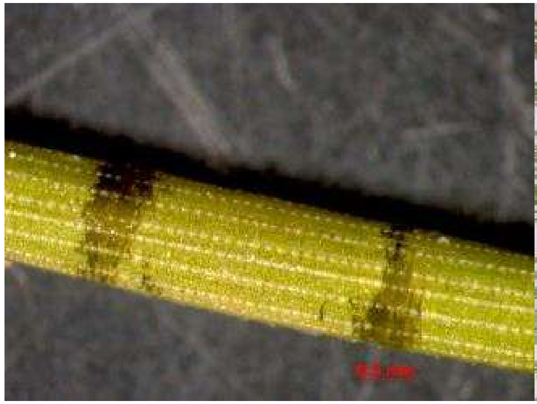
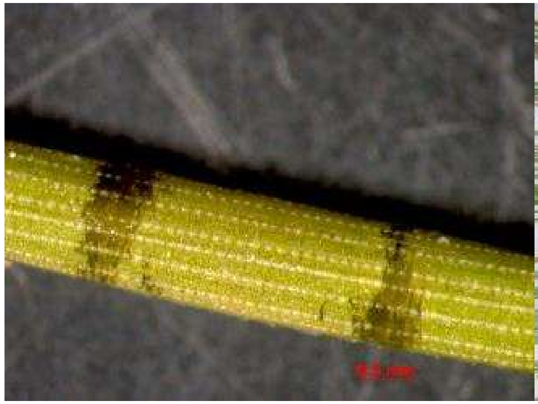
- Quantification of growth impacts will support cost/benefit analysis
- RNC epidemiological model will support disease forecasts and spray decisions




# Conclusions – RNC control

- Copper (Dothi standard) consistently reduces RNC severity
- Impact of spray timing still to be tested under severe disease
- Quantification of growth impacts will support cost/benefit analysis
- RNC epidemiological model will support disease forecasts and spray decisions
- Environmental sustainability and social licence to operate need to be considered
  - Copper accumulates in soils
  - Environmental toxicity – FSC high hazard pesticide restricted list

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# Alternative control options for Dothistroma

- 2021 stakeholder workshop
- Proposed tools all scored similarly – a combination of tools required
- Recommendation that both shorter and longer-term options investigated

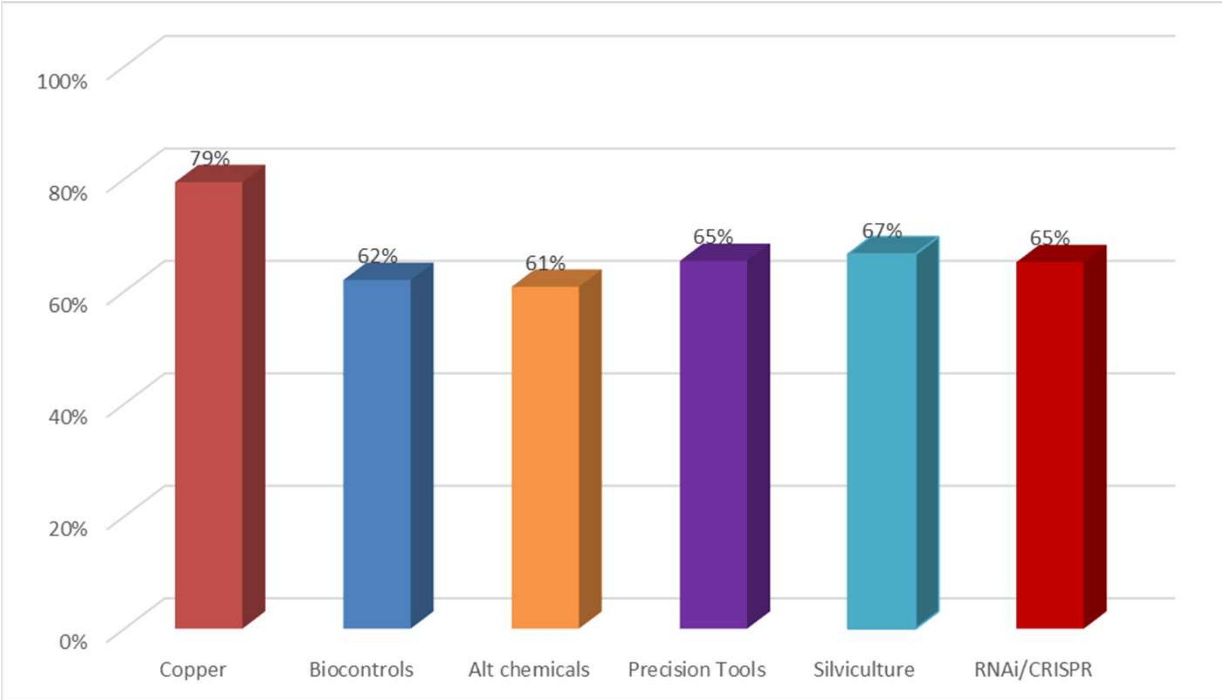


**Fig 7**. The overall rating of each alternative option

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Date:
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# Technical Note

## Report Title: Review of alternative metal salts with potential direct control activity against pine needle pathogens.

**Summary:**

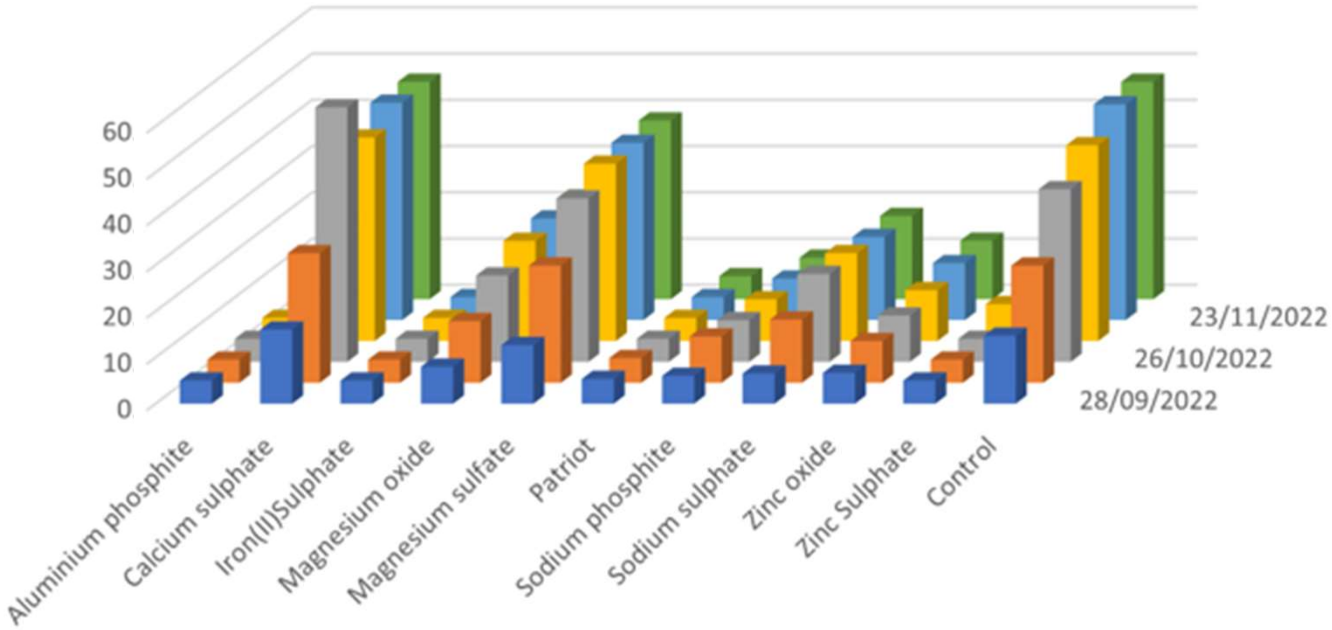
This review has identified many inorganic fungicides that may be efficacious against pine needle pathogens. Inorganic fungicides identified include elemental metal, simple metal salts, metal impregnated materials, natural metal nanomaterial and highly engineered nanoparticles. Inorganic fungicides typically have a multi-site mode of action reducing the risk of resistance developing. The metal ion bioactivity typically derives from electrophilic binding to protein amino acids and nucleic acids disrupting cellular processes and the integrity of cell membranes. Also, metal ions/particles catalyse redox processes generating free radicles, which causes damaging oxidative stress leading to cell death. The form of the metal product; dissolved ions, chelated/complexed, impregnated, nanoparticulate etc, along with the nature of the counter ion or capping groups, can determine the bioavailability and the dissolution rate of metal ions. For New Zealand forestry purposes, a suitable inorganic fungicide would need to have a similar cost and efficacy profile to cuprous oxide with lower environmental impacts. This eliminates many heavy metal containing fungicides (toxicity) and many nanoparticulate systems (cost). Likely candidates include salts of iron, zinc, magnesium, aluminium, potassium, and sodium. Iron and zinc are most likely to exhibit similar properties to copper having a similar intermediate acidity. Due to demonstrated anti-fungal activity of phosphites, metal salts of phosphite are considered promising if cost and availability are not prohibitive.

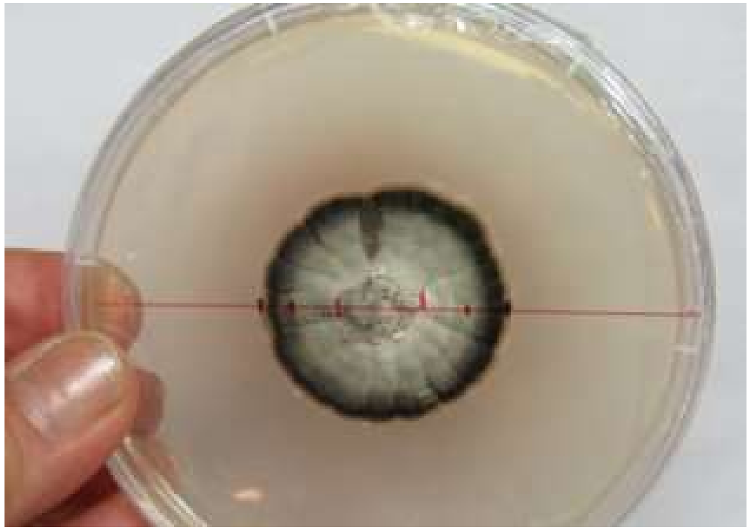
**Author/s:** Justin Nairn (Scion)

Table 1: Recommended candidates for testing

| **Chemical name** | **Formula** | **Product/supplier** |
|---|---|---|
| *Copper (I) oxide* | *$CuO$* | |
| Iron (II) oxide | $FeO$ | |
| Iron (III) oxide | $Fe_2O_3$ | |
| Iron (II, III) oxide | $Fe_3O_4$ | |
| Iron (II) sulphate | $FeSO_4$ | Tui moss control |
| Iron (III) sulphate | $Fe_2(SO_4)_3$ | |
| Zinc oxide | $ZnO$ | |
| Zinc sulphate | $ZnSO_4$ | Zineb, Autech industry co. ltd |
| Zinc phosphite | $Zn_3(PO_3)_2$ | |
| Zinc Hydrogen Phosphite | $ZnHPO_3$ | |
| Magnesium oxide | $MgO$ | |
| Magnesium sulphate | $MgSO_4$ | Epsom salts |
| Calcium oxide | $CaO$ | |
| Calcium Phosphite | $CaHPO_3$ | |
| Calcium sulphate | $CaSO_4$ | Lime sulphur / Grochem |
| Sodium phosphite | $Na_2HPO_3$ | Phostrol 500 / Nufarm |
| Sodium sulphate | $Na_2SO_4$ | Fertilizer |
| Silicon phosphite | $Si(HPO3)_2$ | FOSSiL / Orian |
| Potassium phosphite | $K_2HPO_3$ | Agri-fos 600 / Key industries |
| Aluminium phosphite | $Al(HPO_3)_3$ | Aliette / Bayer |
| Aluminium sulphate | $Al_2(SO_4)_2$ | Fertilizer |

# Alternative metal salts impact on *Dothistroma septosporum in vitro*



- Aluminium phosphite, Iron sulphate, Sodium phosphite, Zinc sulphate most efficacious.
- No impact of dose for these four salts.
- Calcium sulphate, Magnesium oxide, and Magnesium sulphate did not reduce culture growth (maybe even increased growth).

# Conclusions – Dothistroma control

- A range of alternative metal salts show direct inhibition.
- Activity *in planta* yet to be tested.
- *in planta* assays can be used to investigate longer-term options.
- Environmental sustainability and social licence to operate need to be considered.

# Acknowledgements

- Mike Baker, Manulife Investment Management Forest Management
- Kate Richards (Muir) and Edward Pirini, Juken New Zealand
- Dothistroma Control Committee
- Resilient Forests Technical Steering Team
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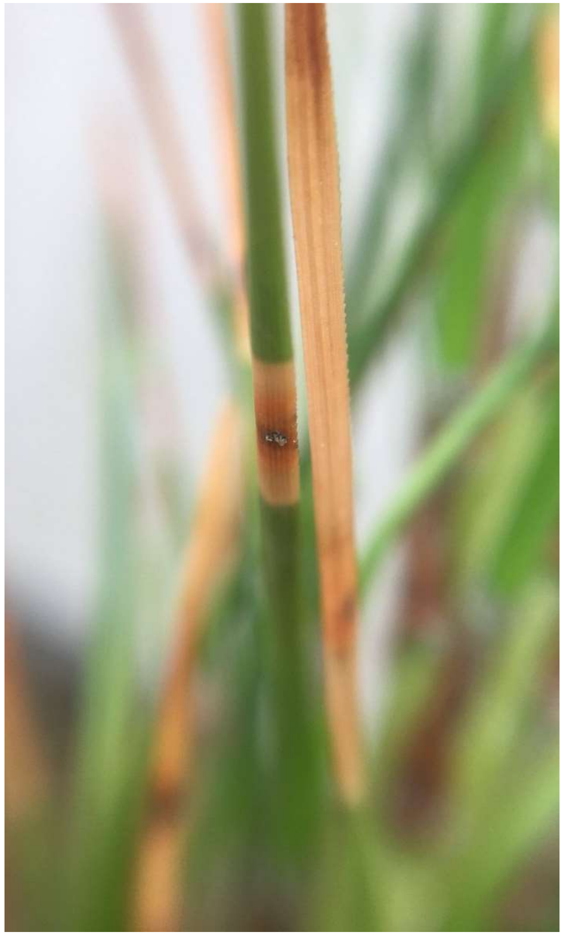

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RESEARCH ARTICLE Open Access

New Zealand Journal of Forestry Science

# Efficacy and optimal timing of low-volume aerial applications of copper fungicides for the control of red needle cast of pine

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## Abstract

**Background:** Red needle cast (RNC) is a foliar disease of radiata pine (*Pinus radiata* D.Don), caused by *Phytophthora pluvialis* Reeser, Sutton & E.Hansen and occasionally *Phytophthora kernoviae* Brasier, Beales & S.A.Kirk. The disease has impacted plantations in New Zealand since at least 2008. To develop management recommendations for red needle cast, research has focused on identifying chemical control options and understanding pathogen epidemiology to guide optimal timing of spray application. The objectives of this study were to: (1) assess the efficacy of aerial copper fungicide application for the control of red needle cast in mature radiata pine plantations; and (2) investigate optimal spray timing.

**Methods:** To address these objectives, three operational-scale field trials were undertaken in successive years between 2017 and 2019 at a forest in the Central North Island of New Zealand. RNC severity was assessed in canopies of forest blocks exposed to cuprous oxide applied at 0.855 kg ha$^{-1}$ active ingredient in low-volume aerial spray at different times of the year (November, February and April (or May)). Needle cast from plantation trees and infection levels on trap plants were also assessed in some years.

**Results:** Application of cuprous oxide significantly reduced RNC severity in all three trials. As well as reducing disease severity, application of cuprous oxide also tended to reduce needle cast from plantation trees and infection on trap plants in years when these were also assessed. No consistent effect of spray timing was observed. Generally, all three spray timings reduced disease severity compared to the unsprayed control, but differences were not always significant, and few differences were detected between different spray timings.

**Conclusions:** The results reported here are the first to show that low-volume aerial applications of cuprous oxide applied at 0.855 kg ha$^{-1}$ active ingredient can reduce the severity of RNC in commercial radiata pine plantations. No consistent effect of spray timing was detected. These findings support the development of management recommendations for RNC.

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