Simulation of insect vector population growth over space and time

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Roadmap

- Overview
- Methodology
  - simulation of insect vector populations within AADIS
  - simulation of insect vector populations external to AADIS
- Results
- Conclusions

Overview

- Infectious disease models: ‘flight simulators’ to be used as decision support tools by those responsible for disease control
- Provide a means by which large amounts of information can be combined in a structured (and logical) way
- Useful for estimating the likely effect of different control measures (e.g. stamping out versus vaccination)
- A tool to assist decision making, not replace it

Overview

- The Australian Animal Disease Simulation (AADIS) model
  - developed to support FMD preparedness and response
  - a ‘hybrid’ model: within-herd (equation-based) and between-herd (agent-based) components
  - provides the facility to incorporate jurisdictional variations in control measures and resourcing
  - interest within the Department of Agriculture and Water Resources to extend AADIS capabilities to other diseases

Overview

- Project aim: to extend AADIS to model the infection dynamics of bluetongue virus

- To do this we focus on two tasks:

  – simulation of the spatial and temporal distribution of the insect vector for bluetongue, *C. brevitarsis*

  – simulation of the transmission of BTV virus between host and insect vector populations

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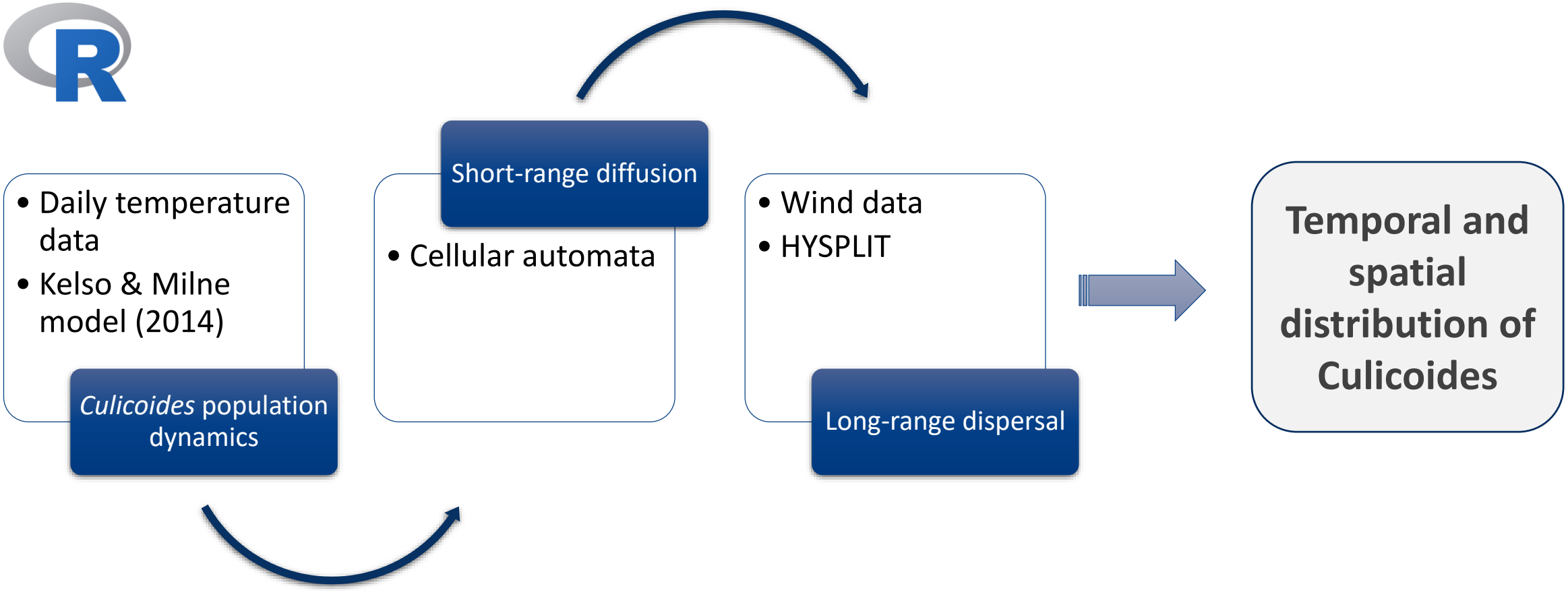
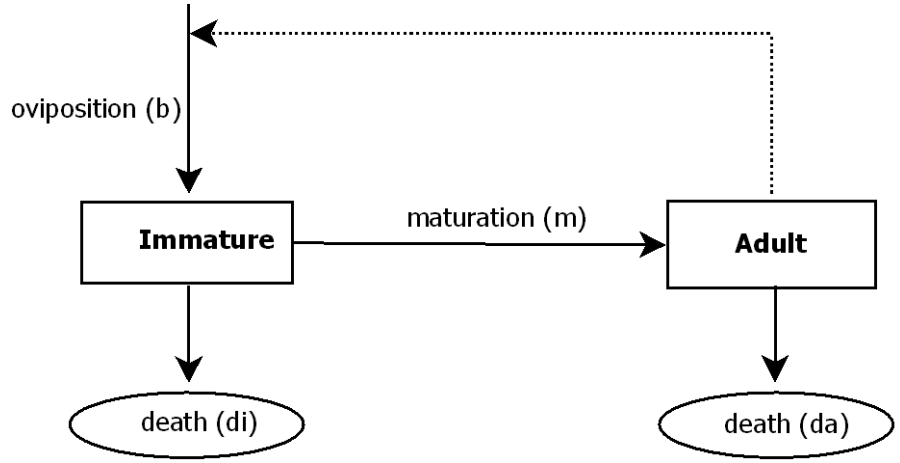
Methodology



Methodology

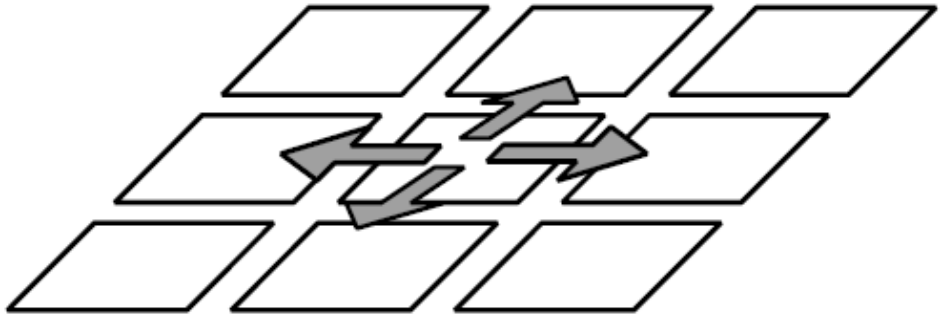
- Culicoides population dynamics
  - prepare the mean daily temperature raster maps (Australian Bureau of Meteorology)
  - Culicoides spp. population growth model described by Kelso and Milne (2014)
  - counts of immature and adult stages of Culicoides spp. computed for each grid cell



Vector population dynamics sub-model compartments. State transitions of individuals are indicated by solid lines with the associated rate parameter symbol given in italic type (Kelso and Milne, 2014)

Methodology

- Short-distance spread
  - given appropriate wind conditions there will be a ‘random walk’ of midges to neighbouring cells

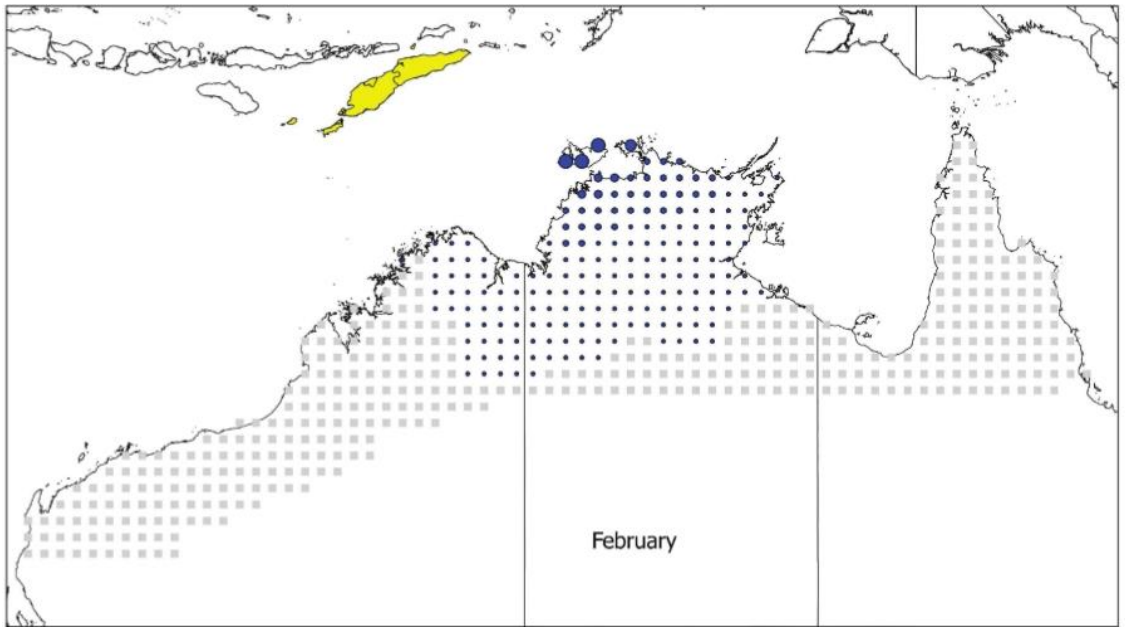


Methodology

- Long-distance spread
  - long distance dispersal ‘lofting’ of *C. brevitarsis* can occur over several hundred kilometres when winds are no stronger than 8 km.h^{-1} (stay on the ground and attached to plants if the wind is stronger)
  - lofting occurs when average daily temperature is ≥ 18 °C
  - lofting modelled using HYSPLIT (Hybrid Single Particle Lagrangian Integrated Trajectory model, Draxler and Hess 1998)

Methodology

- HYSPLIT
  - a model used to estimate the direction and distance of agents dispersed by the wind
  - numerous uses in emergency response (e.g. radiological, volcanic ash), air quality (e.g. smoke, dust, dioxins) and diseases spread (foot and mouth disease)
  - used to estimate Culicoides dispersal by Eagles et al. (2012); mentioned by Kelso and Milne (2014) but not actually used



Simulated *Culicoides* dispersal in February from Timor as modeled by HYSPLIT. Blue cells scaled by number of arrivals relative to source population; grey cells = 0 arrivals. Eagles et al. (2012)

Mount Sinabung: Airlines issue 'red notice' as Indonesian volcano erupts on island of Sumatra

Updated yesterday at 11:02pm

VIDEO: Indonesia volcano erupts, spewing a 5,000-metre ash cloud (ABC News)

Mount Sinabung on the Indonesian island of Sumatra has shot billowing columns of ash more than five kilometres into the atmosphere and hot clouds down its slopes.

The National Disaster Mitigation Agency said there were no fatalities or injuries from the eruption on Monday (local time).

The regional volcanic ash advisory centre in Darwin issued a "red notice" to airlines.

The volcano, one of three currently erupting in Indonesia, was dormant for four centuries before exploding in 2010, killing two people.

Another eruption, in 2014, killed 16 people, while seven died in a 2016 eruption.

Disaster agency spokesman Sutopo Purwo Nugroho said hot ash clouds travelled as far as 4.9

RELATED STORY: Search for survivors after deadly Mount Sinabung volcanic eruption

RELATED STORY: More than 1,200 evacuated as Indonesian volcano erupts

MAP: Indonesia

Culicoides density

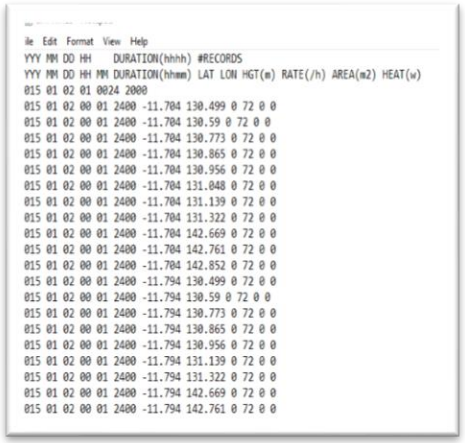
Identify cells eligible for wind-borne dispersal

Feed data to HYSPLIT

Update each cell using the population growth model short-distance spread

Eligible grid cells

- temperature ≥ 18°C
- cattle present
- wind ≤ 8 km.hr^{-1}



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EMITIMES file

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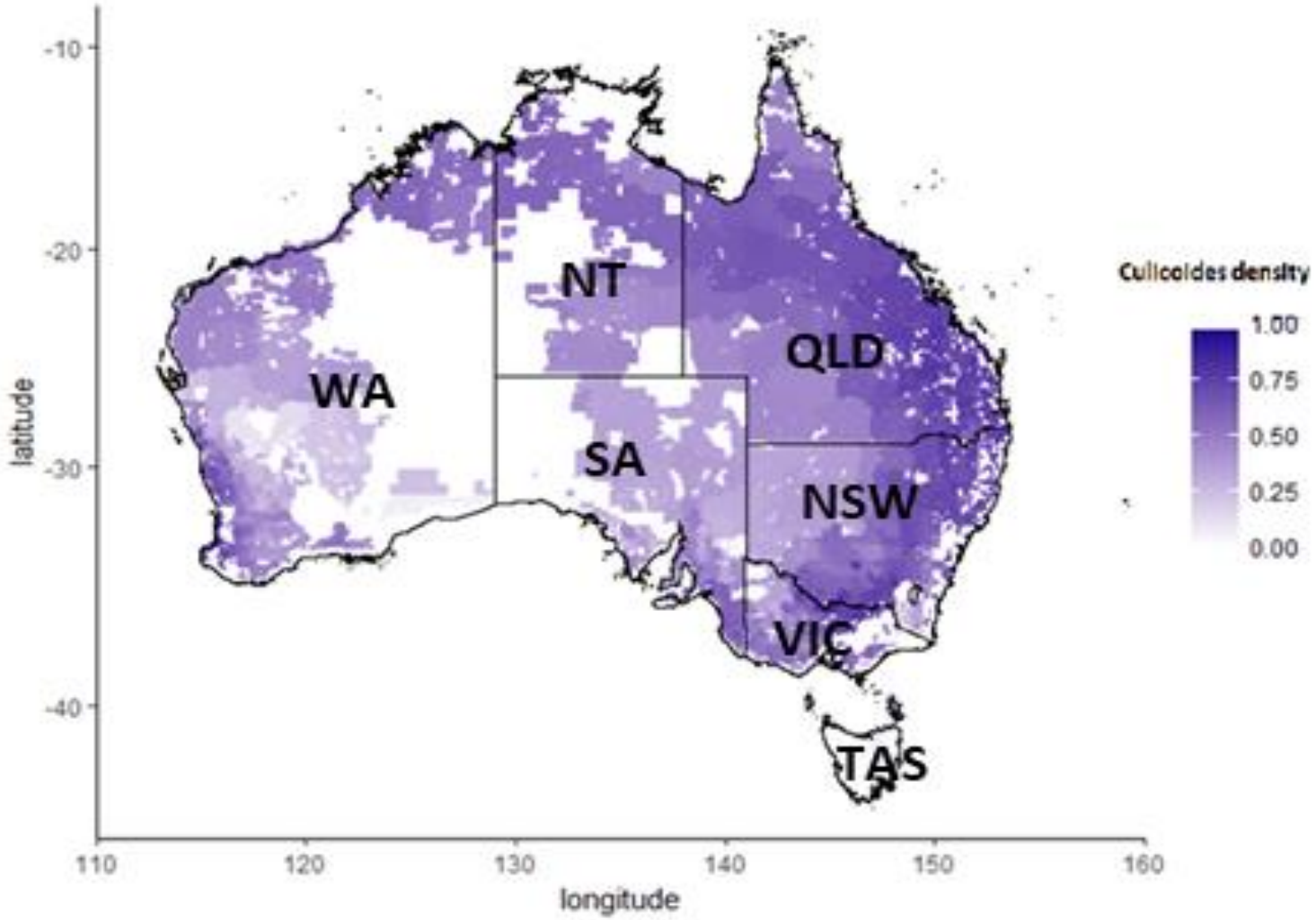
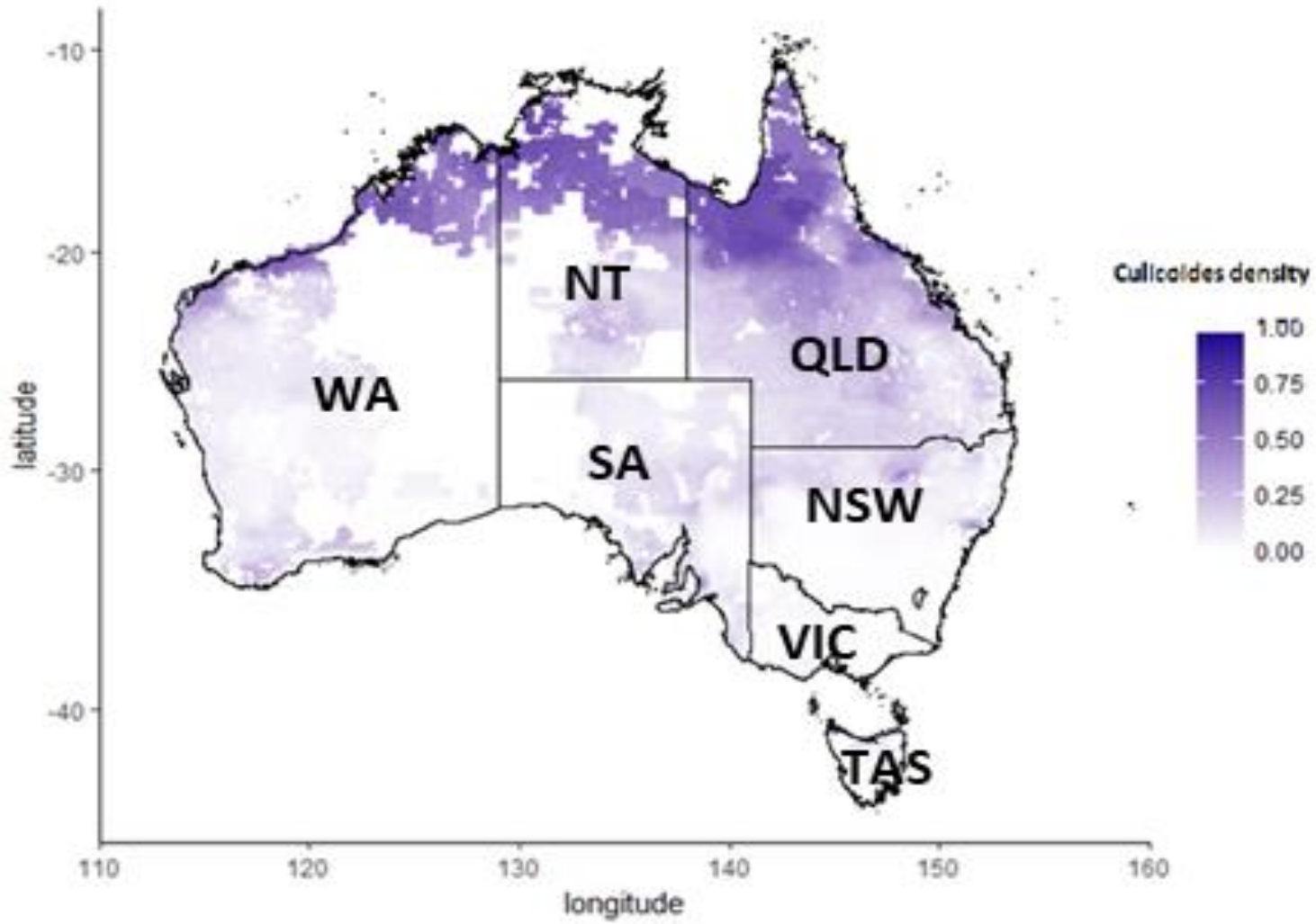
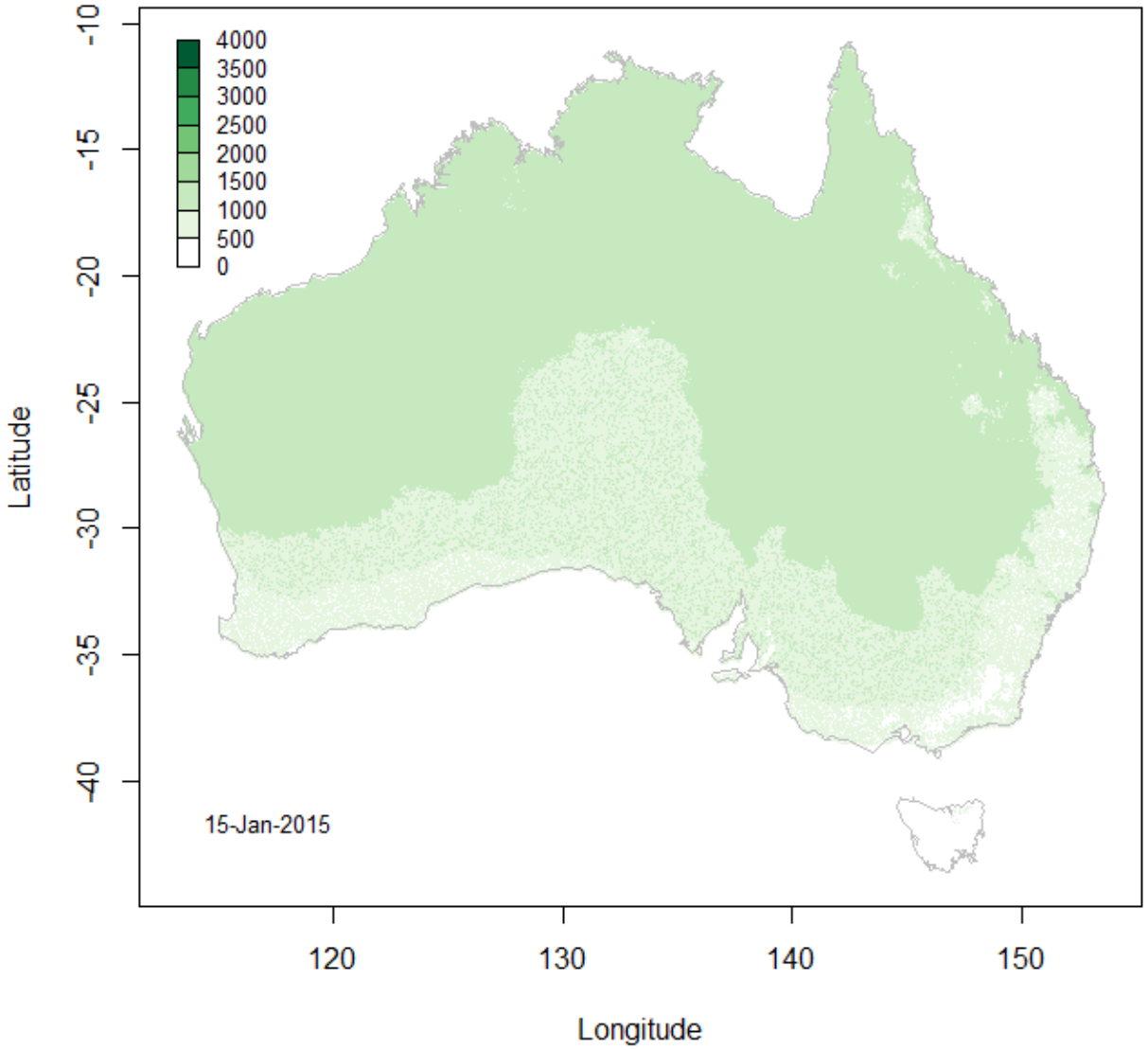
Map of Australia showing the relative spatial distribution of Culicoides spp. based on our simulation model: summer.



Map of Australia showing the relative spatial distribution of Culicoides spp. based on our simulation model: winter.



Map of Australia showing the estimated adult Culicoides spp. counts by day, 1 January to 31 December 2015.



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Conclusions

- We present two approaches for estimating the spatial and temporal distribution of insect vector populations using Culicoides spp. as an example

- Within-AADIS estimation of insect vector abundance allows deployment of models to assist rapid decision making at the national level

- Externally generated estimates of insect vector abundance allows subject matter experts to develop (and then deploy) vector distribution models better suited to support decision making at finer spatial scales