

Australia's dengue risk driven by human adaptation to climate change

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Dengue is transmitted by the mosquito *Aedes aegypti*

- *Aedes aegypti* probably arrived in Australia with the First Fleet (1788)
 - Ships that resupplied in African ports sailed off with adult females and/or eggs
 - Highly domestic mosquito – larva develop in artificial containers
 - Desiccation resistant eggs
- Dispersed by humans within Australia - QLD, NSW, NT and WA
- Retreated into QLD over the last 60 years due to changes in water management
 - Emergence of reticulated water and removal of potable water storage (rainwater tanks)
 - Removal of steam engine based railway locomotion and station water storage
- Distribution since 1980 includes >70 towns in Queensland



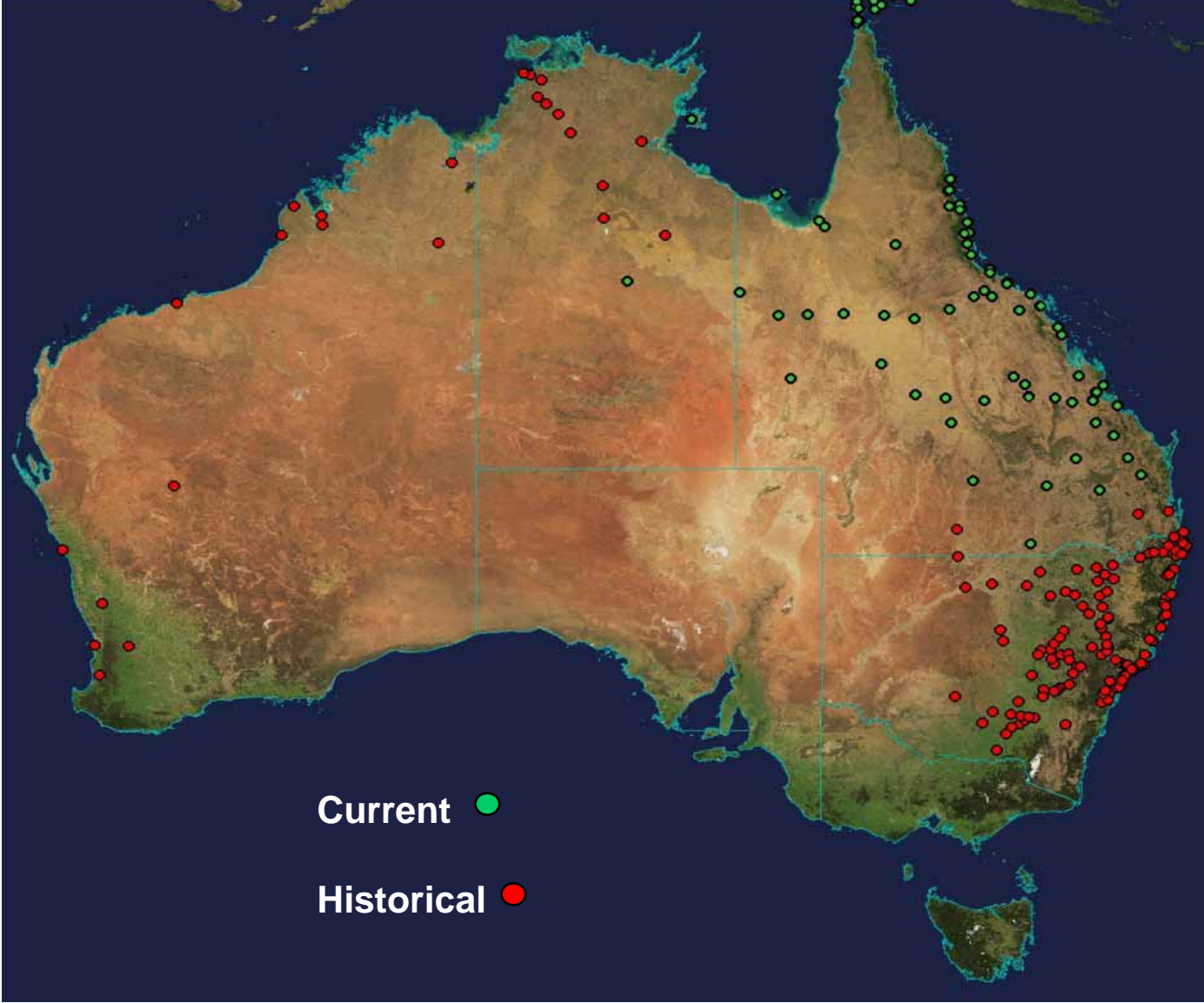
Climate change adaptation and dengue risk?

- Current and projected regional drying for SE Australia has resulted in
 - Increased water restriction
 - Explosion of domestic water storage containers
 - Stable oviposition sites for mosquitoes - *Aedes aegypti*
- Brisbane alone has installed >75,000 govt-rebated domestic water tank
 - >20% households
 - Other cities/towns etc. have rebates for water tanks
 - South Australia leads with number of rainwater tanks/household
 - Water storage in non-regulation containers!

If mosquitoes can access and move between these stable larval sites, what would be the risk of

1. *Aedes aegypti* again appearing in regions south of Queensland?
2. Dengue again appearing outside north Queensland?

***Ae. aegypti* collection sites in Australia (234 sites)**



Ecological niche modelling

For each of the 234 collection site

- 8 climatic layers
- OzClim Climate change scenarios (CSIRO)
- Spatial resolution of 0.025° (2.5km grid)
- TNTmips (GIS platform)

Includes climate layers:

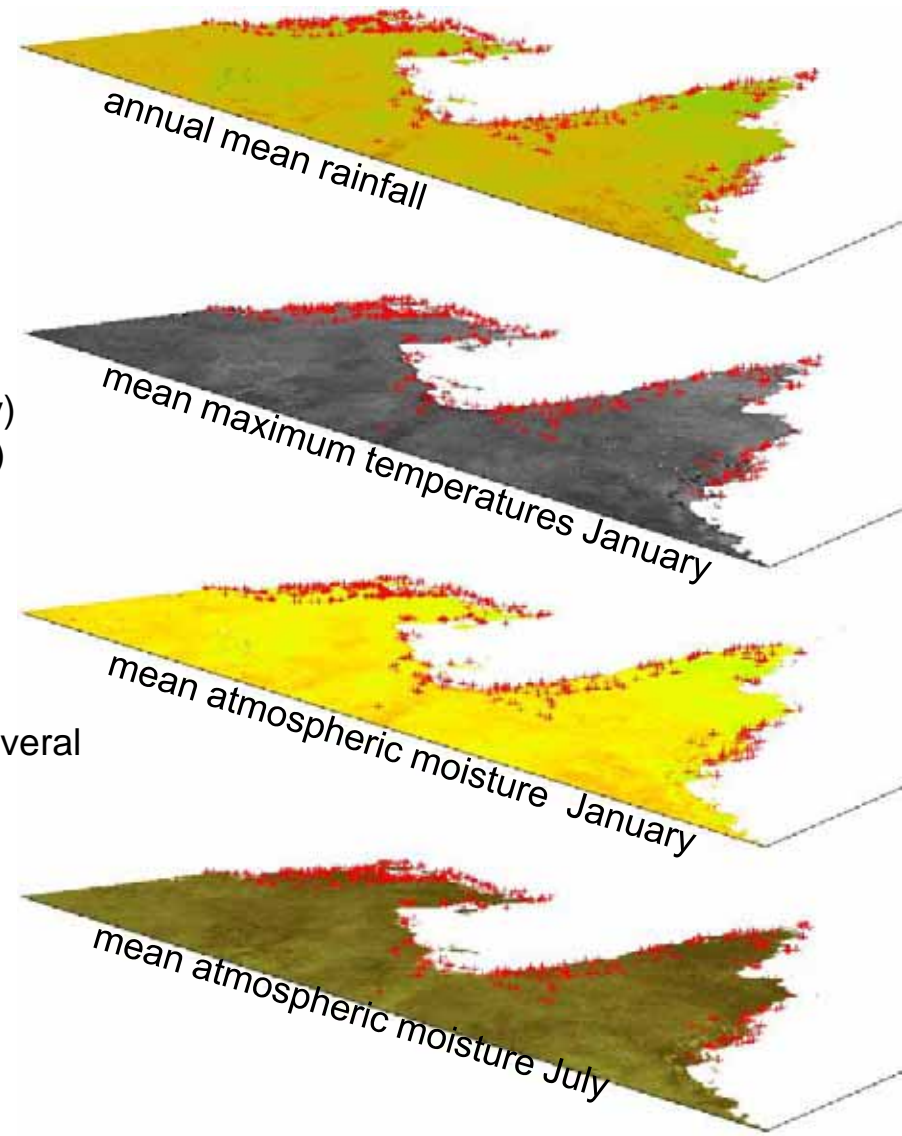
- annual mean rainfall
- annual mean temperature
- mean maximum temperatures (January and July)
- mean minimum temperatures (January and July)
- mean atmospheric moisture (January and July)
- non-climate layer elevation

Models are generated in GARP

- Genetic Algorithm for Rule-set Prediction
- Artificial intelligence-based approach utilizing several inference tools

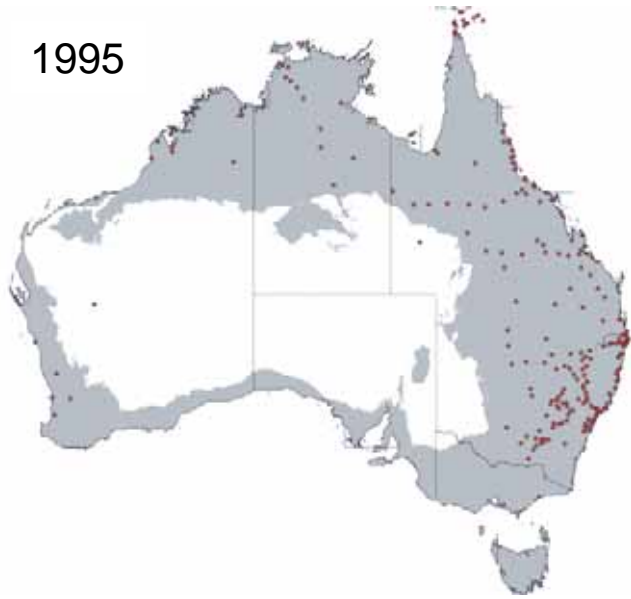
Climate change scenarios 2030 & 2050

- Mid sensitivity impact scenario A1B
- Changes projected in OzClim were added to the base layers

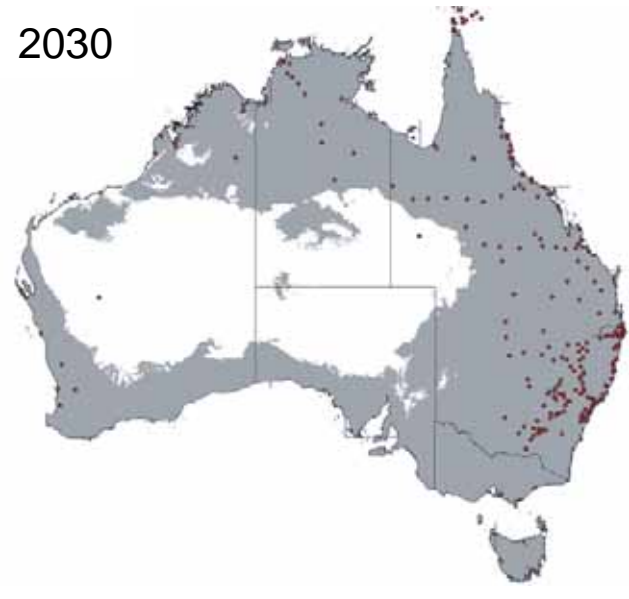


Aedes aegypti distribution modelled in GARP

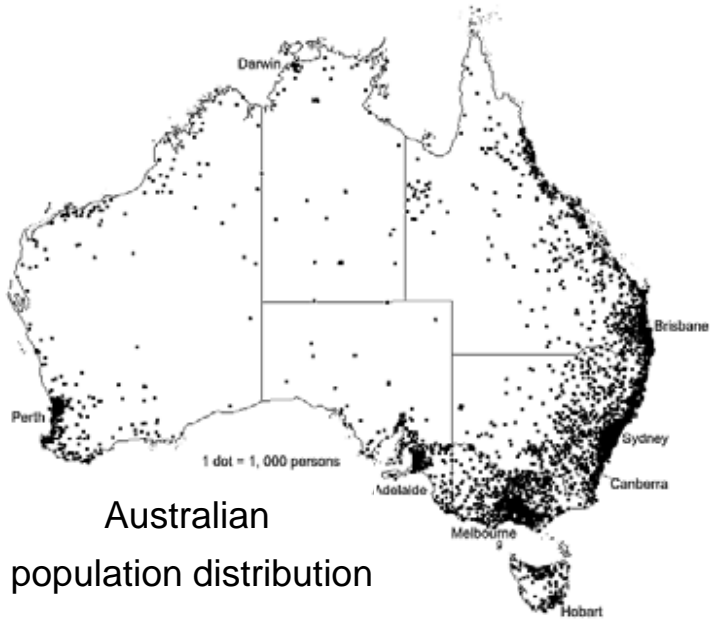
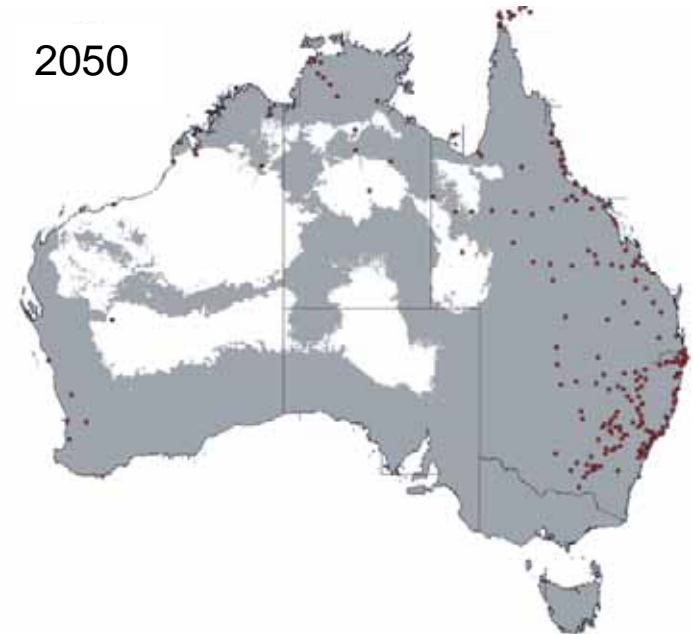
1995



2030



2050



Australian
population distribution

Theoretical temperature limits of *Ae. aegypti*

Rickhard Christophers (1960)
10°C winter (July) mean isotherm

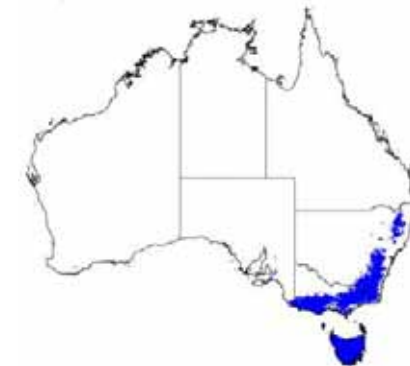
Marcelo Otero, et al., (2007)
15°C annual mean isotherm



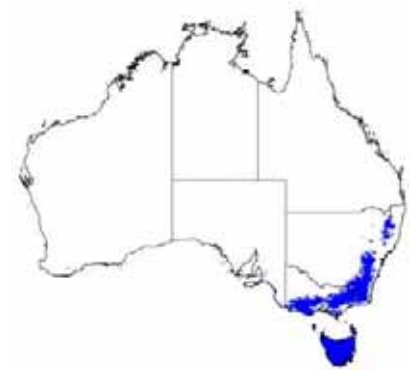
1995



2030



2050



Some interesting *Aedes aegypti* collection sites



GARP ecological niche model



10°C July mean isotherm



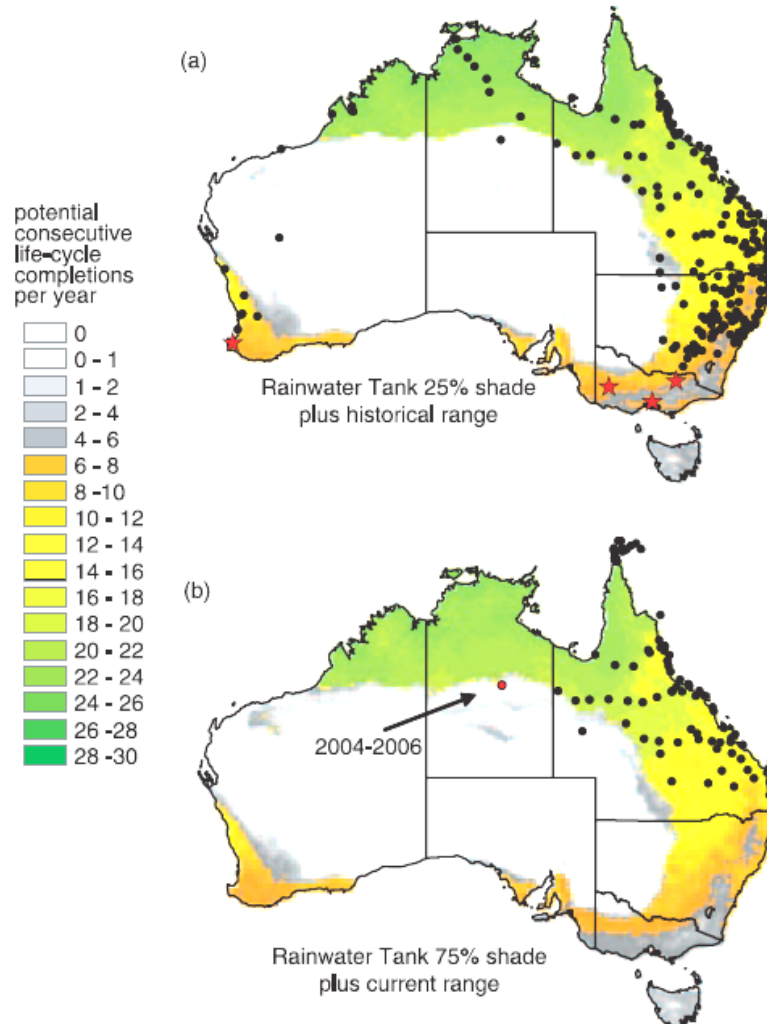
15°C annual mean isotherm

Site	Locality	Annual mean temp (°C)	Mean temp July (°C)
98	Breadalbane	12.4	5.25
116	Culcairn	14.7	7.05
187	Wagga Wagga	15.4	7.6
133	Junee	15.1	7.3
131	Harden	14.3	6.65
189	Wallendbeen	13.9	6.3

- Temperature may not be as important as we think?
- Rainwater tanks can provide temperature buffers for larvae
- Houses can provide buffers for adults

Mechanistic modelling of *Ae. aegypti* in Australia

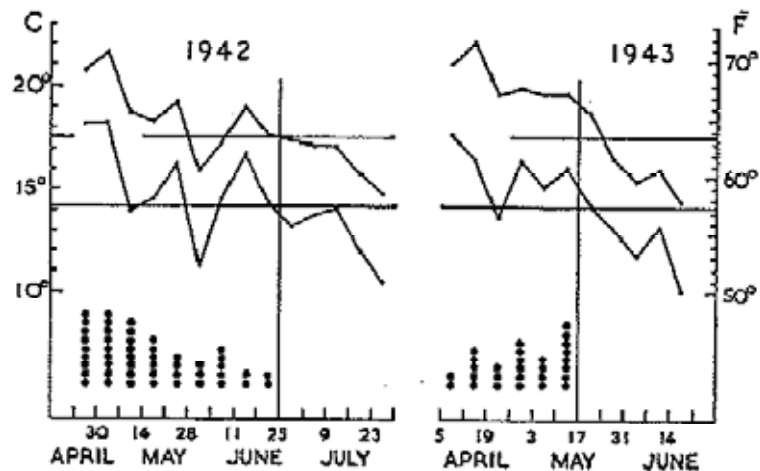
- Mechanistic model of *Aedes aegypti* (Kearney et al. 2009)
- Biophysical models of climate–animal interactions
- Climate influence on reproduction and larval development



Dengue transmission in Australia

- Australia is no stranger to dengue epidemics
 - Northern Queensland in the late 1800s (e.g. SE-QLD in 1904-5)
- The 1926 dengue epidemic swept out of SE-QLD into NSW
 - Stopping short of Sydney
- 1942 & 1943 epidemics stopped when they ran into winter
 - Winter began one month earlier in 1943 than 1942 (Derreck & Bicks 1958)
 - dengue transmission ceased in both epidemics at 15-14°C wet bulb isotherm (14.2°C T_w)

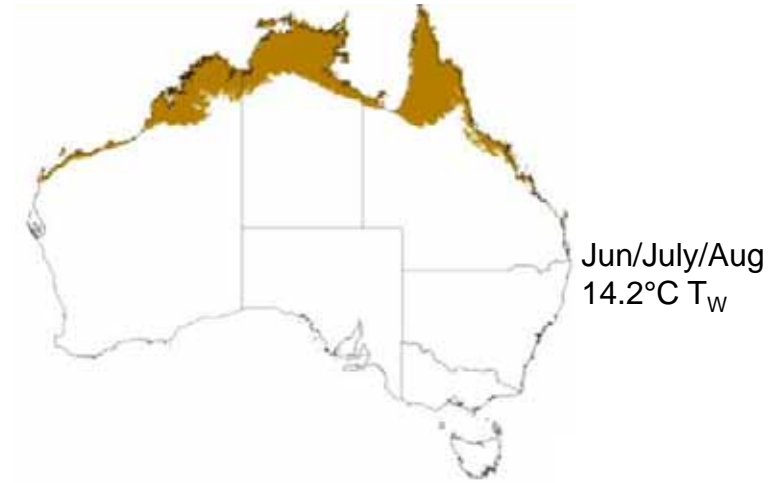
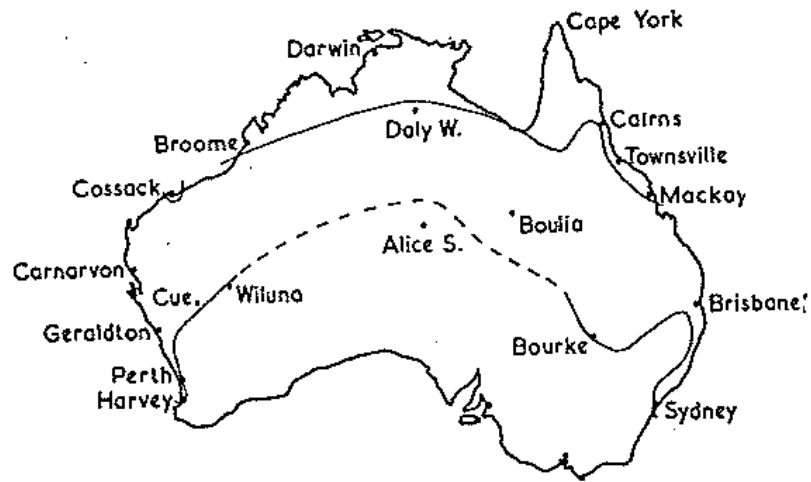
Dengue epidemics 1942 & 1943



(Derrick & Bicks 1958)

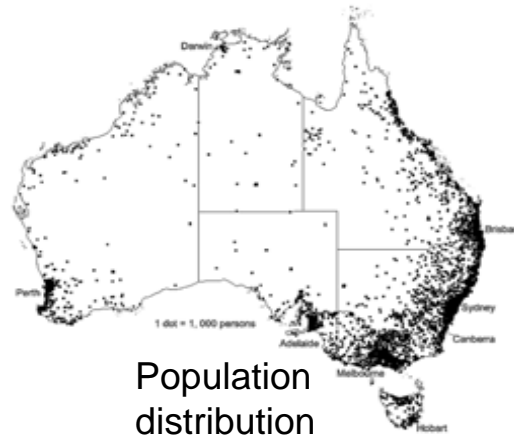
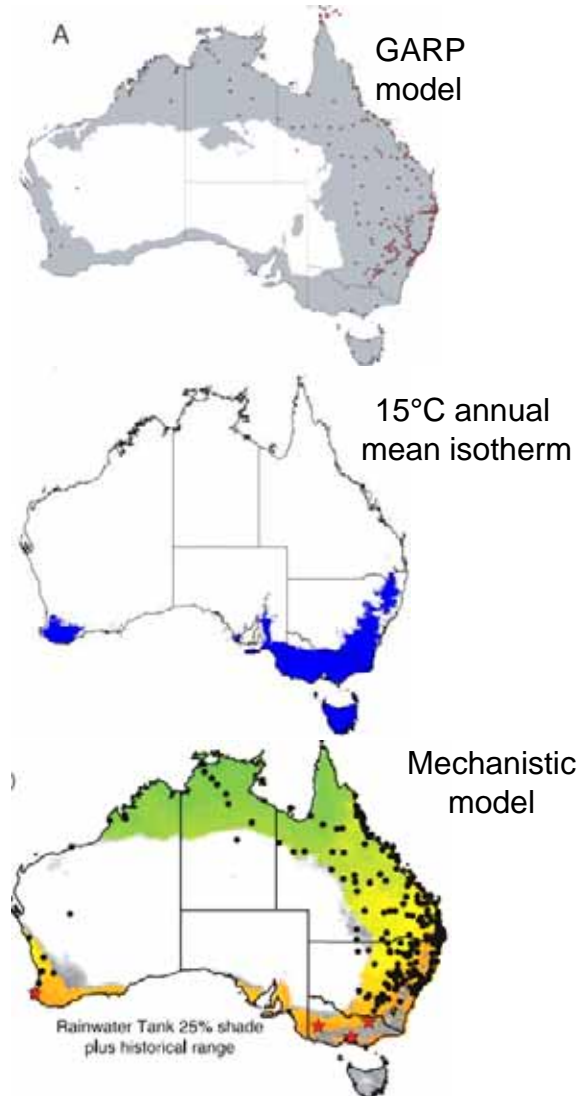
Dengue transmission in Australia

- Derrick & Bicks (1958)
- Annual $14.2 T_w$ isotherm best represented the 1926 epidemic

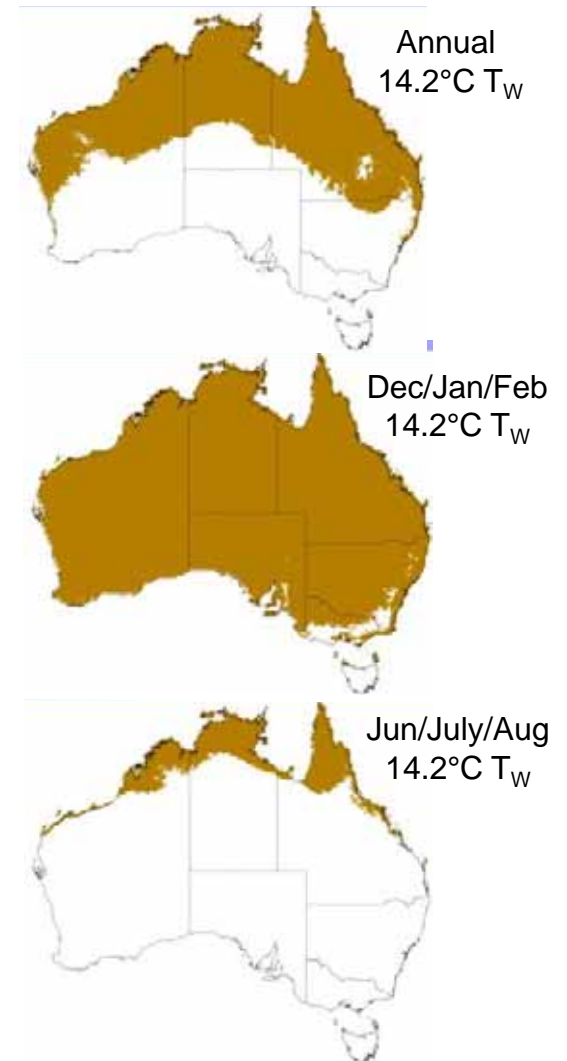


If *Ae. aegypti* could again utilise these stable larval sites...

1) Hypothesised limits: *Ae. aegypti*



2) Hypothesised limits: dengue transmission



In adapting to climate change we are recreating the environment that could permit another southern range expansion of *Ae. aegypti*

Where would the dengue virus come from?

- Year to June 2008 there were 250 Australian dengue notifications
 - Queensland had 113 (most were local transmission)
 - New South Wales had 72
 - Northern Territory had 15
 - South Australia had 12
 - Victoria had 8
 - Western Australia had 28

Summary

- Modelling the potential distribution of *Ae. aegypti* using environmental parameters is problematic and incongruence was identified between the our GARP models and theoretical temperature limits.
 - Difficulty of relating the point occurrence data of an invasive species that is not in equilibrium.
 - Highly domestic behaviour buffers the external climate
 - Mechanistic modelling of life process parameters was more powerful.
 - Suggest that climate - and in particular temperature - play a less important role in determining the range of this species

Summary

- If the installation and maintenance of domestic water storage tanks is not tightly controlled today
 - A range expansion of *Ae. aegypti* is absolutely possible
 - Could expose the majority of Australia's population to this dengue vector
 - Resulting in the risk of dengue transmission occurring south of Queensland during our warm summer months.
- Human adaptation to climate change poses a larger dengue risk to Australia than the projected warming.

The Team

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