Myrtle rust weather-risk update and commentary to 30 April 2021

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In this update:

1. **Weather risk October 2020 – April 2021 associated with a new myrtle rust observation in Christchurch**
2. **New risk index to compare seasons and regions for climatic suitability for myrtle rust**
3. **Discussion about climatic risk and potential geographic range of *Austropuccinia psidii***

Background

On 21 April 2021 a new observation of myrtle rust from Spreydon in Christchurch, Canterbury was posted on iNaturalist (https://inaturalist.nz/observations/74675317) and this appears to be the first report of secondary spread, and therefore establishment, of myrtle rust in Canterbury. An earlier report in March 2020 was of infected plants relocated from the North Island (https://www.inaturalist.org/observations/39539901).

Understanding drivers for myrtle rust in South Island areas is important for understanding establishment and spread in areas of marginal climatic suitability so we can predict the ultimate geographic range of *A. psidii* and identify possible refugia where conditions are unsuitable for rust but suitable for vulnerable host plants to survive.

To determine if there were unusual weather conditions associated with the new Christchurch observation, myrtle rust climatic risk was analysed for the area around Christchurch in 2020 – 2021 and compared with other seasons and regions. This was done using the Myrtle Rust Process Model (MRPM)[1] with weather data from the following three sites in the HortPlus™ weather station network:

1. Lincoln (Selwyn District, Canterbury), 15 km from the iNaturalist rust observation in Christchurch.
2. Riwaka (Tasman), representing the area where myrtle rust was first detected in the South Island in April 2018.
3. Owairaka (Mt Albert, Auckland), representing conditions in the northern North Island.

Time series graphs of predicted infection risk, latent period (time from infection to new spores) and sporulation risk (likelyhood that existing infections will produce spores) were constructed (Appendix 1). Weekly myrtle rust climatic risk maps produced by NIWA were also examined during key periods to understand the spatial variability of climatic risk.

A new index of 'overall risk' was calculated from MRPM output as the daily infection risk multiplied by daily latent development rate (1/latent period). This index was accumulated annually between 1 July and 30 June to compare relative climatic suitability for myrtle rust over time between regions and years.

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[1] Beresford RM, Turner R, Tait A, Paul V, Macara G, Yu ZD, Lima L, Martin R 2018. Predicting the climatic risk of myrtle rust during its first year in New Zealand. New Zealand Plant Protection 71: 332-347.

1. Myrtle rust risk in Christchurch October 2020 to April 2021

Infection risk, as 7-day running mean values (Fig. 1, solid red line), showed two episodes of moderate risk (0.4-0.6), the first between 20 December and 18 January and the second from 26 February to 4 March. Over the whole 7 months, 25 individual days had high (0.6-0.8) to very high (>0.8) infection risk. Therefore, conditions favourable for *A. psidii* infection occurred reasonably frequently in 2020-2021.

Latent period, as 7-day running mean values (black dashed line), was mostly between 7 and 14 days (high to very high risk) between early December and early April, showing that *A. psidii* could have completed multiple infection cycles over the 7 month period.

Sporulation risk, as 7-day running mean values (solid orange line), was generally moderate (0.4-0.6) from mid November to mid April and was occasionally higher during the warmest periods.

Conditions, overall, were therefore reasonably favourable for myrtle rust around Christchurch between October 2020 and April 2021.

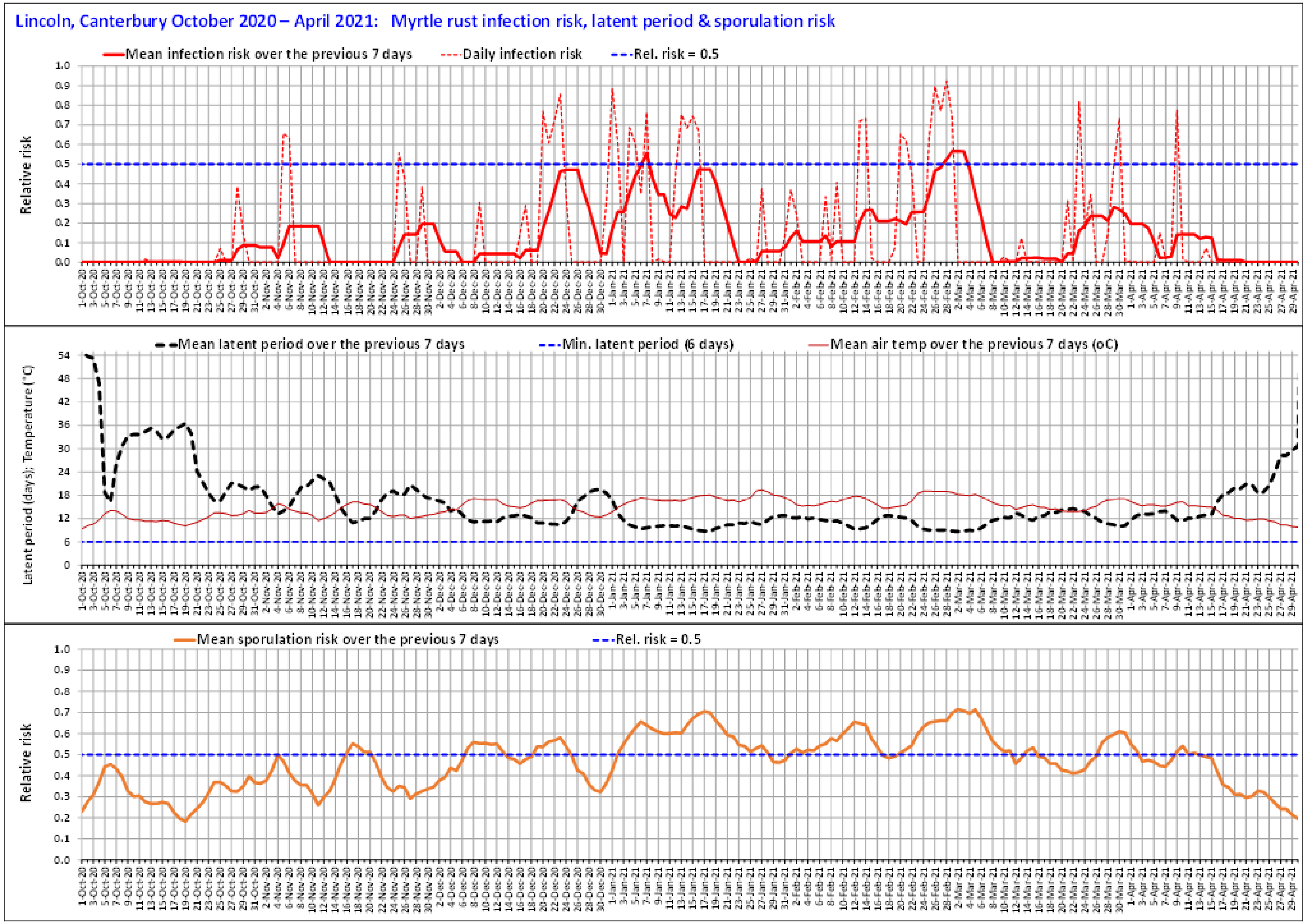

Figure 1. Suitability of weather conditions for myrtle rust predicted by three risk indices of the Myrtle Rust Process Model: Top, infection risk (0-1) as daily (dashed red line) and 7-day running mean (solid red line); Middle, latent period (days) as 7-day running mean (dashed black line); Bottom , sporulation risk (0-1) as the 7-day running mean (solid orange line).

Infection risk maps (Fig. 2) suggested that the two weeks in late February and early March identified as having elevated risk in the time series graphs (Fig. 1) had low (0.2-0.4) to very low (0-0.2) risk. However, the time series daily predictions (Fig. 1 dashed red line) showed individual days with high to very high risk and the 7-day means (Fig. 1 solid red line) indicated up to moderate risk.

The maps show averages over discrete weeks and for the two weeks shown in Fig. 2, the days in February with greatest risk from the time series graphs (26, 27, 28 and 29 February) occurred across the arbitrary cut-off between those two weeks, such that averaging caused the maps to under-represent risk. The maps do, however, show the relative spatial variability of risk including pockets of potentially elevated risk.

Earlier in the season, the days with elevated risk in December and January (Fig. 1) probably contributed to multiplication of myrtle rust leading to the appearance of rust in April, but the days in late February and March probably led directly to the infection discovered on 21 April 2021.

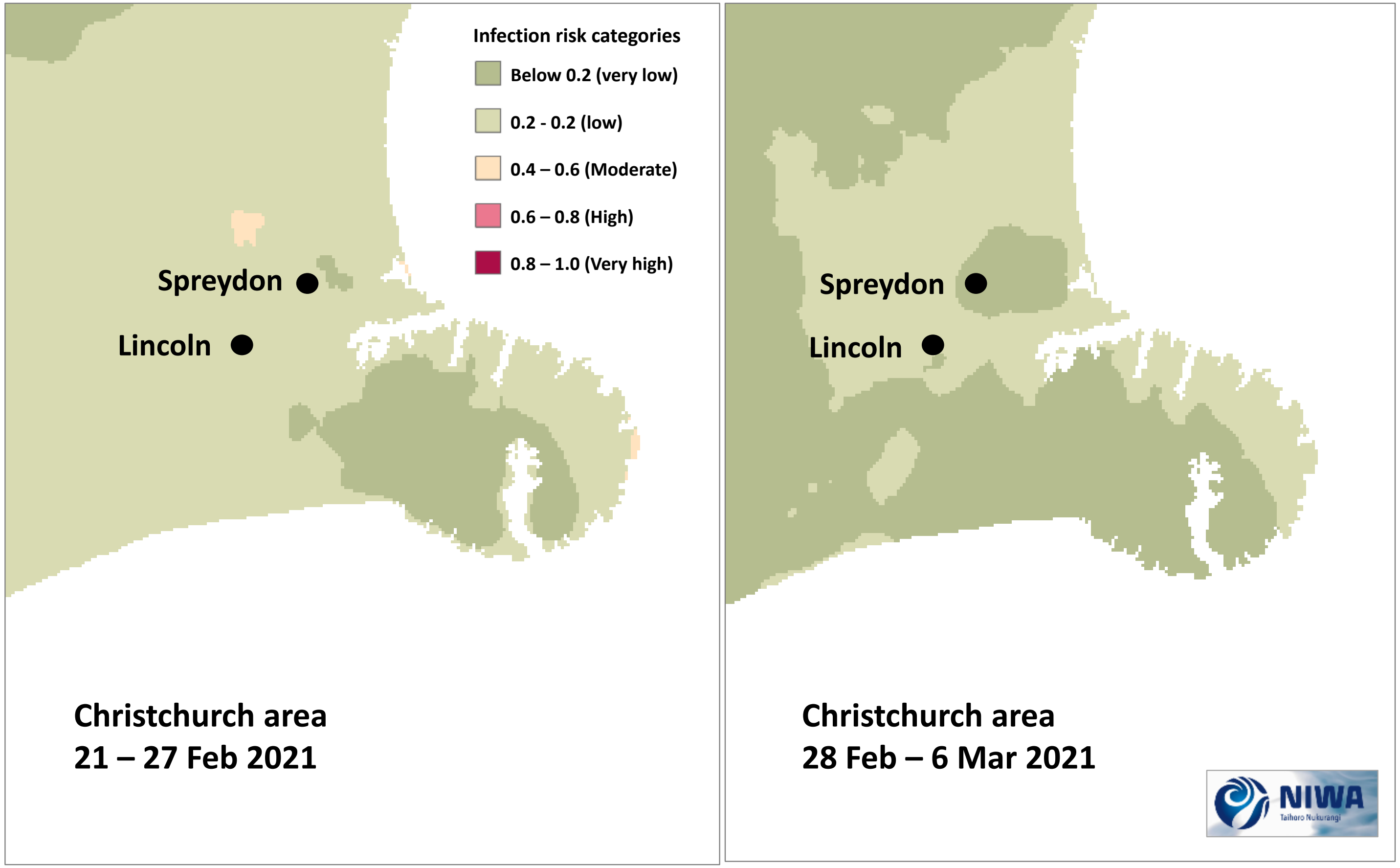

Figure 2 Myrtle rust infection risk, as weekly mean values, for the Christchurch area for two weeks in late February and early March 2021 showing Spreydon, where myrtle rust was observed on 21 April 2021 and Lincoln, where weather data for time series graphs (Fig. 1) was sourced. Maps were produced from the Myrtle Rust Process Model by NIWA using virtual weather data from the New Zealand Convective Scale Model at a 1.5 km spatial grid.

For risk mapping, the problem that averages over time lead to under-representation of risk may be mitigated by using maximum risk, as shown in Fig. 3 (Beresford et al. 2018), where long term average and maximum risk for Aotearoa over a three year period are compared.

Another approach would be to use the number or proportion of days with risk values above a threshold, (e.g. 0.5). However, we find this provides very similar relative patterns of risk to mean risk averaged over various time periods.

All weather risk assessments currently provide only relative differences and so, while most South Island areas certainly have lower risk than areas in the upper North Island, areas identified as very low risk do not necessarily have zero risk.

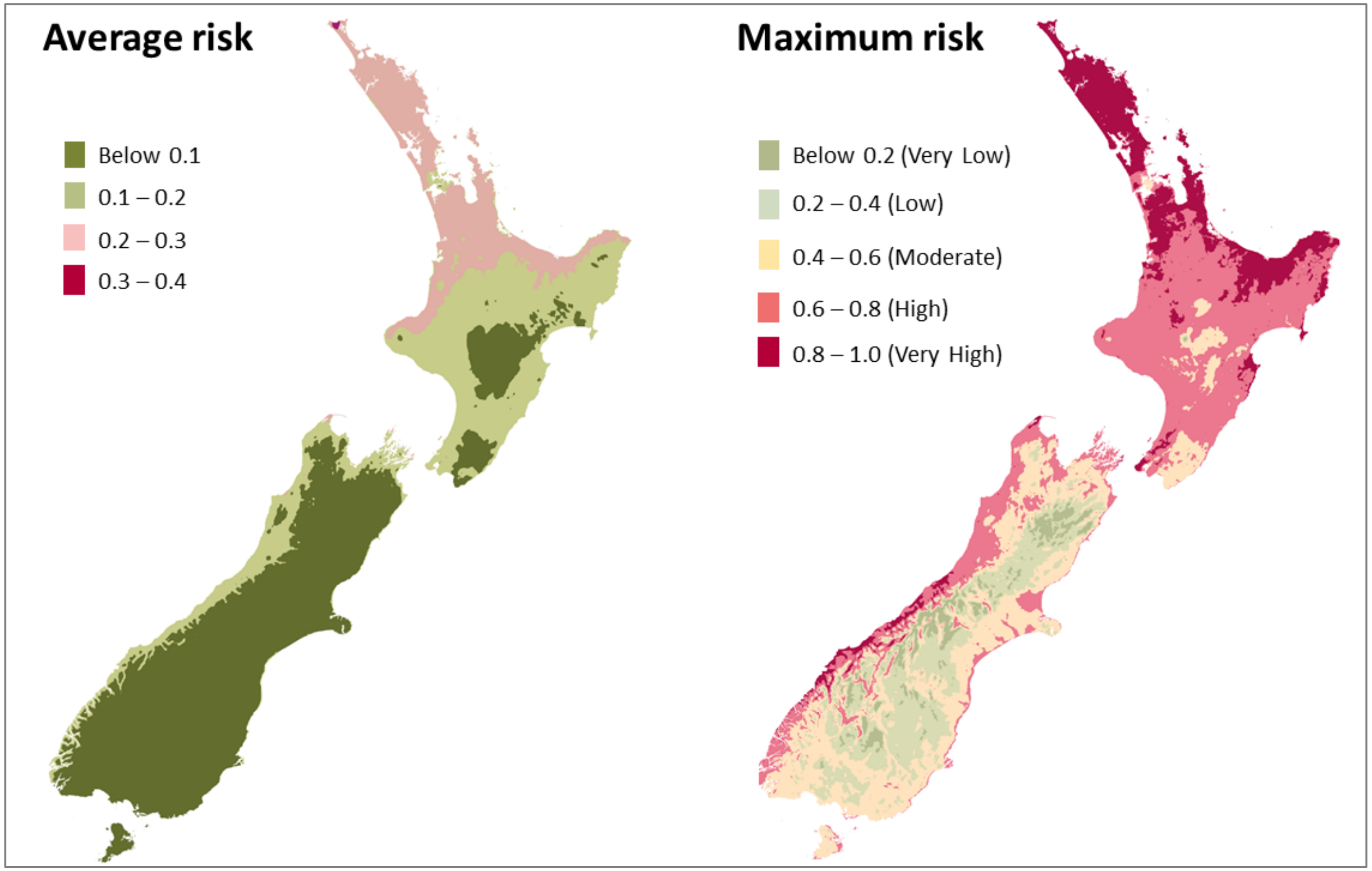

Figure 3. Long term myrtle rust risk in Aotearoa predicted by the Myrtle Rust Process Model between May 2015 and March 2018 (Figure 7 from Beresford et al. 2018).

2. New index to compare seasons and regions for myrtle rust risk

The accumulated overall risk (daily infection risk x 1/latent period) during 2020-21 was not particularly high in Lincoln compared with 2018-2019 and, particularly, 2017-2018 when risk was exceptionally high (Fig. 4). 2020-2021 and 2019-2020 had quite similar accumulated risk up to the end of April, although patterns were quite different earlier in the season.

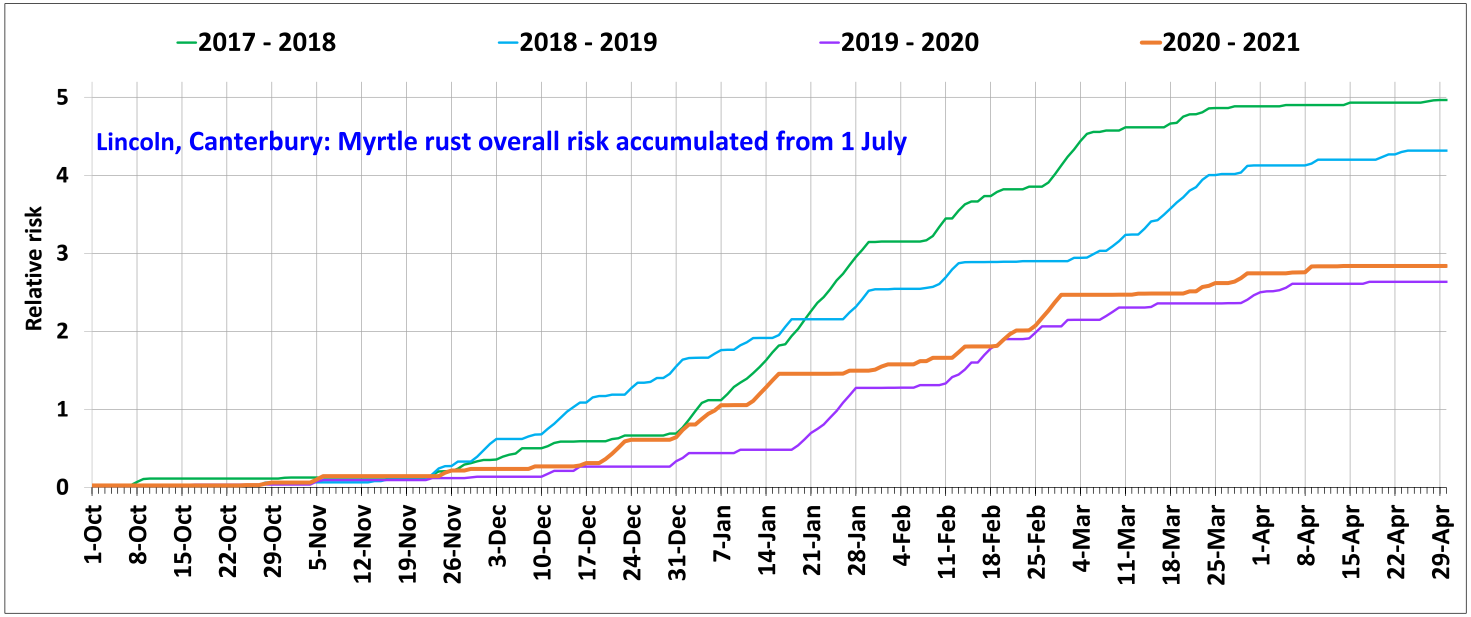

Figure 4. Accumulation of overall risk (product of daily infection risk and latent development rate) at Lincoln between October and April in four years. The relative risk accumulation starts on 1 July.

Comparing accumulated overall risk for Lincoln in 2020-21 with other regions, risk was much lower in Lincoln than in both Riwaka and Auckland (Fig. 5). Although Auckland showed substantial risk accumulation prior to 1 October, all three locations showed similar rates of accumulation during late December and early January. Riwaka showed a higher rate of risk accumulation than Auckland in late February and early March.

The longer ‘season’ of myrtle rust risk in Auckland than further south was largely due to the substantial risk accumulation prior to 1 October and the continued accumulation of risk after early April when Lincoln and Riwaka risk accumulation had levelled off.

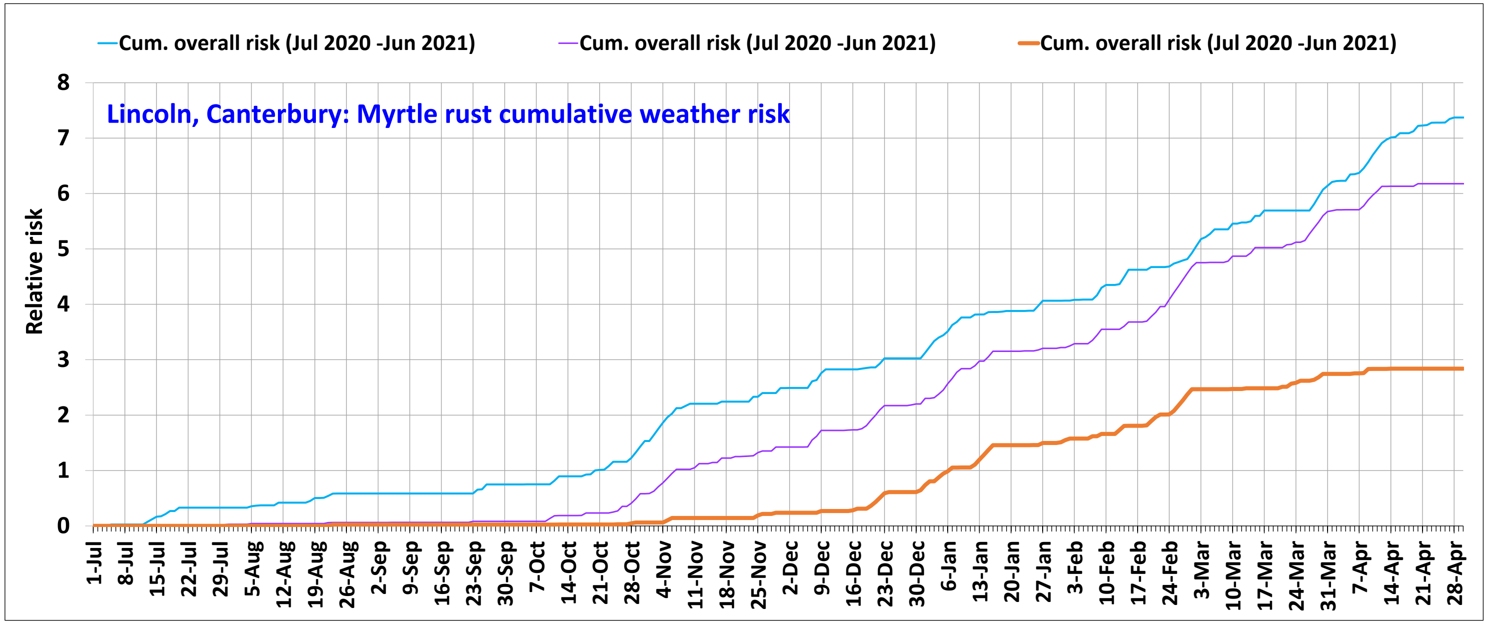

Figure 5. Accumulation of overall risk (product of daily infection risk and latent development rate) in the upper North Island (Auckland), upper South Island (Riwaka) and middle South Island, east coast (Lincoln). The relative risk accumulation starts on 1 July.

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3 Discussion about climatic risk and potential geographic range of *Austropuccinia psidii*

To predict the ultimate geographic range of myrtle rust in Aotearoa we need to be able to predict actual disease risk, rather than just relative weather-related risk. Although the MRPM is a powerful tool for predicting weather risk, prediction of actual disease will require data on geographic distribution of inoculum (spores). Rust disease progression depends on the amount of primary inoculum that initiates an epidemic and this could be estimated from rust severity monitored locally at an appropriate time.

A model to predict site-specific disease progress could be built using local rust severity as the inoculum input and climatic risk to drive the seasonal epidemic. Data on local rust severity would need to be obtained in a structured way using protocols for rust monitoring. Calibration of the inoculum dependence of such a model could be done through analysis of rust disease progress in relation to accumulated overall risk at various sites.

Conclusions

Days with substantial infection risk occurred in Christchurch during summer and autumn 2020-21 and temperatures were suitable for latent development and spore production. Days with high risk in December and January probably contributed to cycles of multiplication and high risk days in late February and early March probably resulted directly in the myrtle rust discovery of rust in Spreydon in late April.

The under-representation of daily risk by both weekly risk maps and 7-day running mean time series graphs highlight a general issue for summarising myrtle rust risk, which is that averages over time do not represent the daily infection events that contribute importantly to myrtle rust development. Mapping of maximum or cumulative risk may give a more meaningful representation of the geographic distribution of risk than mapping averages over a week or longer time periods.

Climate warming will increase the intensity of myrtle rust epidemics and extend its geographic range further south and to areas of higher altitude.

Acknowledgements

This myrtle rust weather risk update is provided through Beyond Myrtle Rust. Weather data for the risk graphs were obtained from HortPlus Ltd MetWatch Online and the New Zealand MetService. The myrtle rust weekly risk maps are made available by Richard Turner and Stuart Moore of NIWA.

Appendix 1: Description of the Myrtle Rust Process Model[2] risk indices

1. ***Infection risk***: Effect of daily mean air temperature, number of hours of high relative humidity and solar radiation on the likelihood of infection by any live spores that may be deposited on susceptible host tissue. Relative risk values between 0 and 1.
2. ***Latent period***: The effect of temperature on the time between infection by urediniospores and the eruption of new uredinial pustules. The shorter the latent period, the greater the risk. The minimum latent period is around 12 days at mean temperatures between 15 and 23°C.
3. ***Sporulation risk***: The effect of temperature on amount of spore production from erupted uredinia, indicating the likelihood that spores from existing infections are available to spread to new infection sites. Relative risk between 0 and 1.

Latent period and sporulation risk are driven only by temperature. Sporulation risk is greater (higher value) at higher temperature, whereas latent period risk is greater (lower value) when the latent period is shorter, which also occurs at higher temperature. Infection risk is driven by relative humidity, temperature and solar radiation, so the pattern of risk varies from day to day according to moisture conditions affected by rainfall and night time dew.

Interpreting the risk indices

Understanding of how the values of the three risk indices relate to myrtle rust occurrence is being developed as more research is done. The relative risk index values of the model are categorised as follows:

Infection and sporulation risk

Index value	*Risk description*
0.0-0.2	Very low
0.2-0.4	Low
0.4-0.6	Moderate
0.6-0.8	High
0.8-1.0	Very high

Latent period

Value (days)	*Risk description*
Above 50	Very low
30-50	Low
15-30	Moderate
10-15	High
Below 10	Very high

Overall risk index: Product of daily infection risk and daily latent development rate (1/latent period), which gives a relative measure for suitability of weather for infection and multiplication of myrtle rust. When accumulated over a year from 1 July to 30 June, overall risk provides a useful comparison of climatic suitability between regions and seasons.

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[2] Beresford RM, Turner R, Tait A, Paul V, Macara G, Yu ZD, Lima L, Martin R 2018. Predicting the climatic risk of myrtle rust during its first year in New Zealand. New Zealand Plant Protection 71: 332-347.
Note: The MRPM latent period and sporulation risk models have recently been updated from recently published data: Beresford RM, Shuey, LS, Pegg GS 2020. Symptom development and latent period of *Austropuccinia psidii* (myrtle rust) in relation to host species, temperature and ontogenic resistance. Plant Pathology 69: 484–494. doi:10.1111/ppa.13145.