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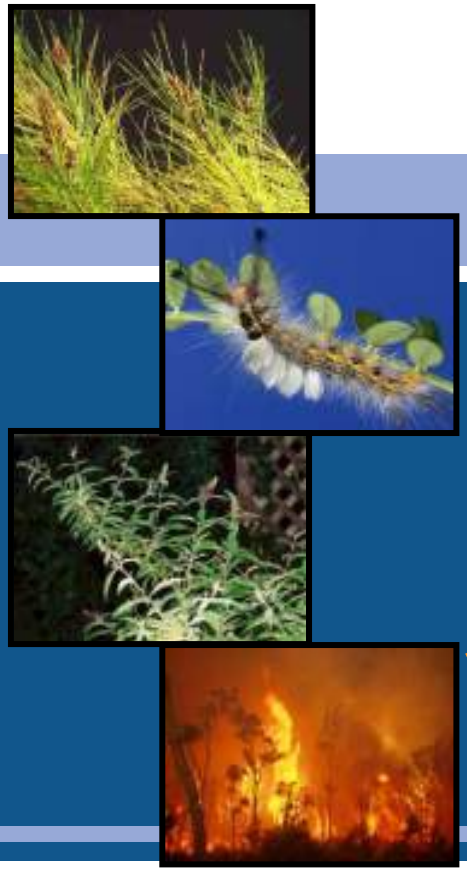
Darren Kriticos



Forest Biosecurity and [illegible]ction

Climate [illegible]d Weed Risk [illegible]nt: Emerging issues and methods

A tale of laggards and slow leaders under global change

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WRA under threat!

- The single most important assumption in most species distribution modelling…
- …that a species range is at equilibrium with its environment…
- …is being systematically undermined by climate change!

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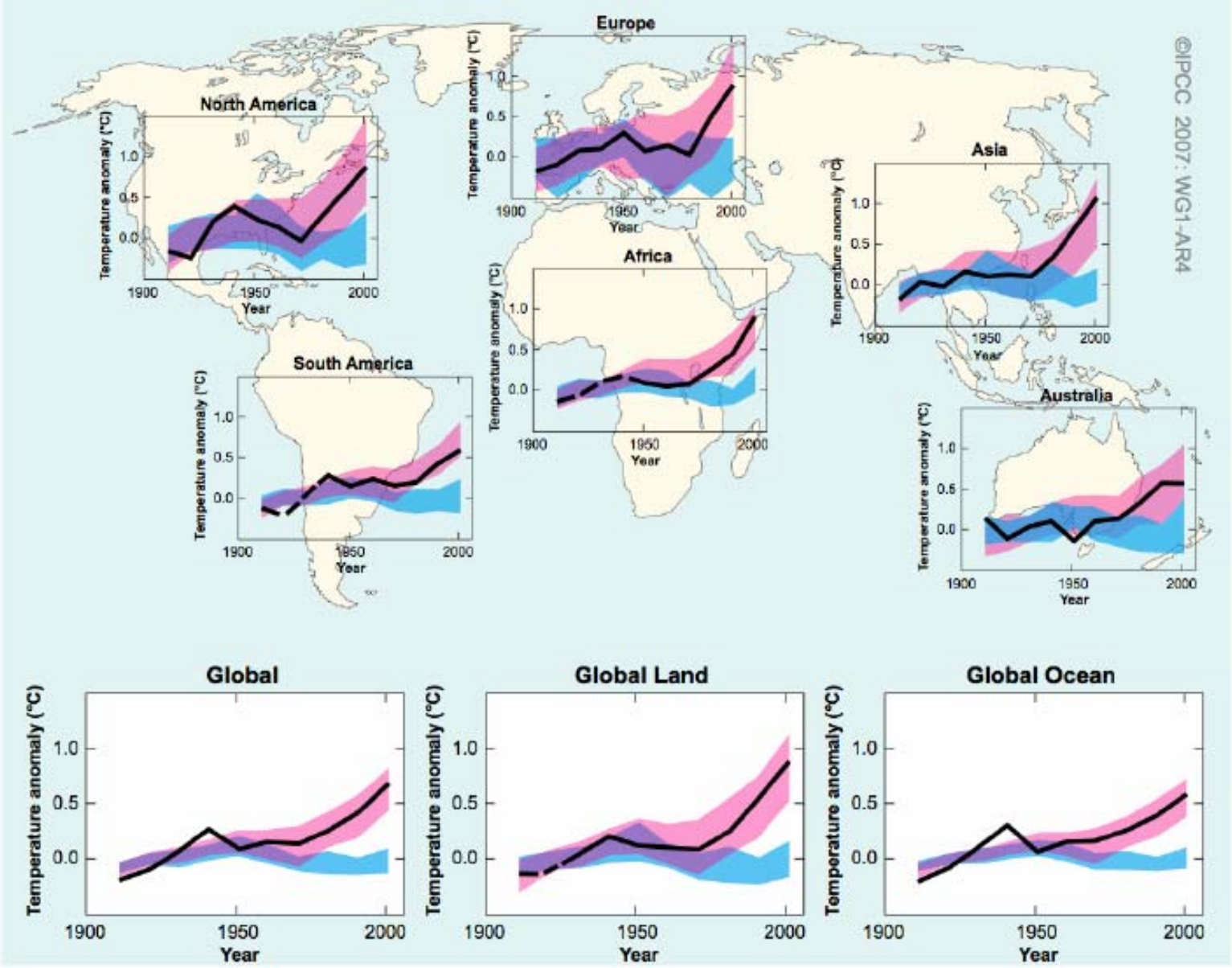
Climate change is occurring and is due to human activities



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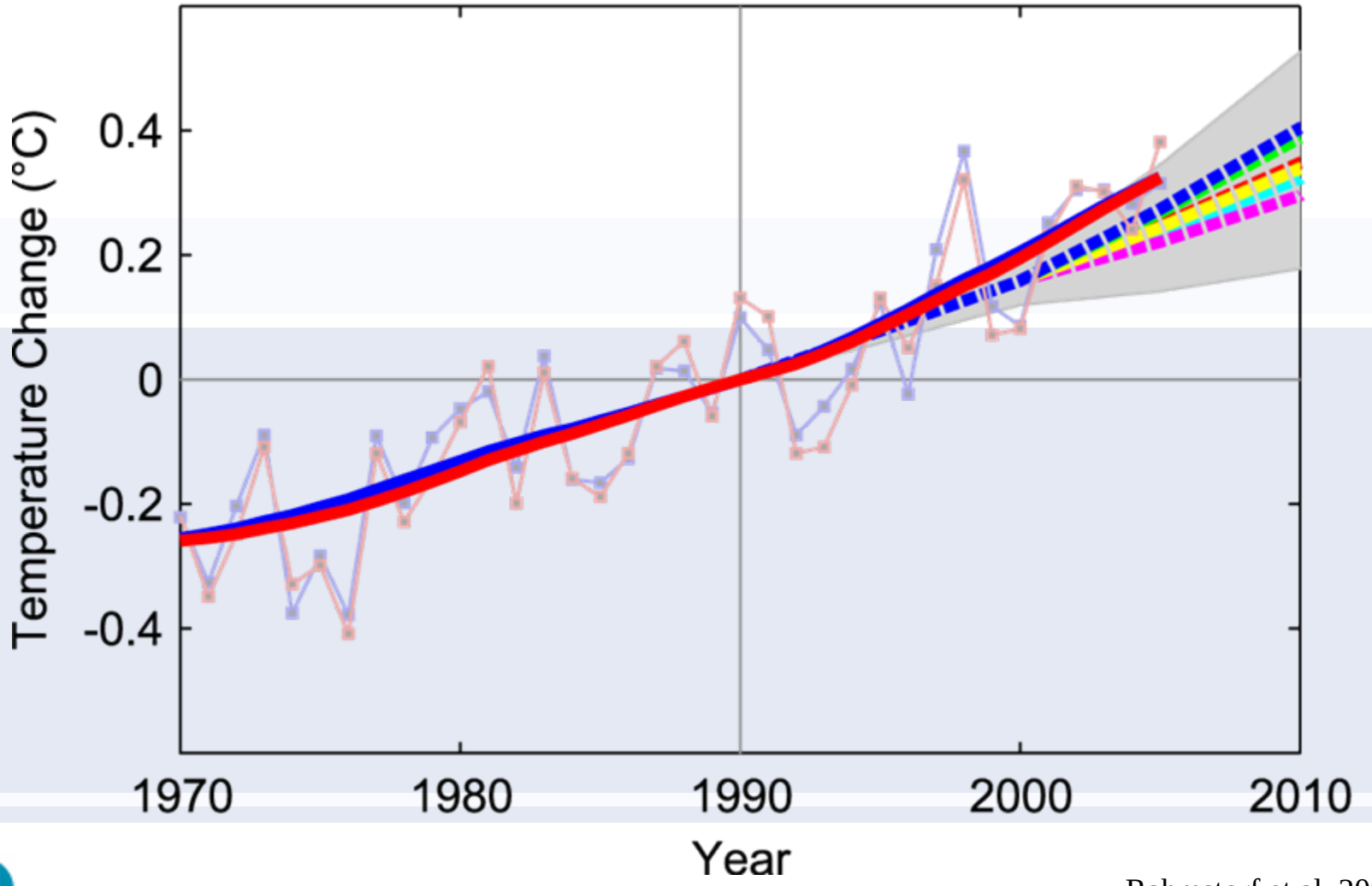
We are currently tracking at the very high end of emission scenarios and temperature projections



Rahmstorf et al. 2007

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Elements of climate change

- CO_2
- CH_4, NOx, SOx
- Temperature
- Rainfall
- Vapour pressure (humidity)

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Impacts on plant growth

- Carbon fertilisation effect (CFE)
- Water-use efficiency (WUE)
- Differential effects on Ps and weeds and crops are somewhat equivocal
  - Ziska, L. H. (2000) The impact of elevated CO_2 on yield loss from a C_3 and C_4 weed in field-grown soybean. *Global Change Biology*. 6(8):899-905.
  - Williams et al. (2007) Warming and free-air CO_2 enrichment alter demographics in four co-occurring grassland species. *New Phytologist*.

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Current Best Practice WRA range modelling

- Determine all known native and exotic locations
- Separate native, exotic (not validation) and exotic validation datasets
- ***Fit*** model to native and some exotic ranges using *Reference Climate* (1961-1990)
  - Consider effects of special land-uses (irrigation)
- Project model into other regions
- ***Verify*** with remaining exotic range (not validation)
- ***Validate*** using remaining records for region of interest
- Explore future climate scenarios to assess future threats (emerging option)

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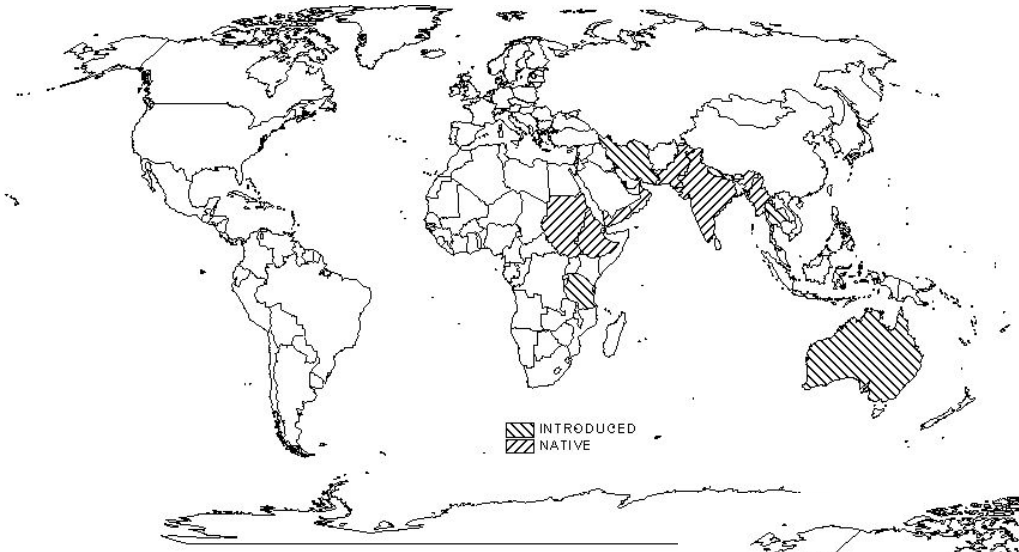
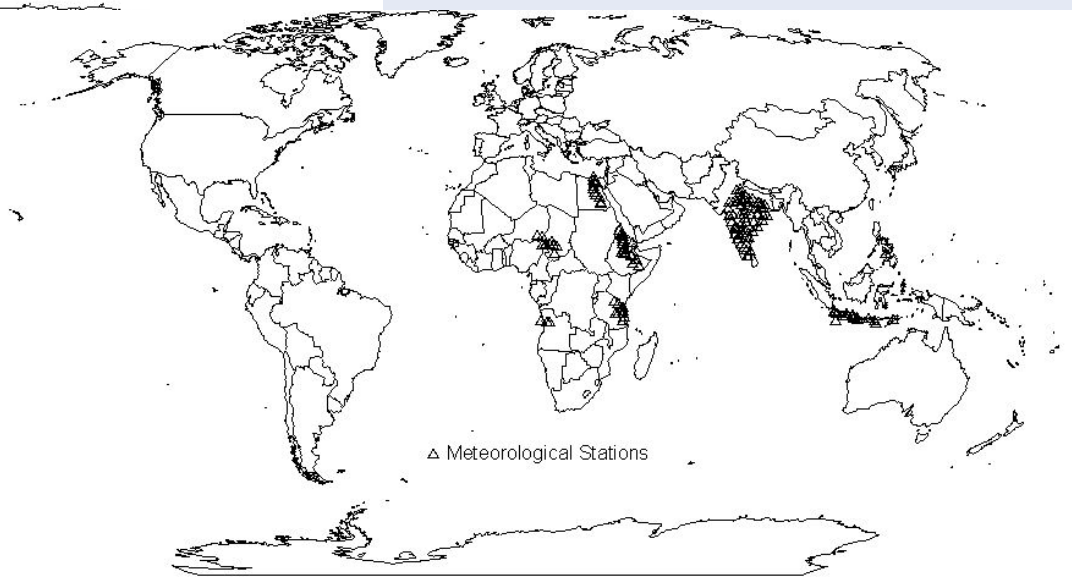
Prickly Acacia





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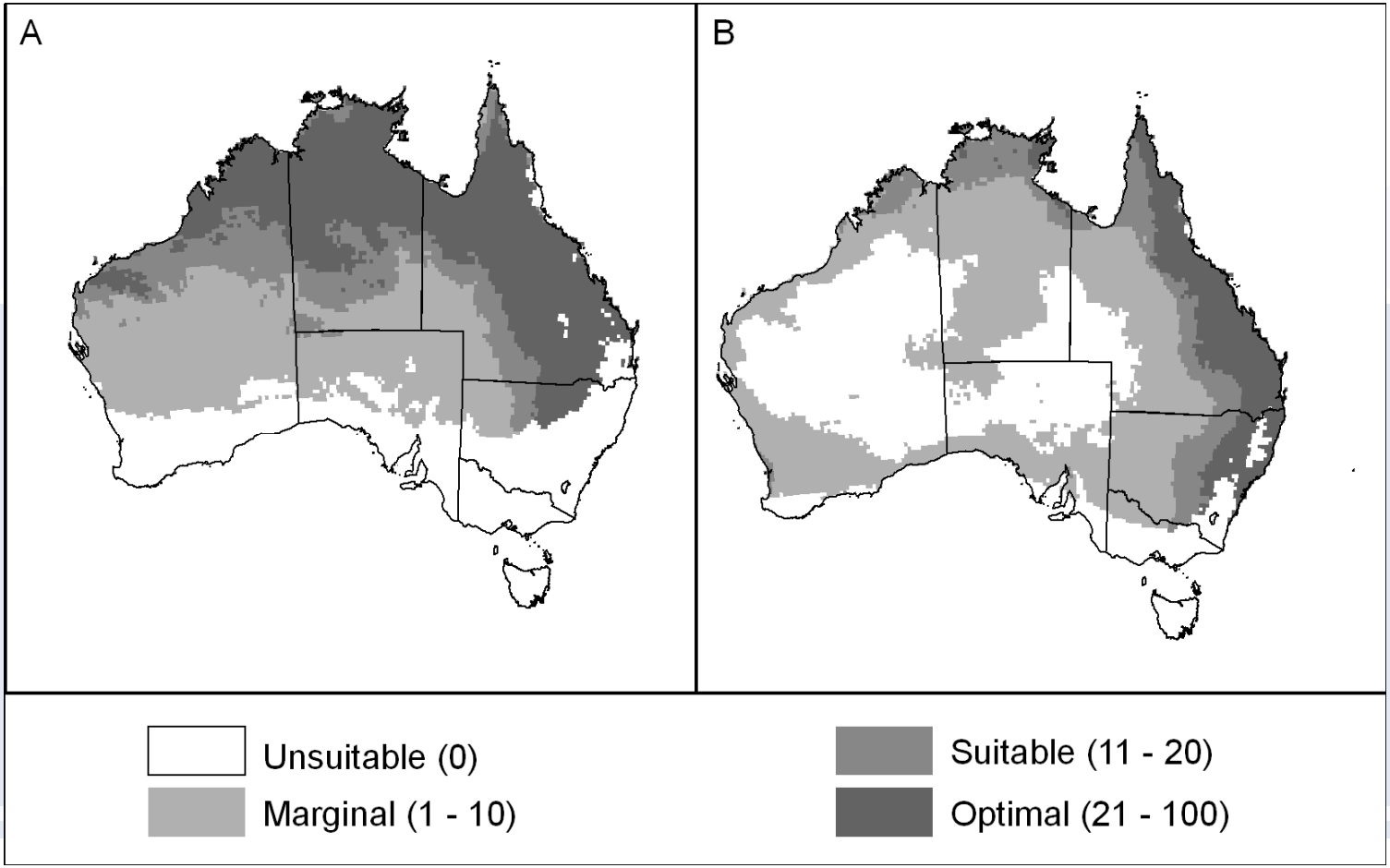
Prickly Acacia



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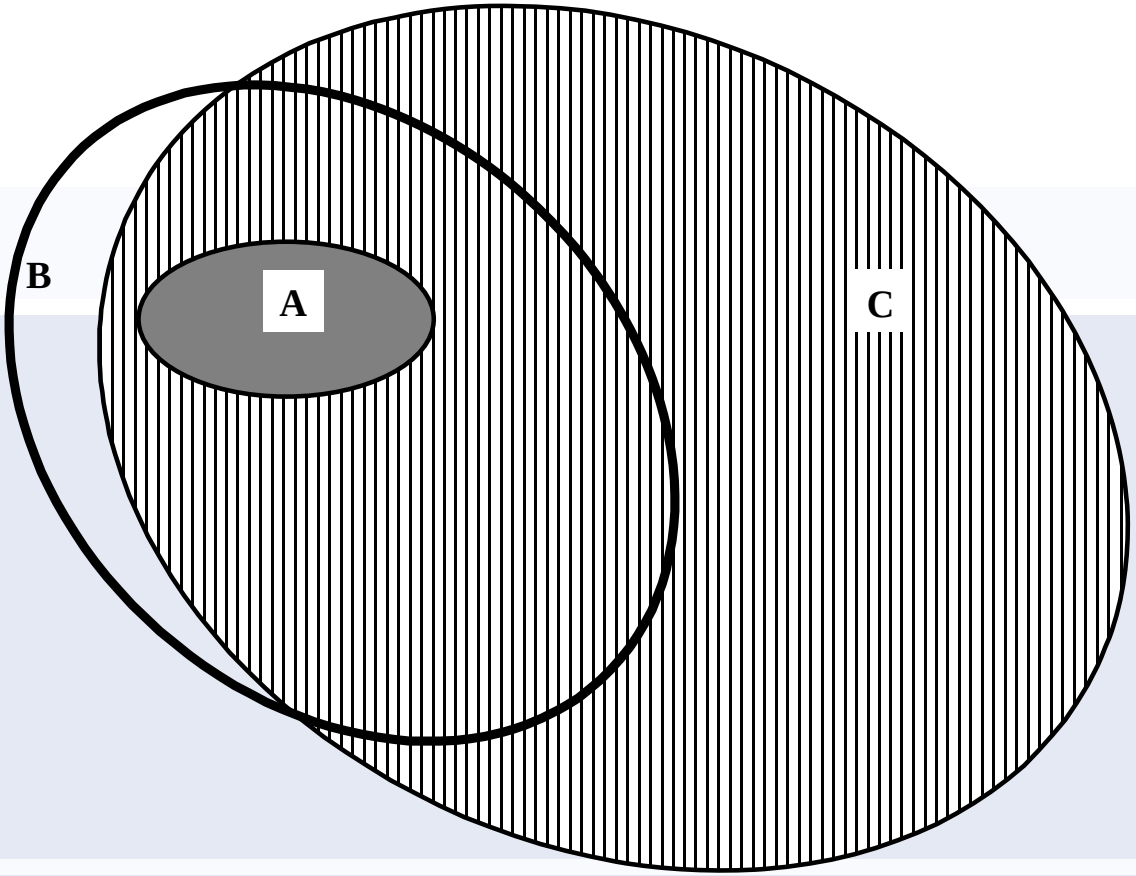
Climate change and biological invasions



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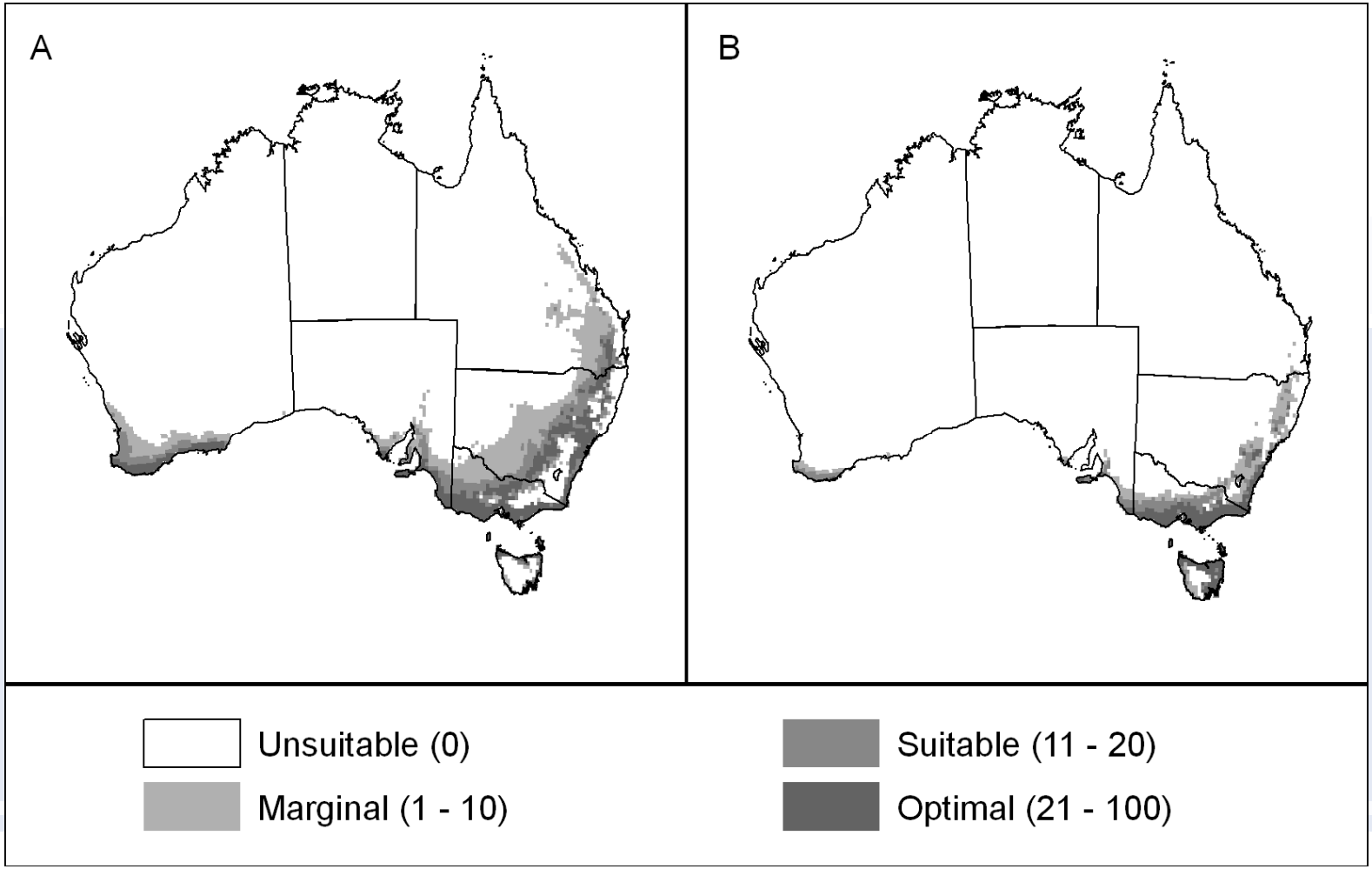
Bridal Creeper



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Climate and species ranges

- Range boundaries differ qualitatively depending upon nature of the limitation
  - Where resources are abundant, biotic factors tend to limit species ranges
    - Eg Hot-wet stress ~ plant competition
  - Where resources are scarce, these tend to limit the ranges directly
    - Drought stress
    - Degree day limits to reproduction
    - Frost damage or other lethal low temperatures

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Climate and species ranges

- Species ranges are ***dynamic***
  - Spatial epidemiology (Carter & Prince)
  - Climate variability
  - Disturbance
  - *Fast* and *Slow* species can react differently
- Some ranges will shift in response to slightly more extreme local weather behaviour
  - Eg slightly warmer seasons might see a plant at its degree day limit produce viable seed that gets dispersed slightly more poleward
- Average ranges will tend to reflect climate averages
- But WHICH climate averages?

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Climate Change and Species Distributions

- Changes in the length of the growing season and the duration of climatically stressful periods
- As climatic limits shift in space, weed populations can respond through range expansion (invasion) into hitherto inhospitable territory, or through local extinction

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Effects of lags in range shifts responding to climate change

- Rates of range ***expansion*** and ***contraction*** for weeds
  - Unlikely to be immediate
  - Occur at different rates
  - Have opposite effects on weed risk assessments

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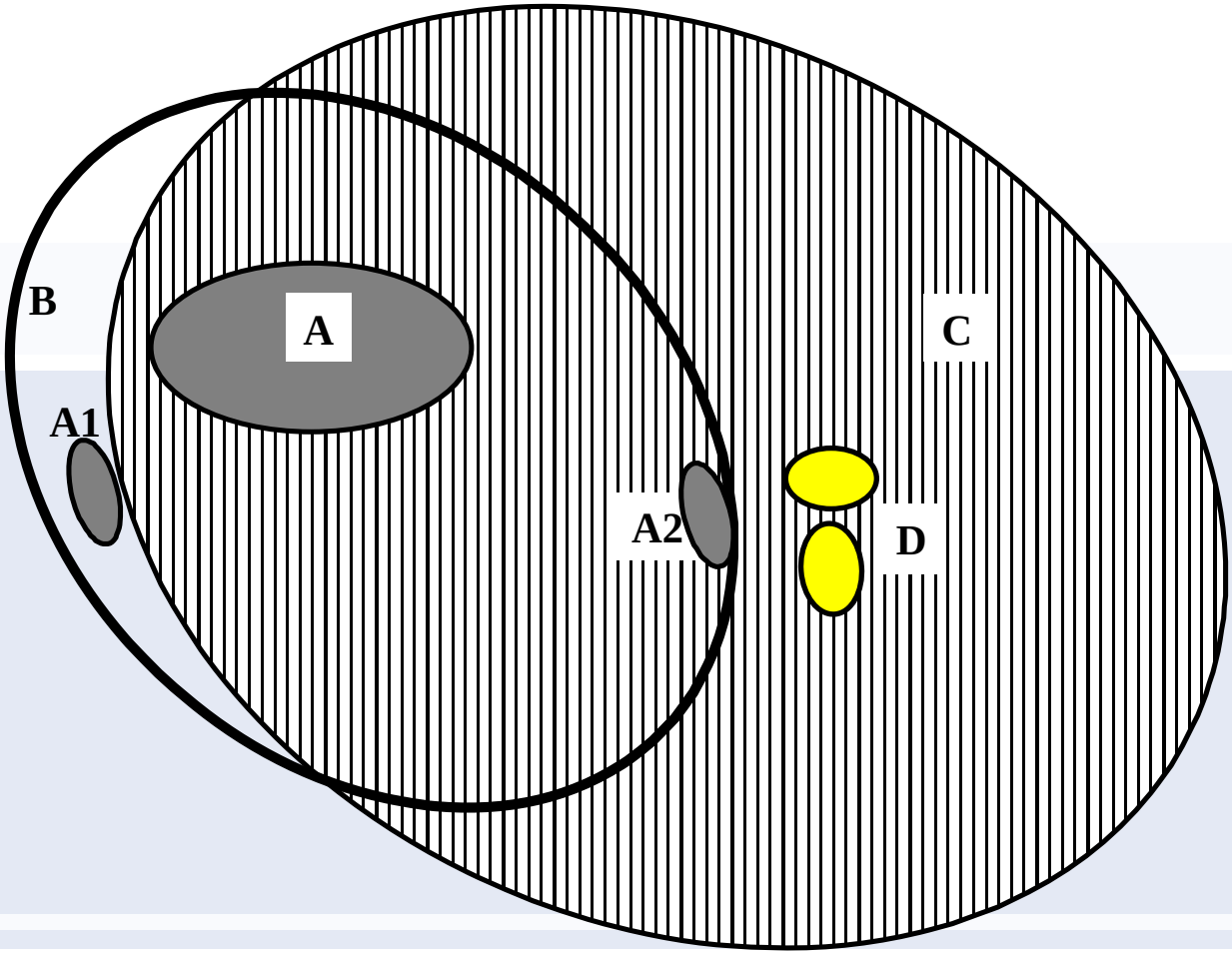
Marginal populations under climate change



- A – Previous distribution (<1990)
- B – Climate suitability under ***Reference*** climate
- C – ***Current*** climate suitability (>1990)
- D – ***Invasion*** leaders (>1990)

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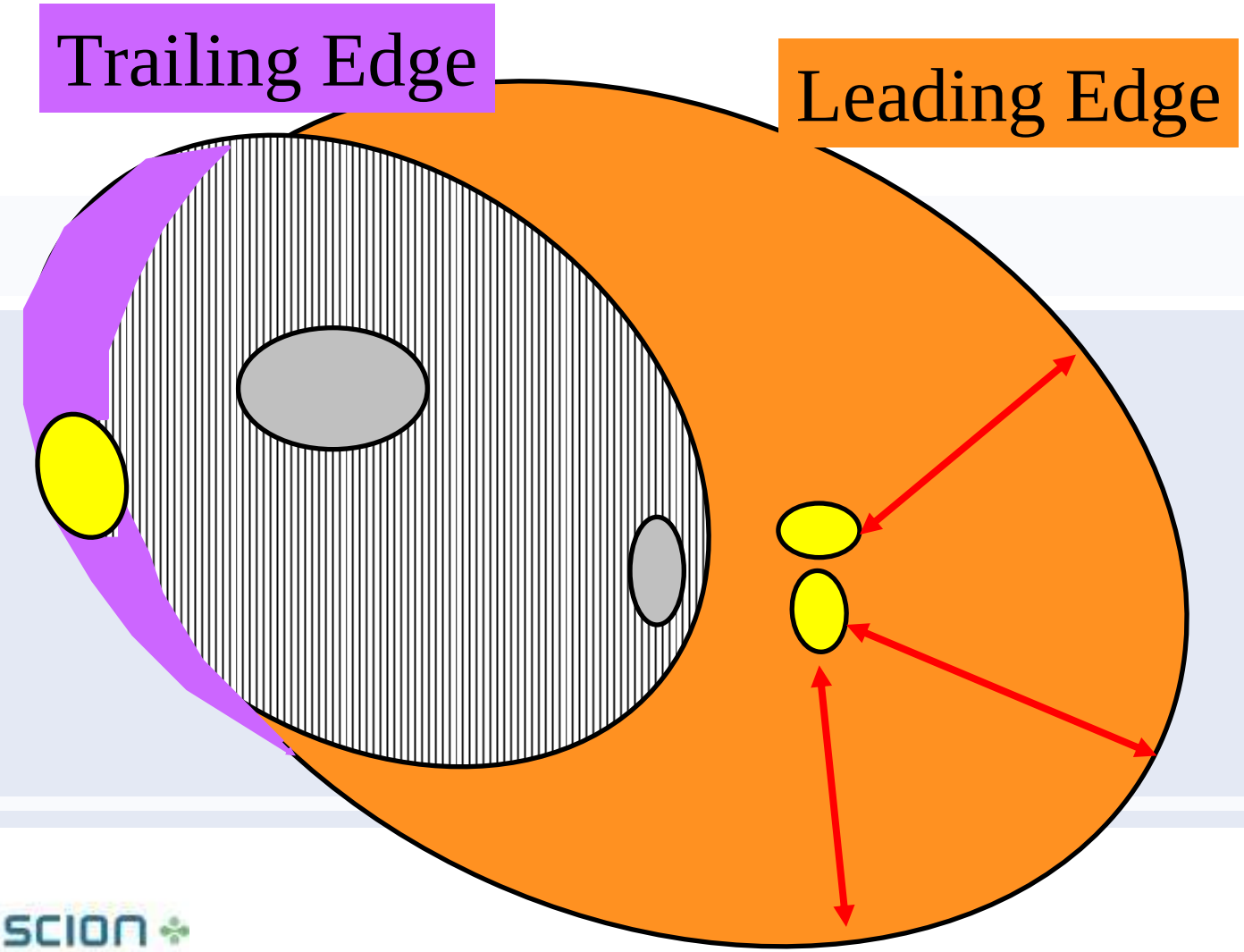
Range Lags



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Trailing Edge Lags

- Driven by ecological inertia
  - No need to disperse and establish seedbanks
- If ***fitted*** with relevant (say reference) climate and ***projected*** with **contemporary** or future climate surfaces. Future projections would be **unbiased**
- If **fitted** with ***newer*** climate surfaces, projected range would be **biased** to include excessively warm locations for the projected climate
  - Eg modelling *Nothofagus moreii* locations in QLD

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Leading Edge Lags

- Invasion lags due to risks of dispersing into marginally suitable habitat
- Will probably include both invasion lags and ***reporting lags***, as it takes time to discover and report new geographic records
  - though ***presence ≠ naturalised***
- If range leaders are fitted with “old” climates, projected potential range under all climates would be **biased** to include ***excessively cool*** locations
- If lagged range leaders fitted using current (newer) climate averages, then the projected potential range would be **biased** to underpredict the suitability of ***cool*** locations

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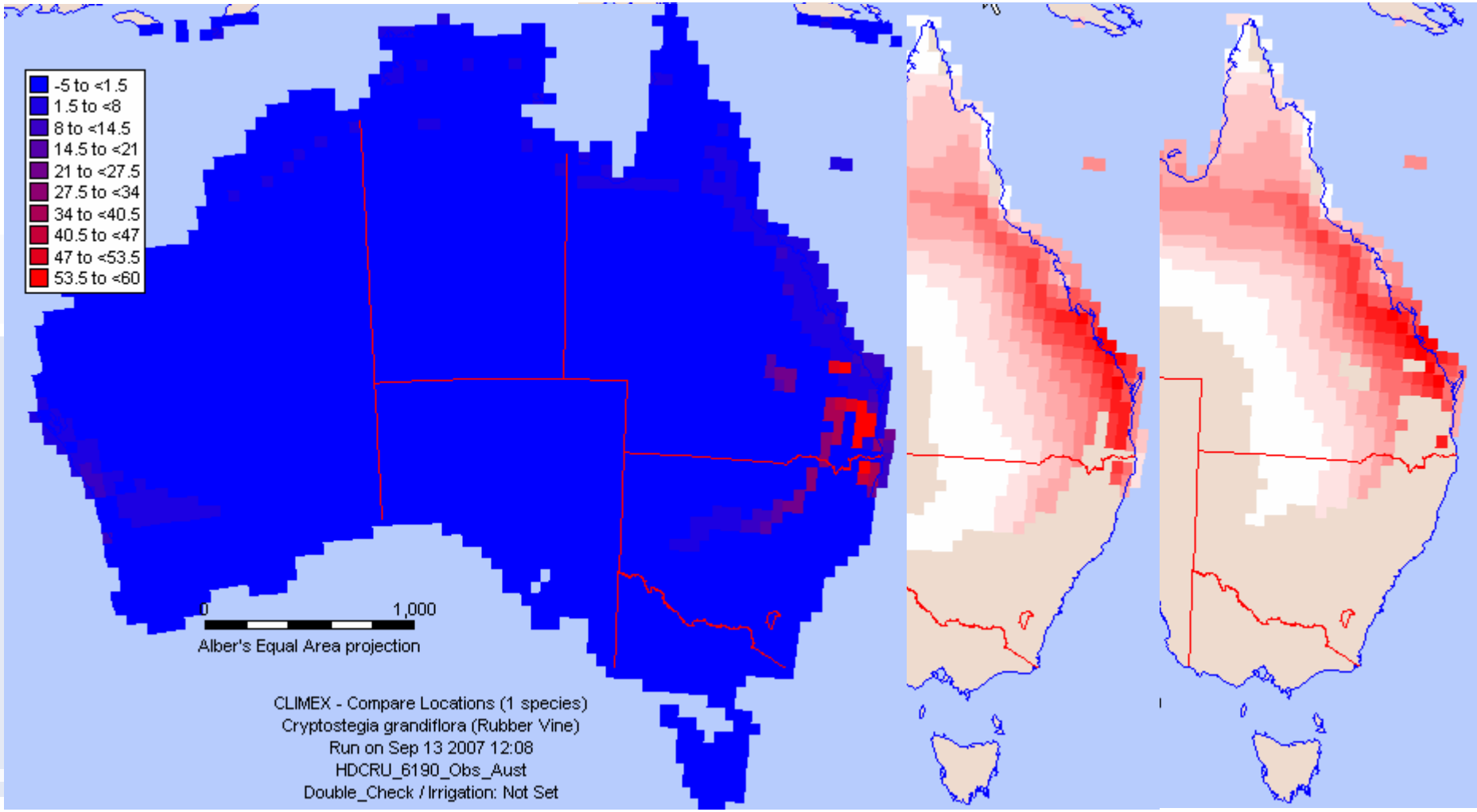
So What? Rubber Vine + 1.2 C



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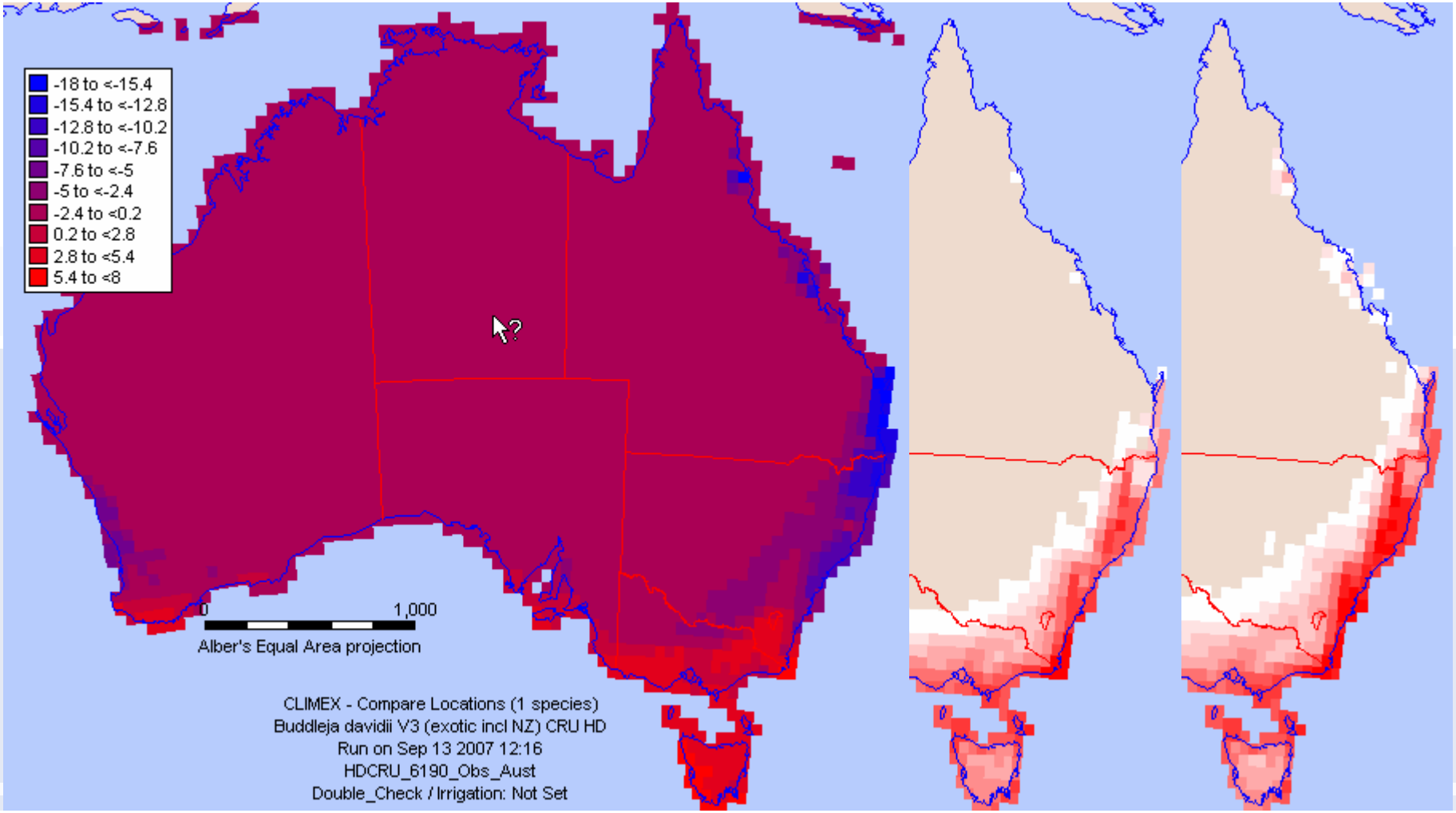
Buddleja davidii +1.2C



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Some options for dealing with the climate change dilemmas

- Develop ***awareness*** of the problem
- Undertake some ***case studies*** to understand the likely extent of the problem – sensitivity analyses
- Update the reference climate to say a 30-year average up to 2000 and live with “unders and overs”
- ***Monitor*** the situation
- ***Date-stamping*** of location records and develop automated techniques for estimating range through time

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Some more options for dealing with the climate change dilemmas

- ***Careful***, ***intelligent*** interpretation of historical range shifts and projected future ranges
  - Explicitly identify climate range outliers and assess and discuss implications in model description
  - Treat black box regression models with even more suspicion!
  - Steer away from bulk modelling exercises
    - speed doesn't matter if your headed in the wrong direction!!
- More testing and use of ***ecophysiological*** information in distribution modelling
  - Problems with ***fundamental*** and ***realised*** niche issues
- ***Model averaging*** across climate datasets
  - 1961-1990 reference plus more contemporary
- Update reference climates
  - Bias and noise problems with shifting from 30-year average to shorter averaging period

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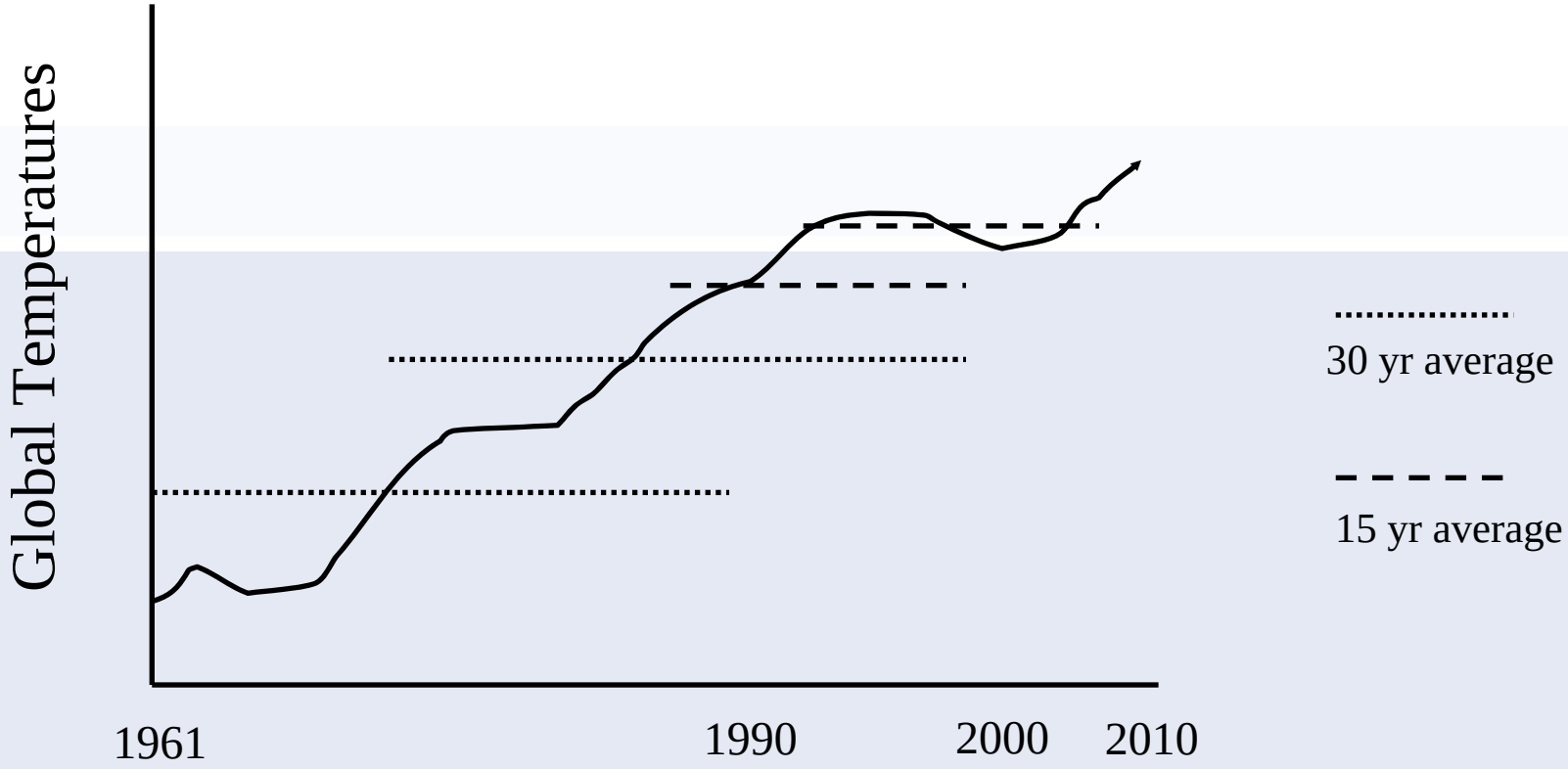
Updating and changing climate average period



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Summary - Emerging Issues for Projecting Weed Ranges

- Climate change is undermining our current modelling approaches
- The primary assumption of most modelling approaches is that the weed's distribution is at equilibrium with climate
- As climates change, ranges shift
  - Range shifts are likely to be lagged behind changing climate suitability
  - *Records* of range shifts may be further lagged
  - Establishment may precede complete *naturalisation* – including *reproduction*
- *Contemporaneity* of distribution data and climate surfaces used for model-fitting is being significantly affected
- The problem is growing
- There is no clear simple solution that will address all the issues