Bioeconomy Science Institute™

Red Needle Cast

Impact on growth, how to predict and control

New Zealand Institute for Bioeconomy Science Limited



Red needle cast (RNC) affects needles on radiata pine and Douglas-fir, impacting forest growth and productivity. It is a highly seasonal disease but a lack of understanding about the disease cycle has made predicting outbreaks difficult. Knowing where and when an outbreak might occur can help forest managers decide on the best control measures to help safeguard their forests. The Resilient Forests Programme has conducted research to better understand the impacts, causes, and control of RNC outbreaks.



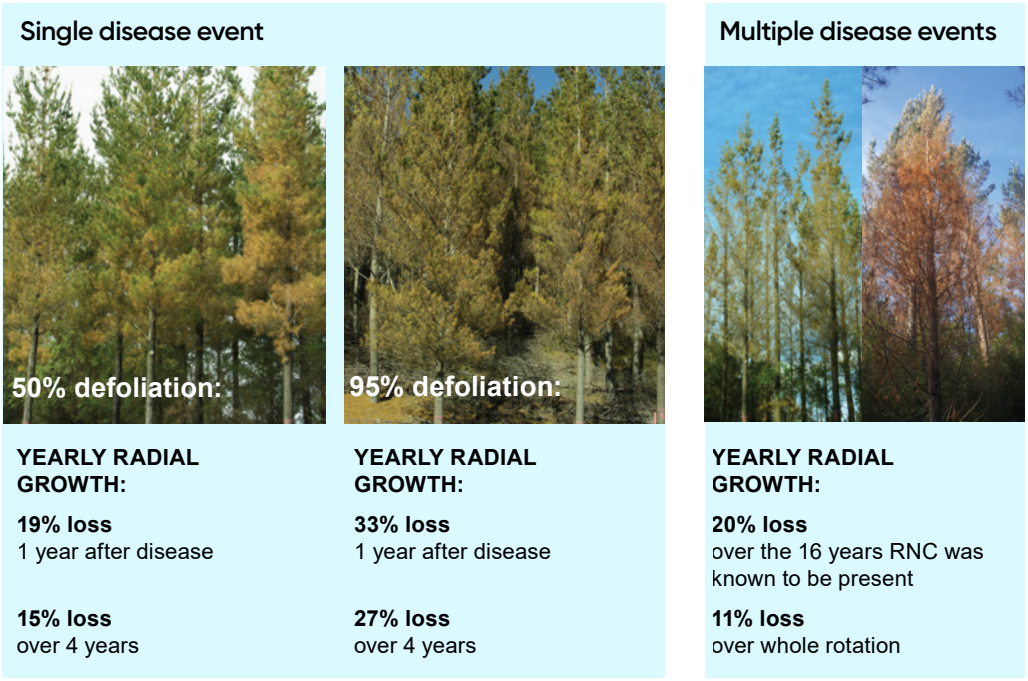


Figure 1 Impact of a single RNC defoliation event 50% (left) and 95% (middle) in a Central North Island forest on radial growth. Impact of multiple RNC events (right) in a Gisborne Region forest.

Impact on tree growth

Red needle cast (RNC) can cause significant defoliation, however, tree crowns can recover in spring and the short- and long-term impacts on tree growth have not been quantified until now. This enables us to apply a cost-benefit analysis to management of the disease.

Radial growth loss resulting from RNC outbreaks was investigated in two locations using wood core analysis. Growth losses following a single outbreak event in a Central North Island forest increased with disease severity. Moderate (50%) and severe (95%) defoliation led to a 19% and 33% growth loss the following year, respectively (Figure 1). Trees took at least 4 years for growth rates to return to healthy tree levels. Mean growth loss over the four years after the disease event was 27% and 15% for severe and moderate severity, respectively.

Growth losses at a site in the Gisborne Region with frequent outbreaks (RNC occurred every 3-4 years) was 31-52% in the year after each disease event. A total growth loss of 20% was predicted across the 16 years of reoccurring outbreaks.

Prediction of outbreaks

To provide decision tools on RNC risk and control we need to understand the disease cycle. Development of RNC management programmes is challenged by the disease's sporadic occurrence. RNC displays seasonal patterns with peaks in winter and spring and very little detection in summer, but the severity of outbreaks varies, often resulting in "boom or bust" years. In some areas control may only be required roughly every six years, however, in other areas more frequent control operations or alternative methods are required. The inability to predict these disease outbreaks makes management decisions on where and when to apply control difficult.

We have started unravelling seasonal RNC patterns by quantifying how the steps in the disease cycle, such as infection and spread, are driven by weather (Figure 3). The more favourable the weather, the faster this cycle can repeat, resulting in a disease outbreak.

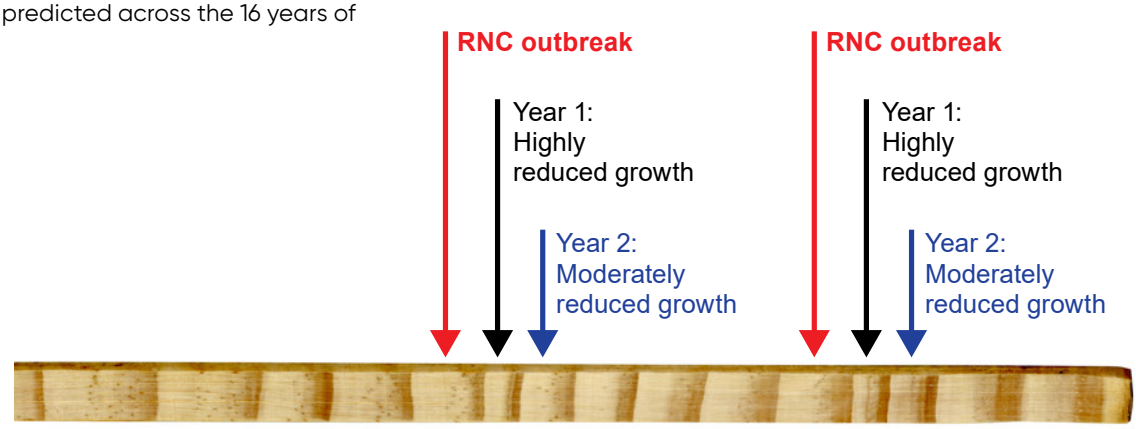


Figure 2 Example wood core showing the impact of two RNC outbreaks on growth

We found the optimal temperatures for RNC are between 10 and 20°C, with cooler temperatures slowing processes. Warm temperatures above 23°C and dry conditions stop the infection cycle, explaining why little disease is typically seen over summer. We have built this into an infection risk model which indicates at a daily scale how suitable weather is for RNC infection (Figure 4).

There is evidence that summer conditions (temperature and rainfall) may be a good indicator of RNC risk each year. Linking satellite detection of disease in the Gisborne Region with summer climate indicates that years with mild, wet summers result in a boom in disease likely due to a high level of pathogen abundance at the start of the period when weather is most conducive (autumn-spring). More recent analysis of a ground-based dataset from the Central north Island and Gisborne regions suggests that weather during autumn was especially important..

Foresters can make a judgment on how wet and mild the summer is and if they need to monitor for RNC outbreaks more closely (e.g. targeted field inspections), deploying control spays proactively. Prediction of boom RNC years may allow preventative spraying before the disease takes hold and defoliation (and growth losses) occur. Scion is working to validate the infection risk model and make it available to foresters to support decision making. The infection risk model may also support longer-term planning, such as the deployment of more resistant genotypes or alternative species.

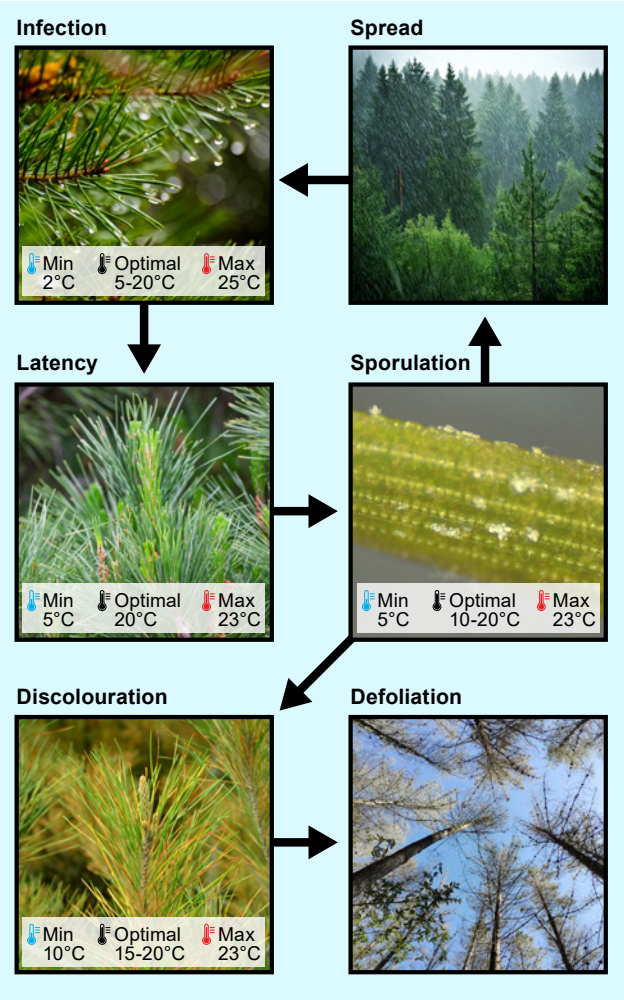


Figure 3 Impact of weather variables on the RNC cycle

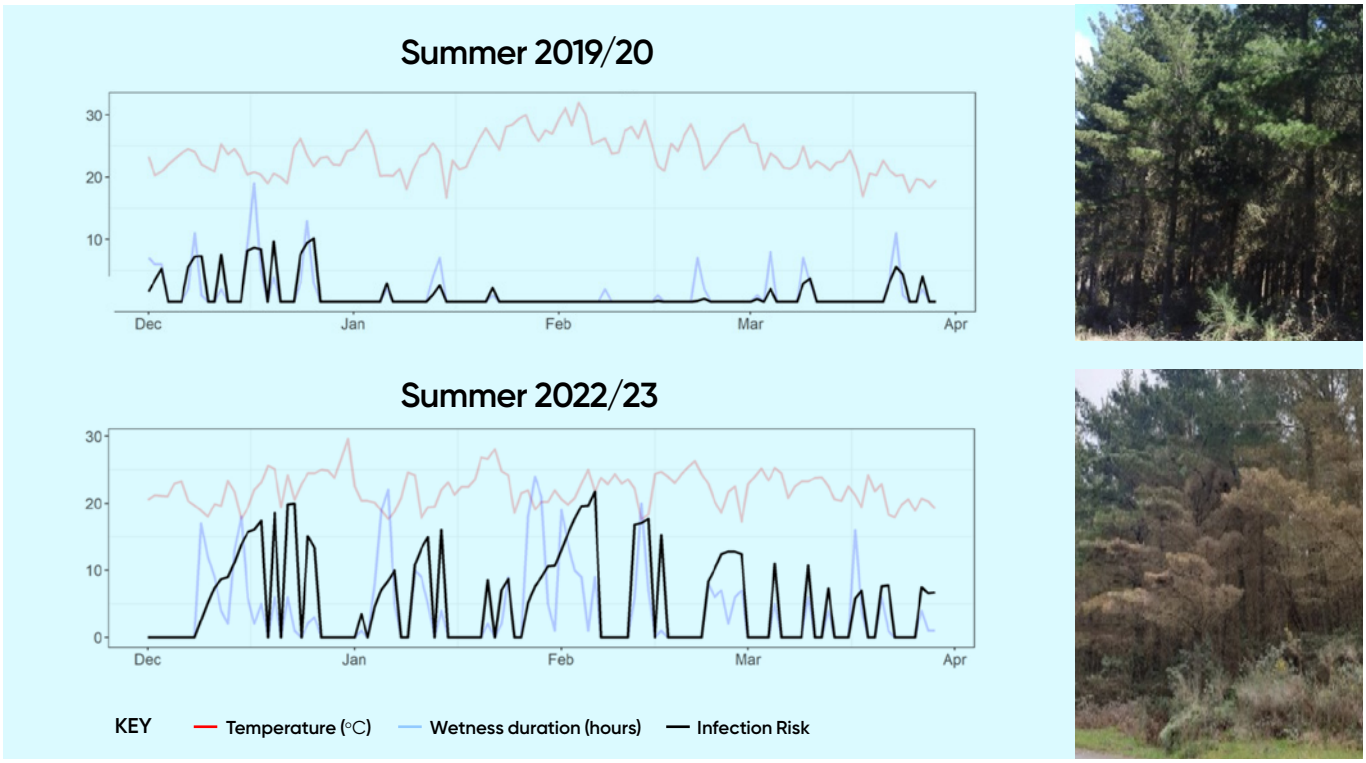


Figure 4 Predicted infection risk over summer at one site in the Central North Island in 2019/2020 and 2022/2023.
Climate data from National Climate Database (CliFlo), NIWA. RNC expression later in the year correlated well to risk during this period.

Options for control of red needle cast

There are currently no routine chemical control programmes in place for RNC. Often by the time symptoms are noticed, application of control measures would be ineffective. However, well timed proactive control operations can reduce disease severity and may mitigate growth losses

Preventative aerial application of low volumes of copper fungicide (cuprous oxide at the same application dose and method used in operational Dothistroma needle blight control) has been shown to be effective in reducing disease severity in several operational scale trials (Figure 5).

Three spray timings (Nov, Feb, Apr/May) were effective in reducing disease severity in a Central North Island trial under low-moderate disease levels between 2017 and 2019. No consistent effect of spray timing was detected. Data analysis from continued trials in this forest between 2019 and 2024 is underway.

More recent trials under greater disease pressure in the Gisborne Region between 2022 and 2024 indicate that copper application in autumn may also be effective under these conditions (full analysis underway). E.g. in 2023 application of copper reduced the median severity of crown loss from over 50% per tree to under 25%.

Implications for industry

Red needle cast impacts have been quantified at two case-study forests, the environmental (weather) drivers of disease outbreaks revealed, and aerial copper sprays shown to reduce disease severity.

Together these developments allow forest managers to:

- **Integrate projected red needle cast growth losses into their decision making** for control operations and investment in other management practices (e.g. development of resistance). Understanding growth changes may also influence harvesting decisions, such as rotation length and inform projected yield tables.
- Better prepare for red needle cast outbreaks. The combination of better prediction of RNC outbreaks (after mild, wet summers and autumns) and targeted monitoring may allow for **proactive spraying of areas at risk or during early stages of infection to reduce defoliation.** A prototype RNC digital decision support tool has been developed and will be demonstrated at the 2025 FGR Conference.
- **Use copper to control developing red needle cast outbreaks.** However, any control operations need to be applied rapidly to have impact. Once an outbreak is fully established, preventative sprays will not be effective.

Further work is needed on the potential non-target impacts of expanded copper use for RNC control and to identify other longer-term and sustainable management options. Our findings support this work: e.g. (1) knowledge of growth impacts will also allow a cost-benefit analysis of investment in, and deployment of, disease resistance breeding and (2) infection risk models will improve risk assessment under climate change and long-term planning and adaptation.

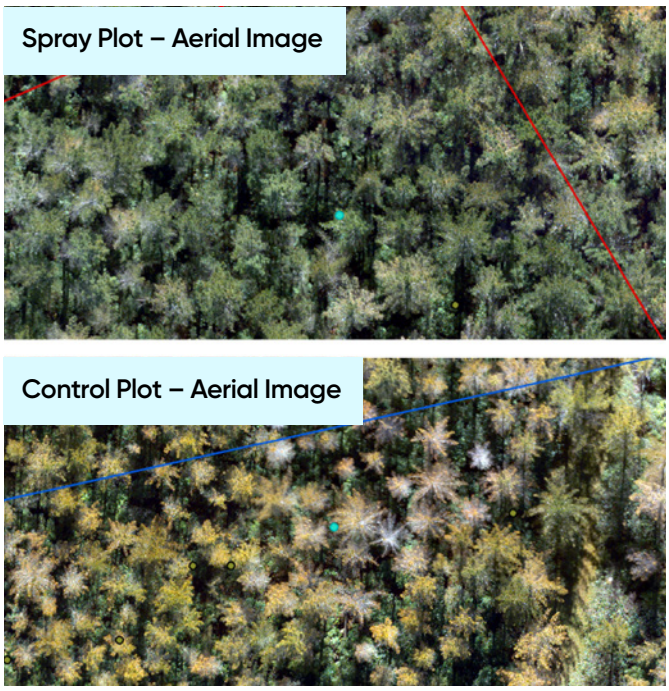


Figure 5 Aerial imagery of example plots demonstrating the impact of copper control. Trees are largely green in the sprayed plot (top), but orange and defoliated in the unsprayed control plot (bottom)

Acknowledgements

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