Red needle cast (RNC) epidemiology

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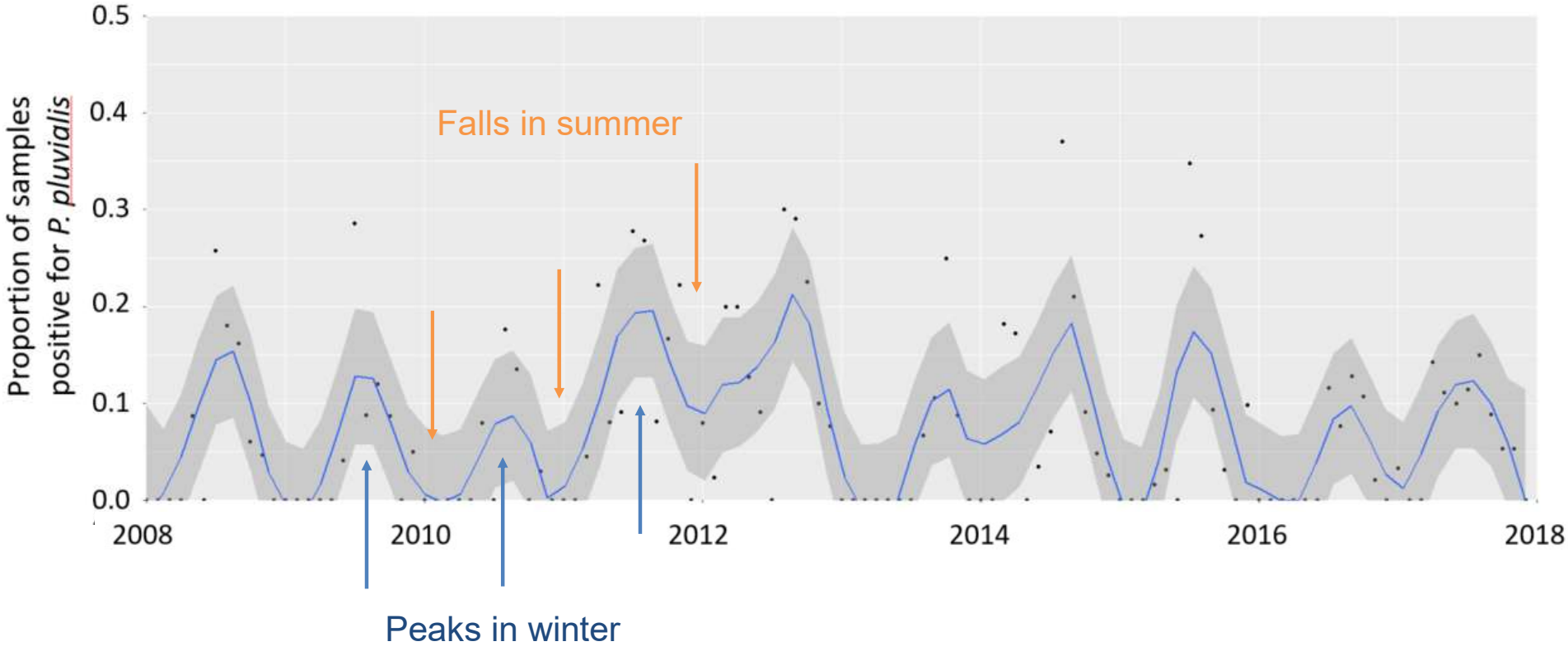
Why study RNC epidemiology?

- RNC can spread asymptomatically under certain conditions.
- RNC has high inter and intra season variability.
- RNC can progress quickly.
- Often by the time symptoms are visible application of control is ineffective, **Reactive sprays are too late**
- In order to provide decision tools on RNC risk and control we need to **understand the RNC disease cycle.**

Red needle cast is seasonal



Fraser et al 2020 *Forest Pathology*

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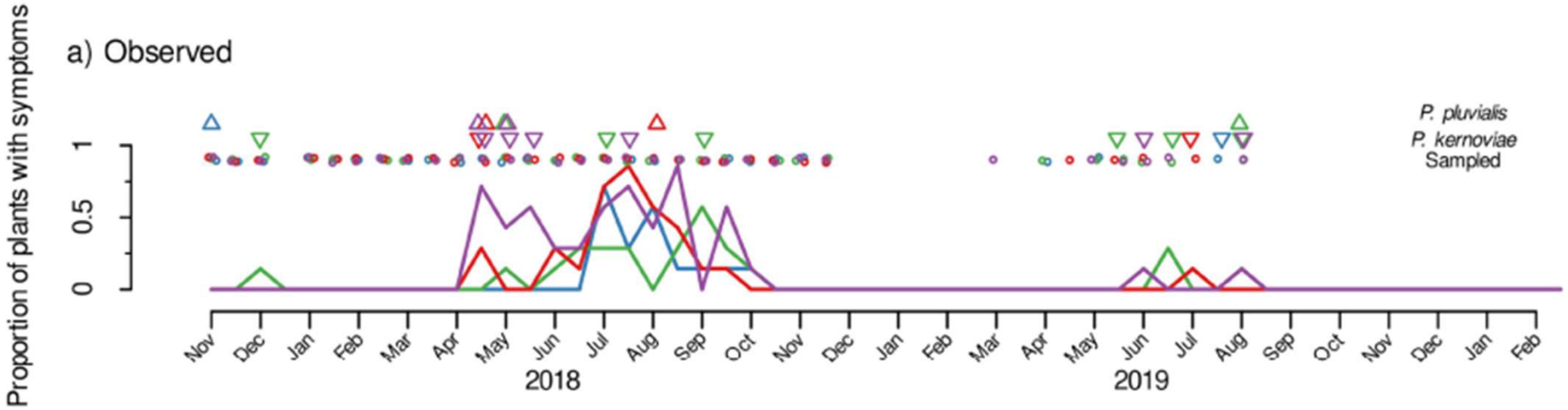
Infection linked to temperature and moisture



Infection more common when:

- Low air and soil temperatures, solar radiation and evapotranspiration
- High relative humidity and rainfall

Hood et al 2022 *New Zealand Journal of Forestry Science*

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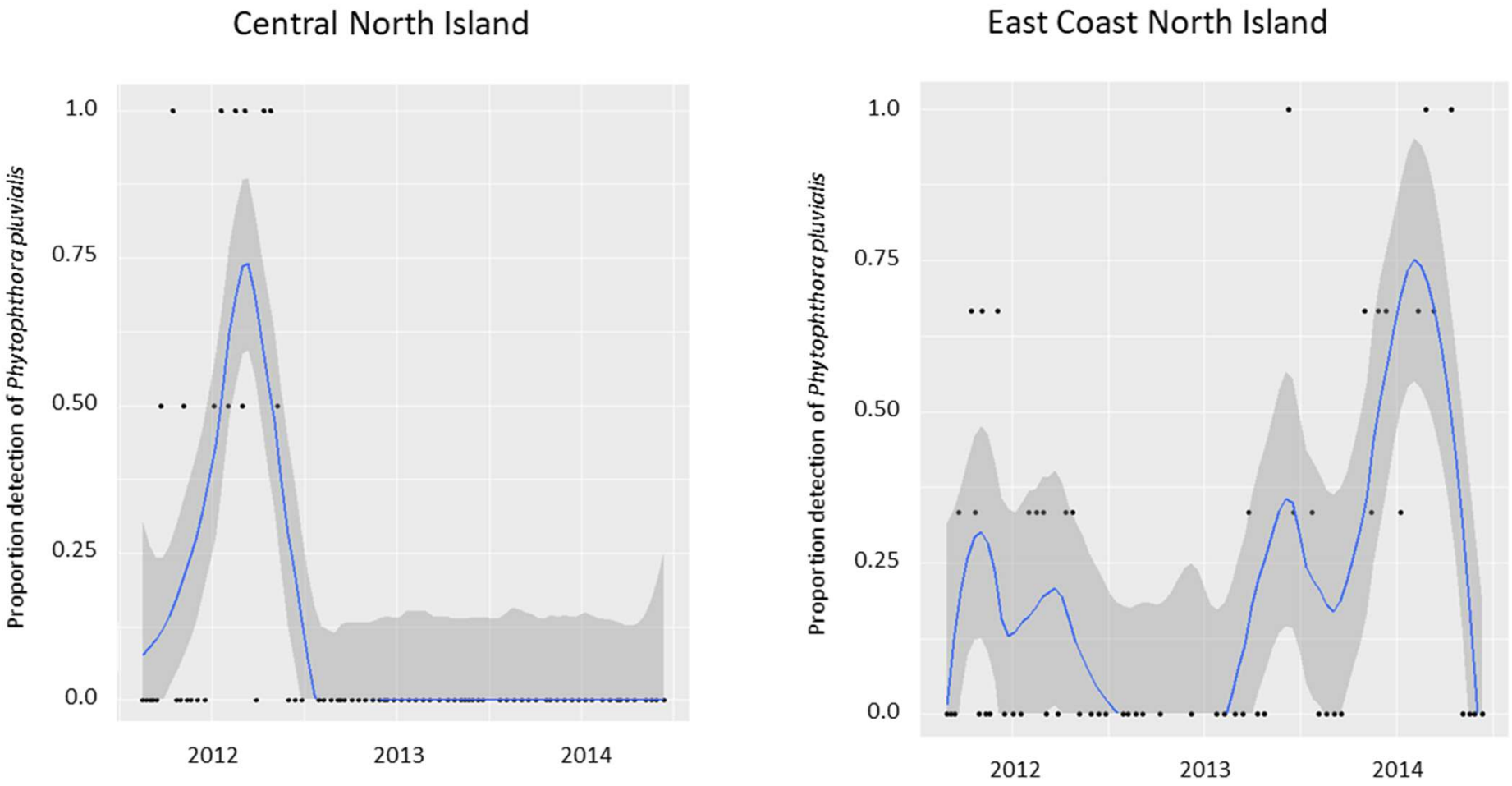
Seasonal pattern not consistent between years

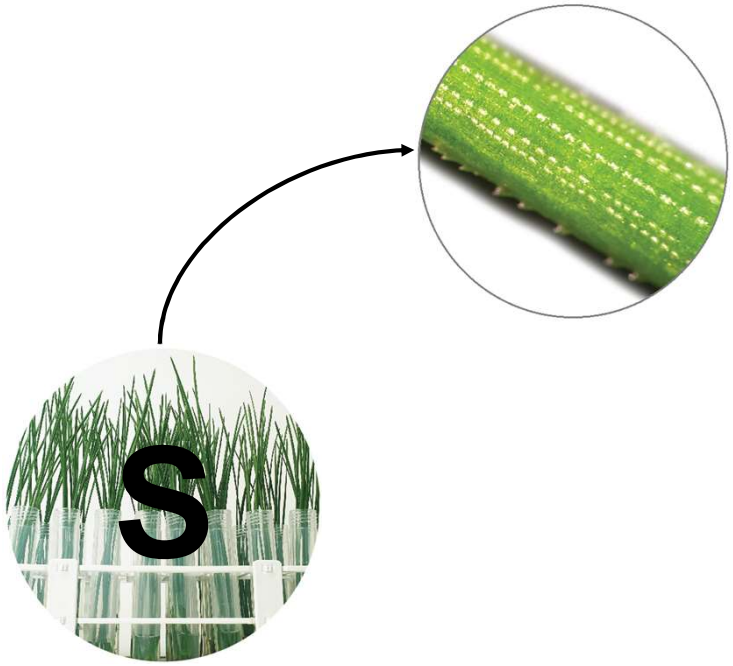


Fraser et al 2020 *Forest Pathology*

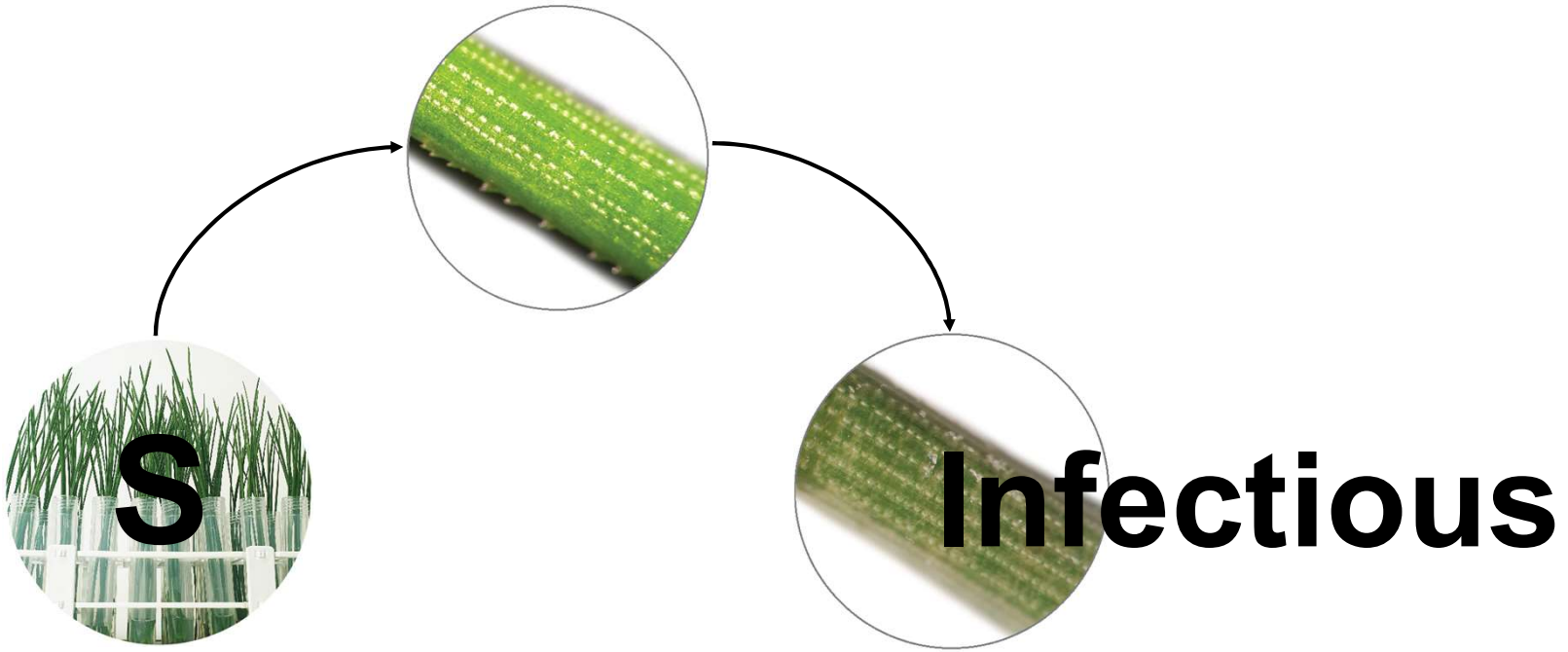
Defining the disease cycle

Susceptible

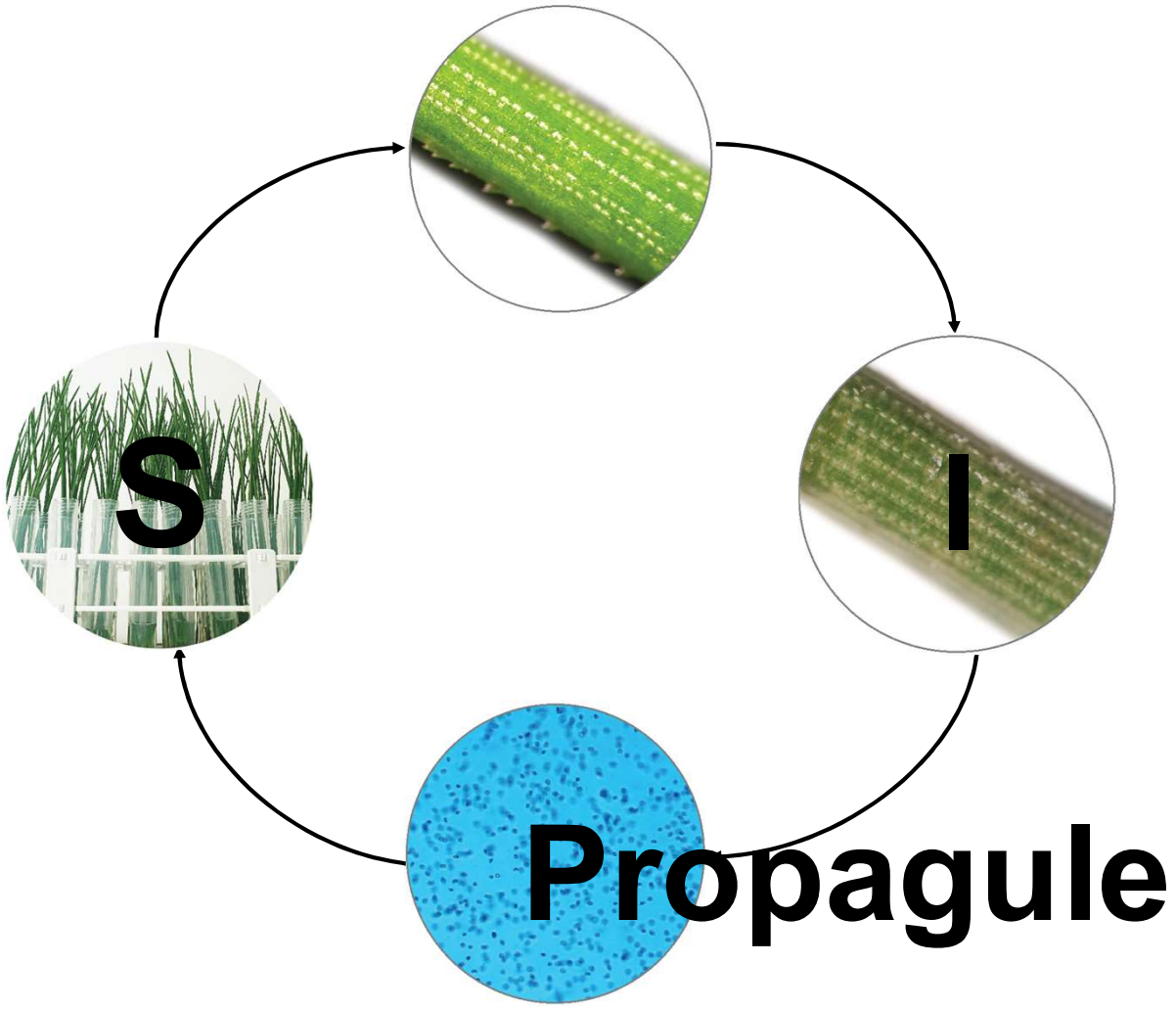
Defining the disease cycle



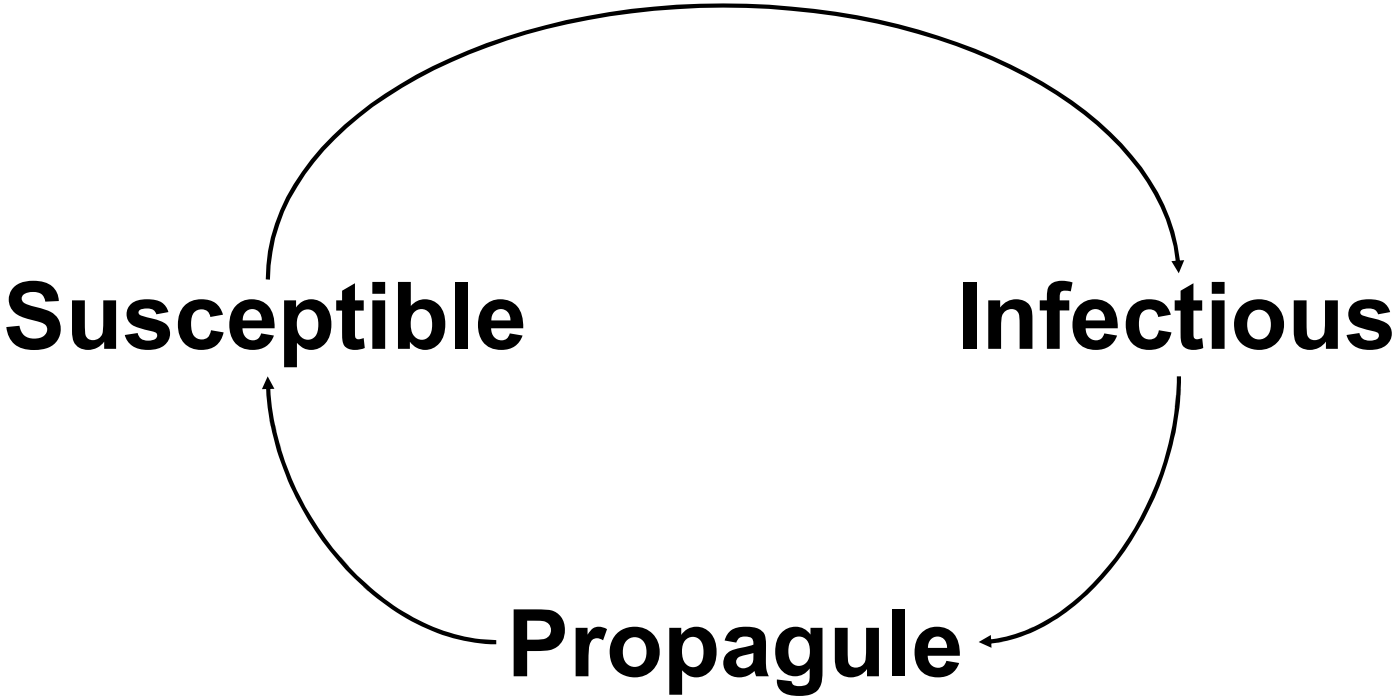
Defining the disease cycle



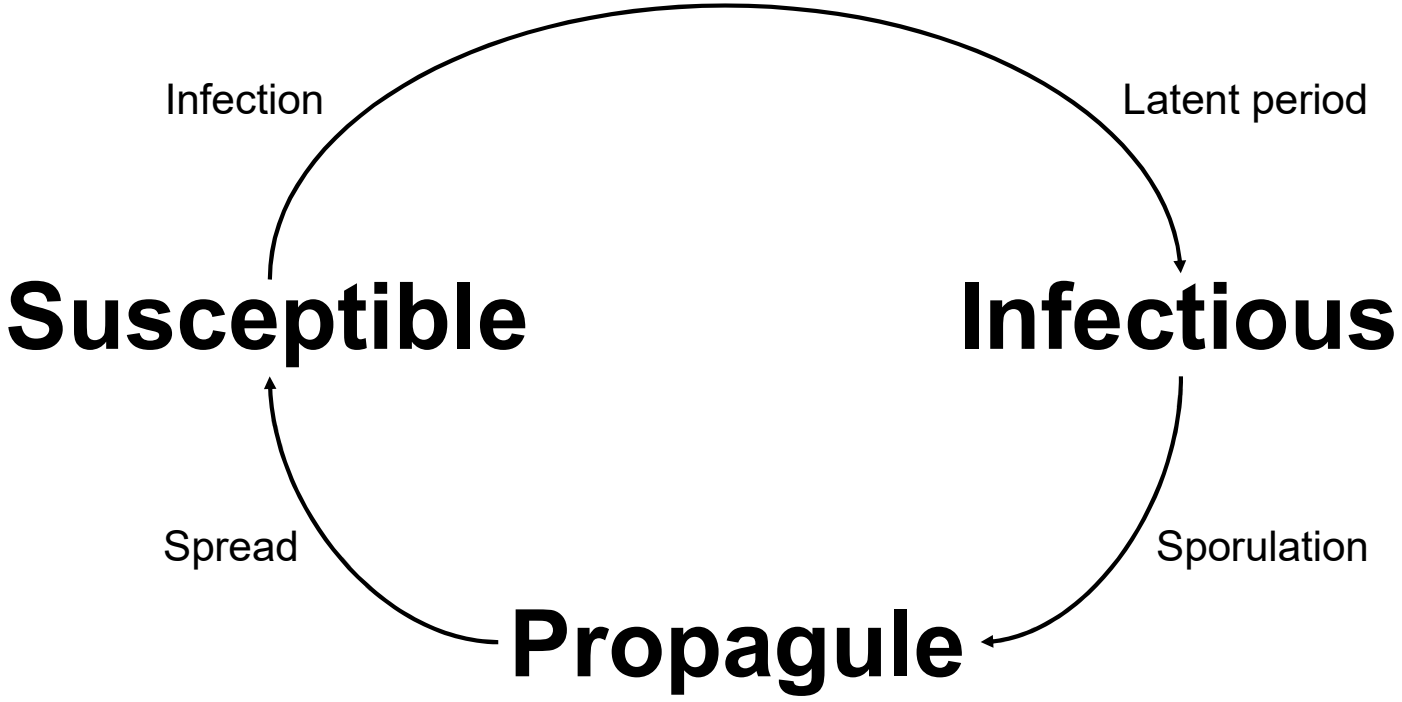
Defining the disease cycle



Defining the disease cycle



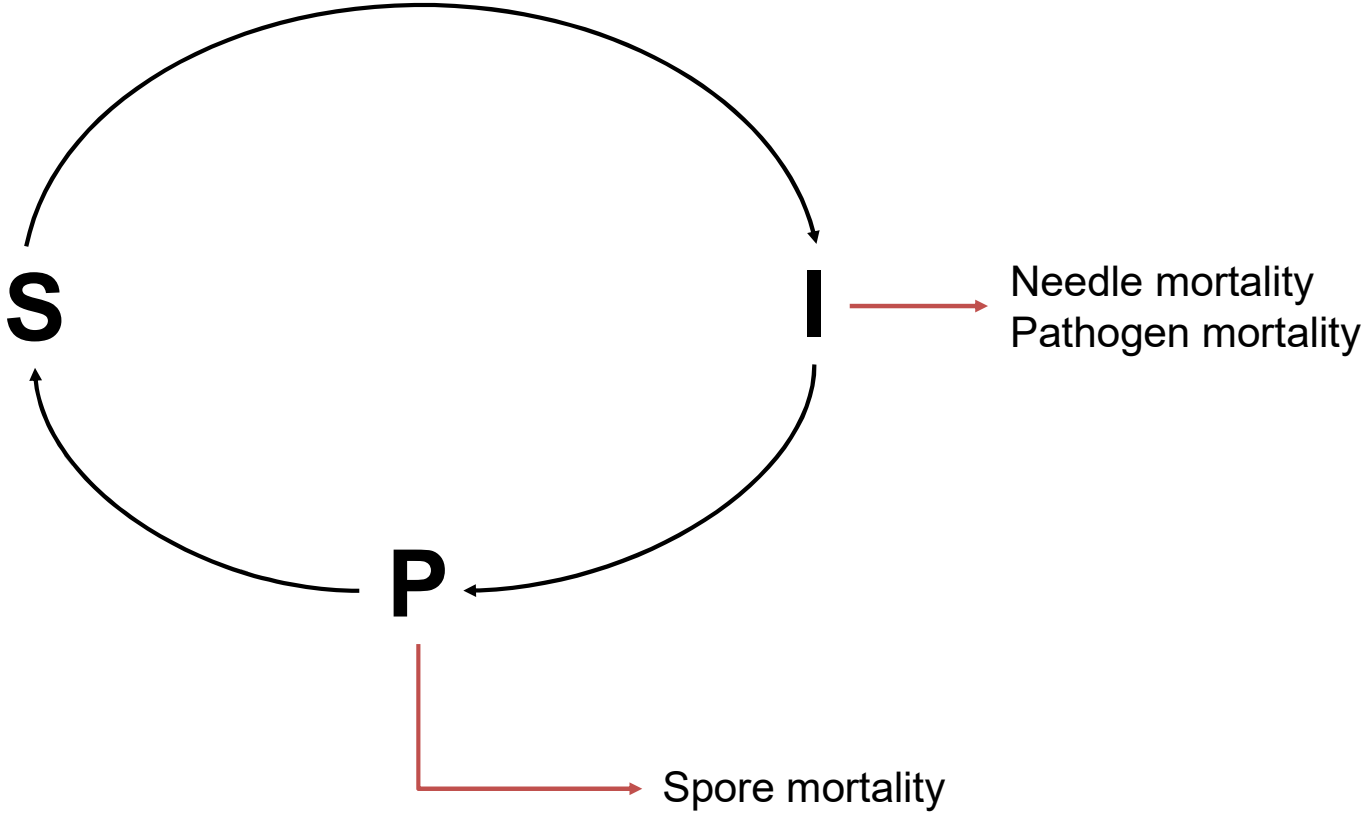
Defining the disease cycle



Turning the cycle into a process-based model

- Localised spread in needle tissue under optimal conditions.
- Comparison between resistant and susceptible genotypes.

Basic epidemiological framework



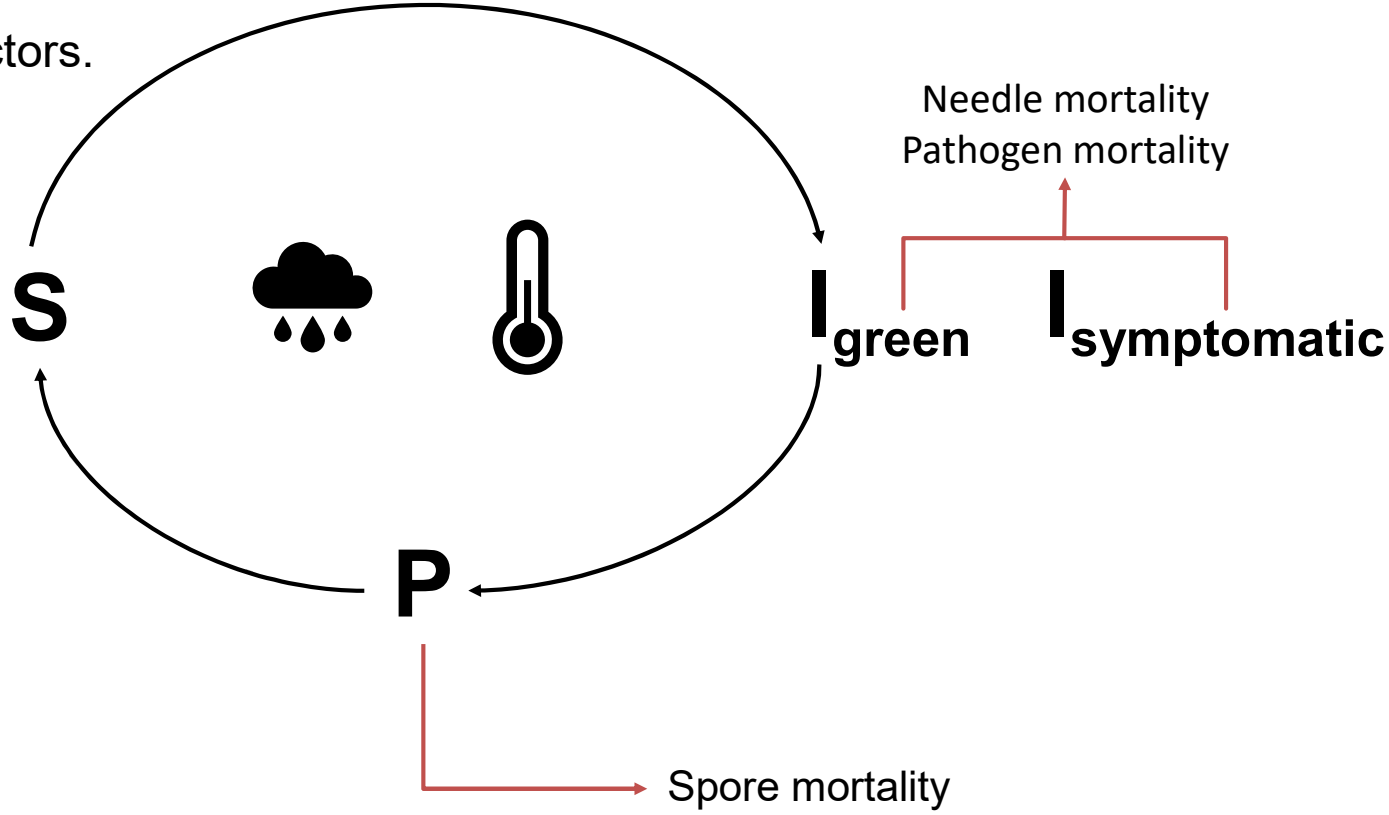
Gomez-Gallego et al. 2019 PLOS ONE

Current work:

Parametrise model with climatic factors.

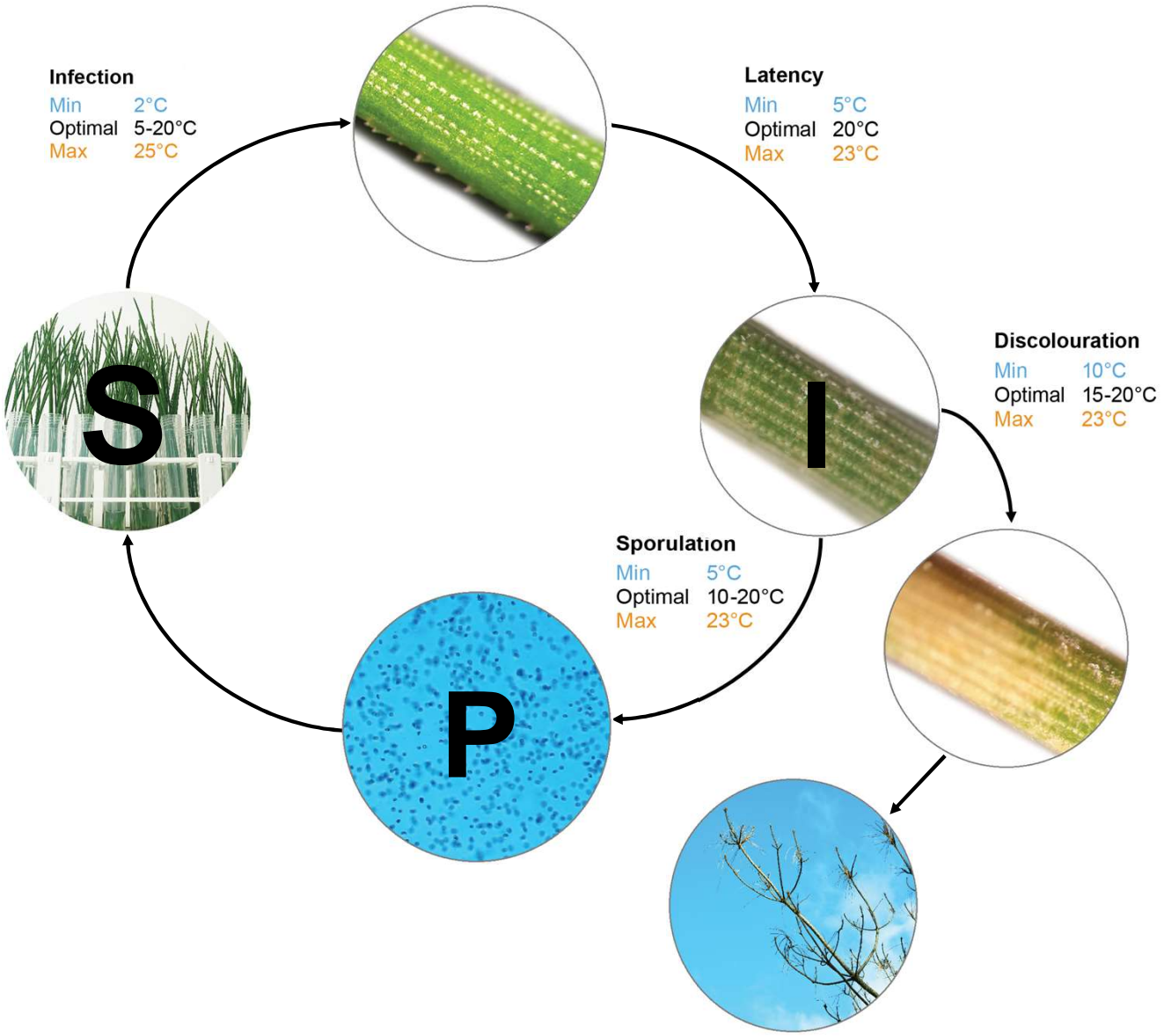
Goal: Predict when an outbreak of RNC might begin, peak and end based on forecasted weather.

➔ Inform management decisions now and with climate change.



Impact of temperature

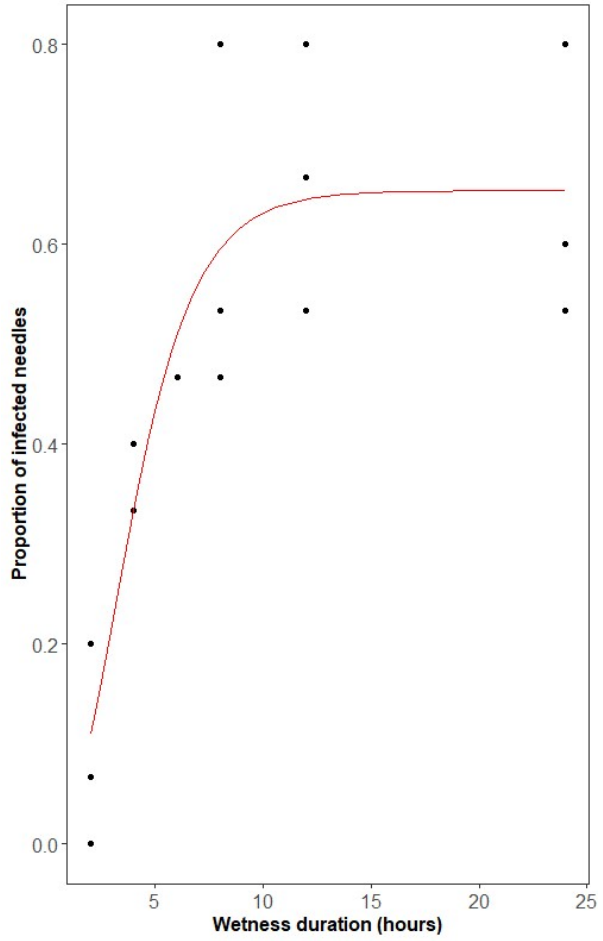
- Optimal range: 10 to 20^{o}C.
- Low temperatures (<5^{o}C) slow disease.
- Temperatures at 23^{o}C and higher limit sporulation.
- Infections are asymptomatic for at least 14 days at 10^{o}C or lower.



Impact of wetness

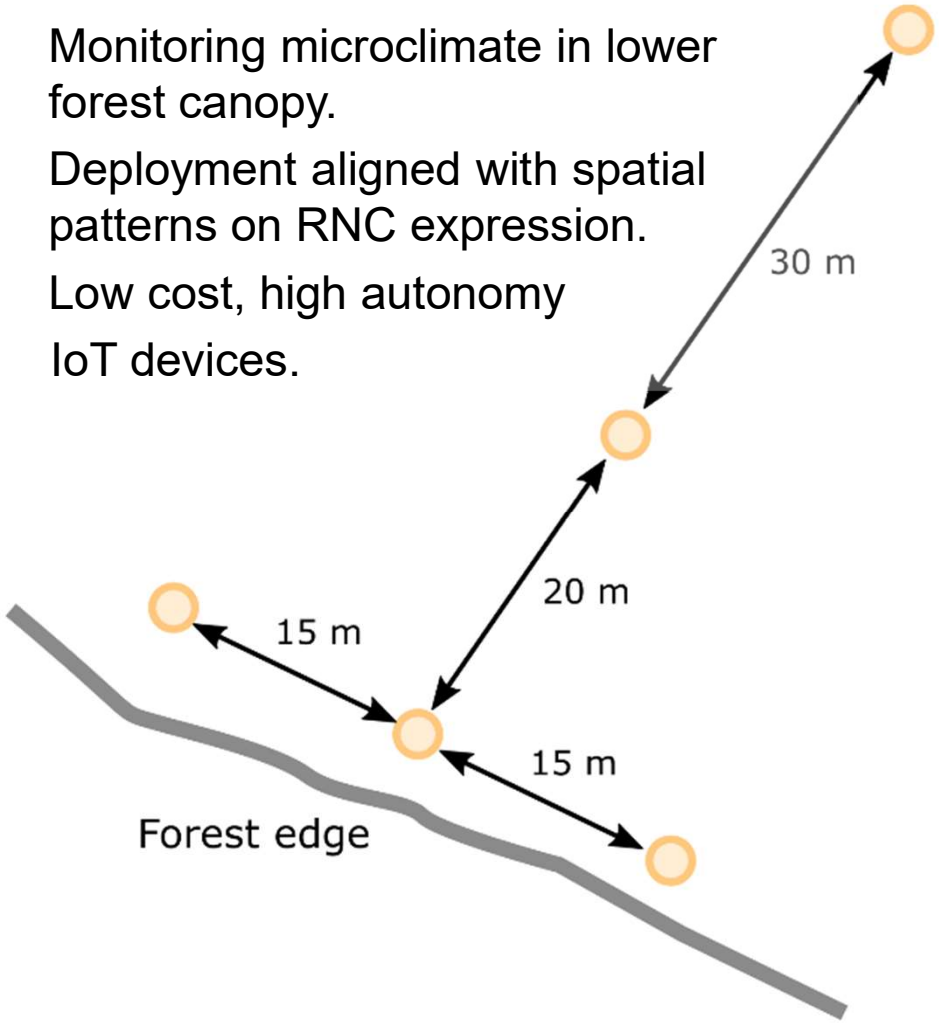
- Wetness is required for infection and sporulation.
- Infected needles may display symptoms regardless of wetness.
- Sporangia often burst upon desiccation.

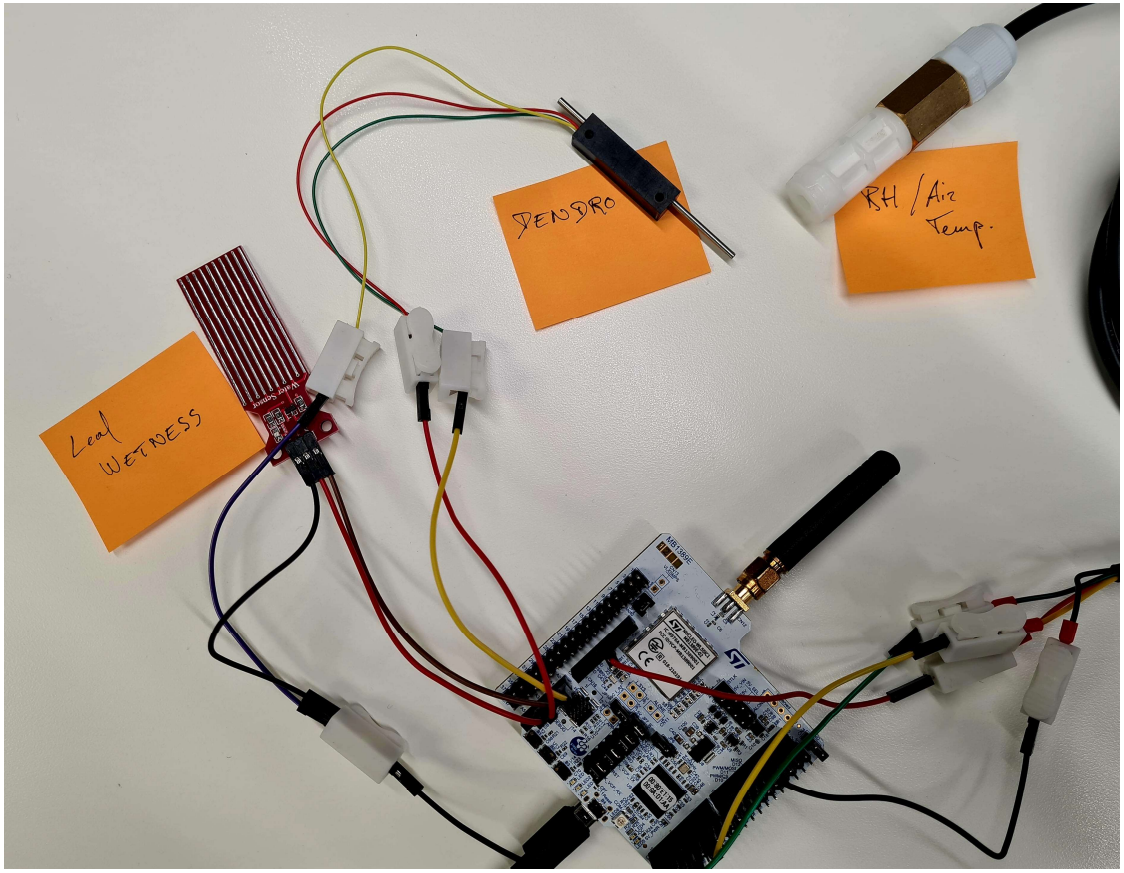
Needle wetness is a requirement for disease spread



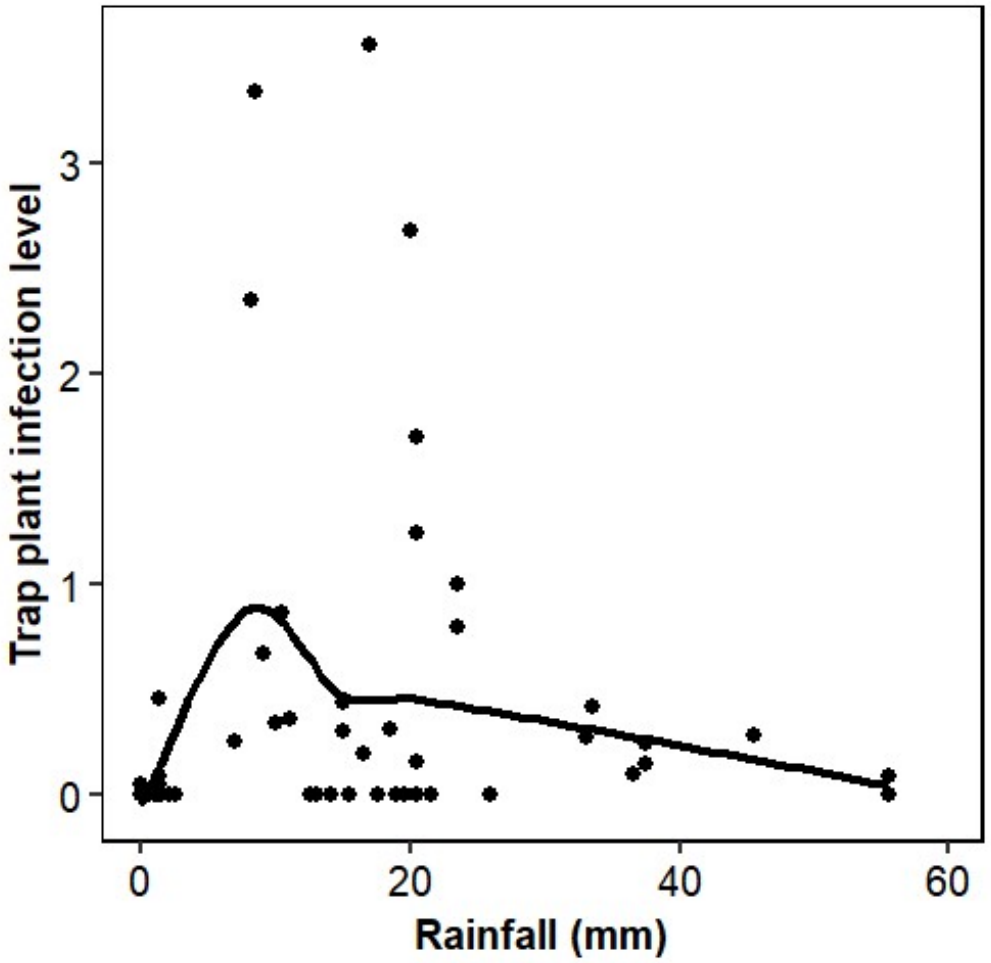
Calibration of model: Tree level sensor network

- Monitoring microclimate in lower forest canopy.
- Deployment aligned with spatial patterns on RNC expression.
- Low cost, high autonomy IoT devices.

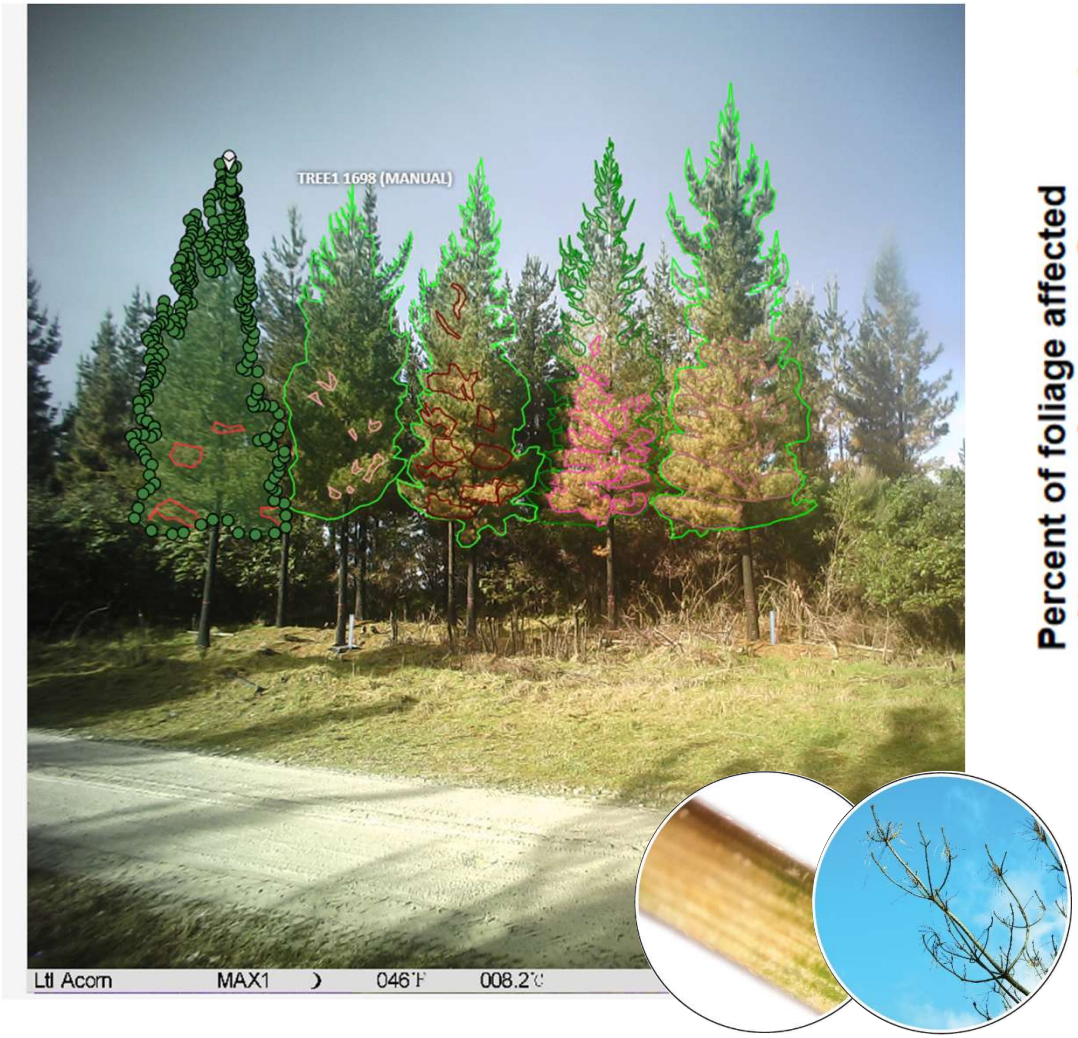


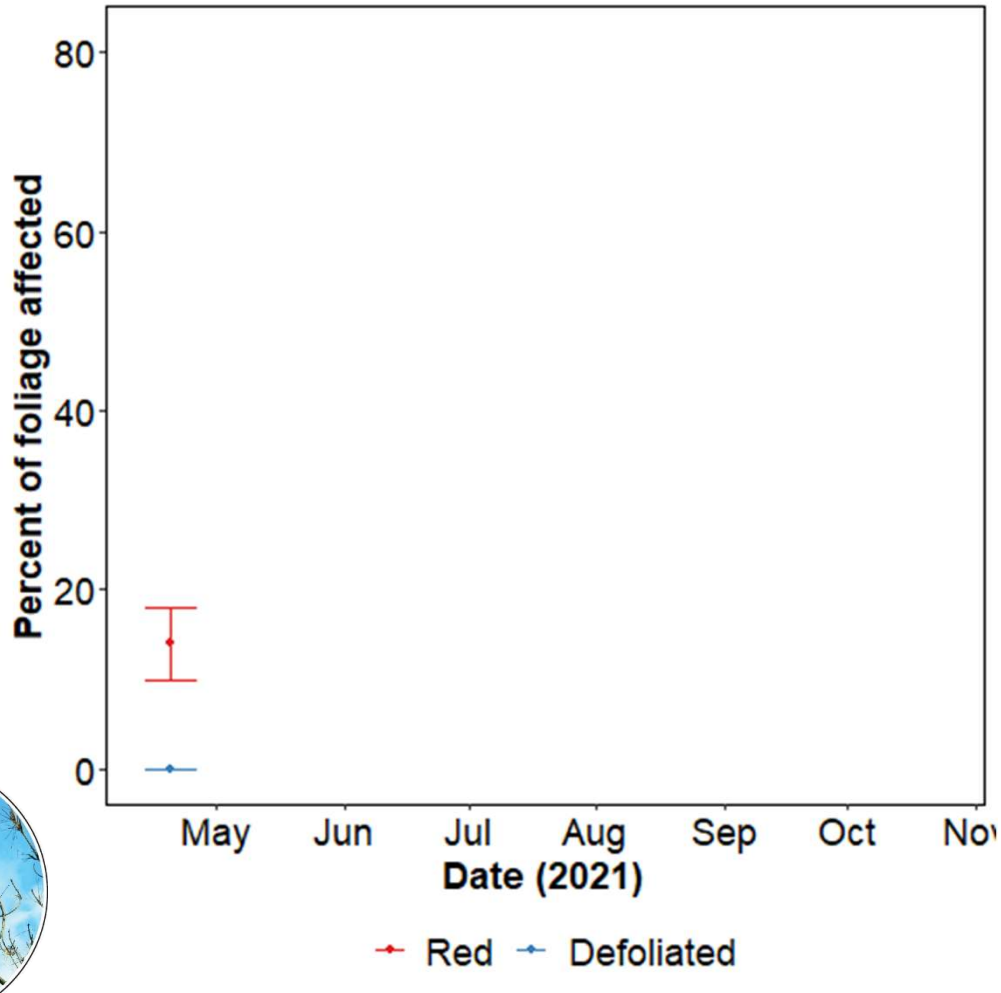


Calibration of model: Infection



Calibration of model: Symptoms





Conclusions and next steps

Conclusions

- RNC is strongly driven by climate:
  high temperatures and low wetness limit disease.
- Quantified climatic drivers of processes within the RNC cycle.
- Sufficient data has been collection to build an infection risk model with climatic inputs.

Next steps

- Build prototype infection risk model.
- Refine and validate model.
- Integrate into decision tool.
- Collect data on spread/survival for model improvement.

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