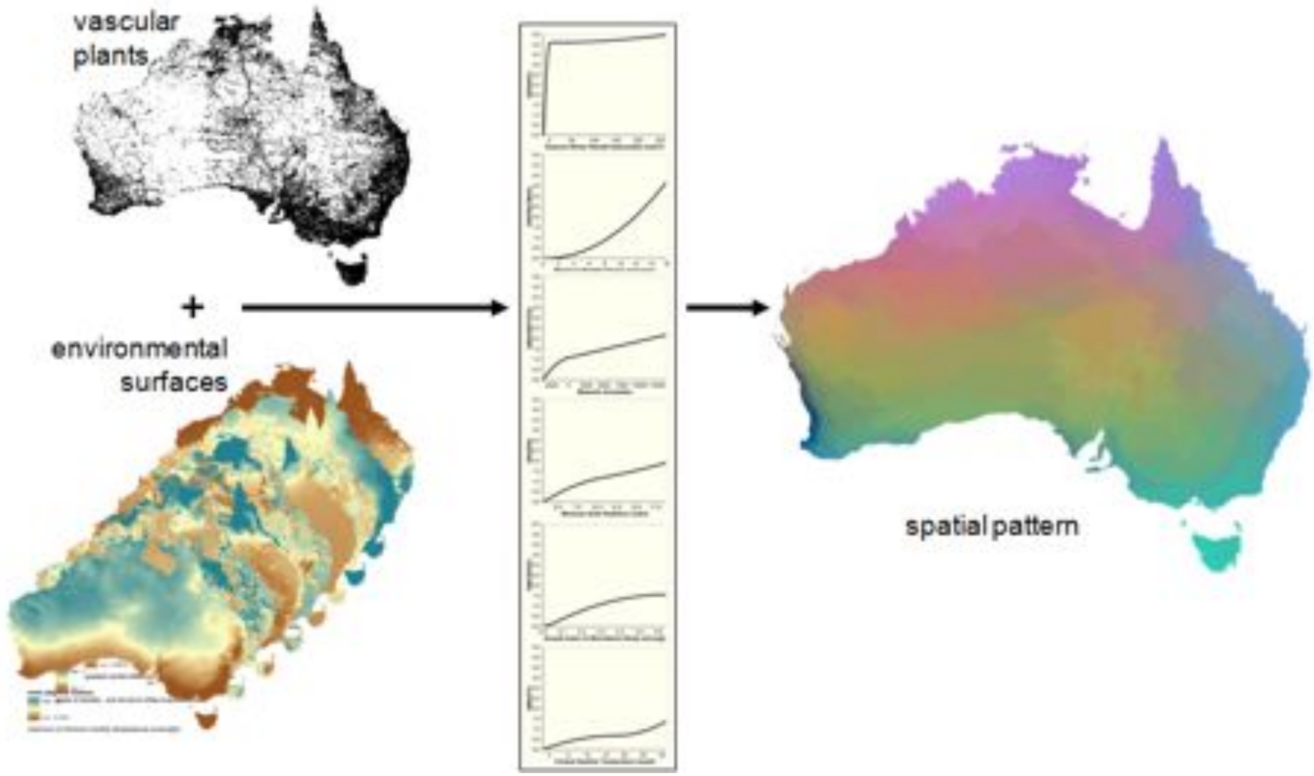

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Informing data models in ecology:
Which layers should I use in my biodiversity model?

Kristen J Williams[1,3], Michael P Austin[1], Simon Ferrier[1], Janet Stein[2], Lee Belbin[3]
[1]CSIRO Ecosystem Sciences, [2]ANU Fenner School, [3]Atlas of Living Australia

ESA2011 Hobart, 21 November 2011, 13:30-13:45

Informing data models in ecology: outline

1 • Why we need to clarify which layers are useful

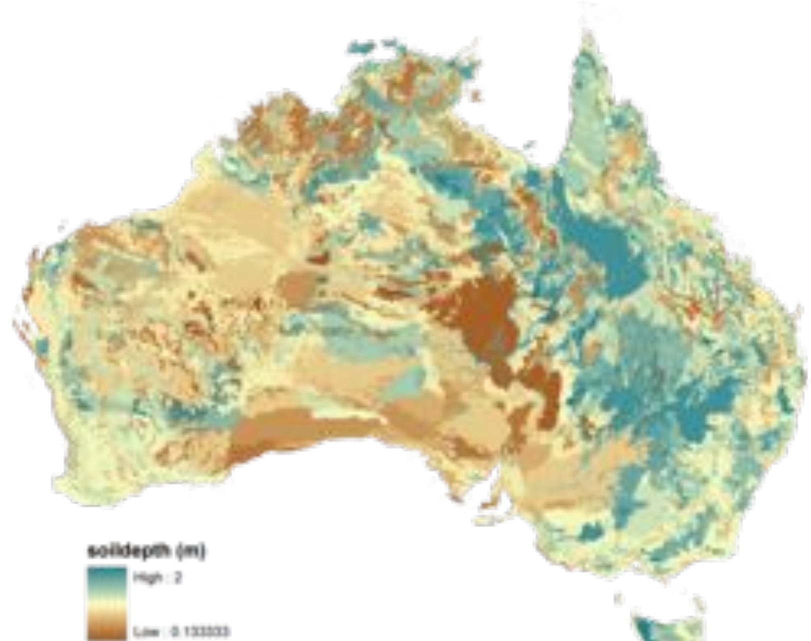
2 • Outlining the data model and case study

3 • Principles for selecting environmental layers

Why we need to clarify which layers are useful

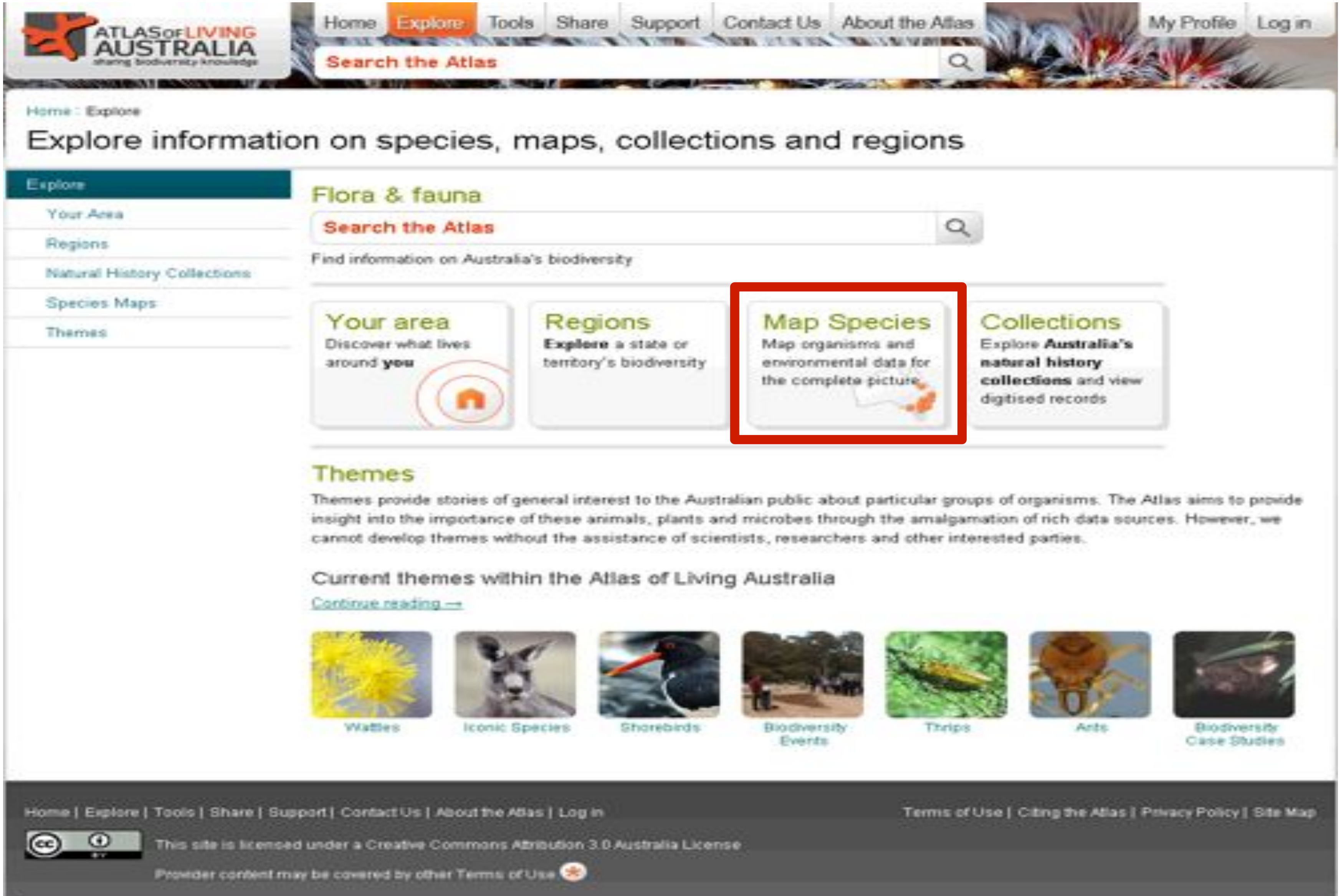
- Digital environmental data is a necessary input to a wide range of ecological modelling approaches
- Deciding on which layers to include is an ongoing challenge
- Open access to models and data, such as through the Atlas of Living Australia (www.ala.org.au), highlight the need for more general guidance on which layers to use for a given purpose

Eucalyptus delegatensis canopy



solum depth (Atlas Australian Soils)

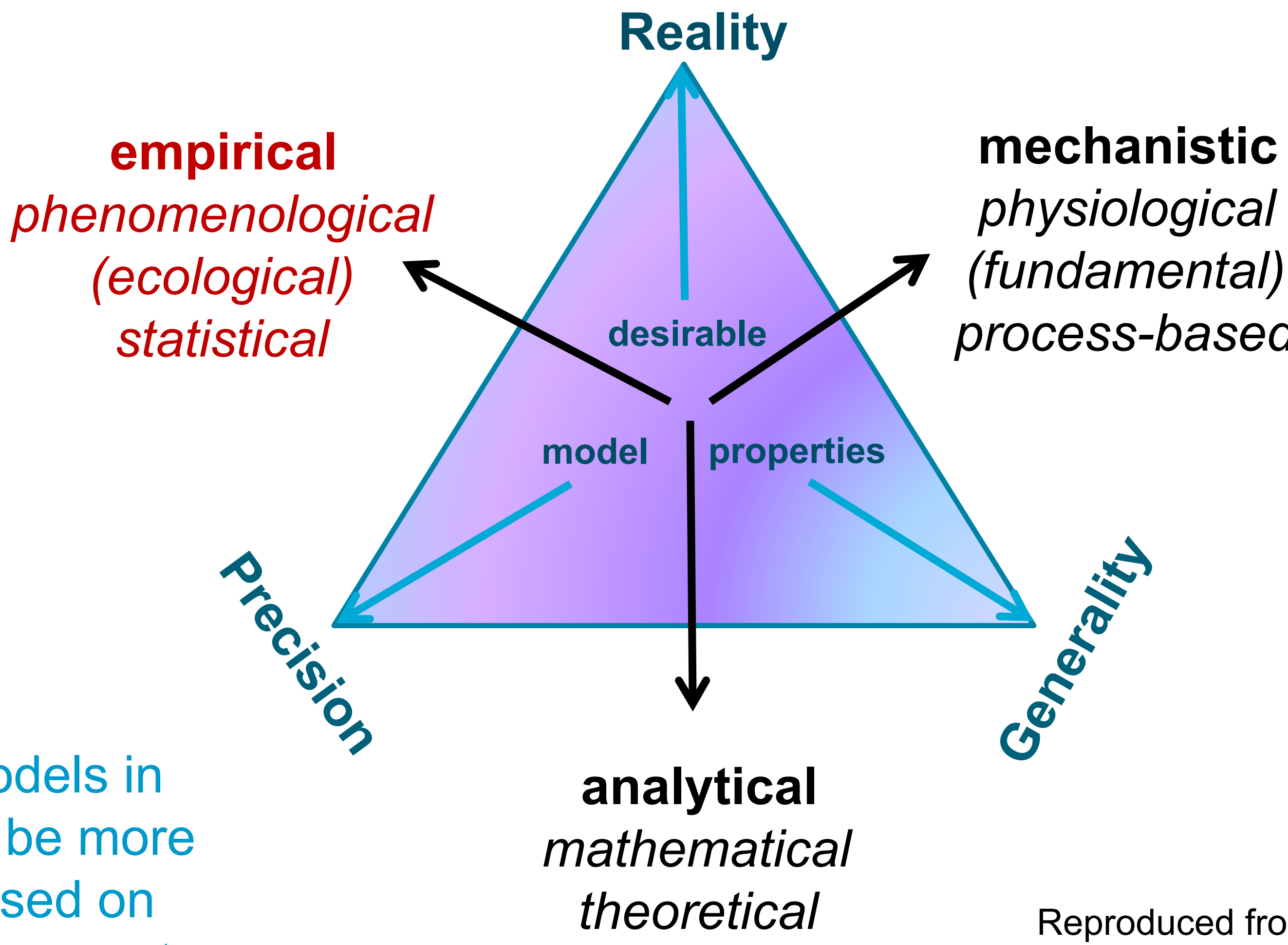
Online data portals provide ready access to data for research and planning: http://www.ala.org.au/



ALA "Map Species" Spatial Analysis Tools: http://www.ala.org.au/explore/species-maps/

- **Sampling**: attribute species occurrence data with values of environmental and contextual data layers
- **Filtering**: use values of environmental or contextual layers to define an envelope and subset species occurrence data
- **Scatter plot**: view the species occurrence data in environmental space for any two variables and an area of interest
- **Prediction**: use MaxEnt to model the relationship between species occurrence data and selected environmental layers
- **Classification**: classify selected environmental layers into domains (the ALOC algorithm from PATN)

Desirable properties and types of models



Empirical models in ecology can be more general if based on meaningful parameters

Reproduced from Fig 2 in Guisan & Zimmermann (2000) *Ecological Modelling 135:147-186.*

Three components of a biodiversity model

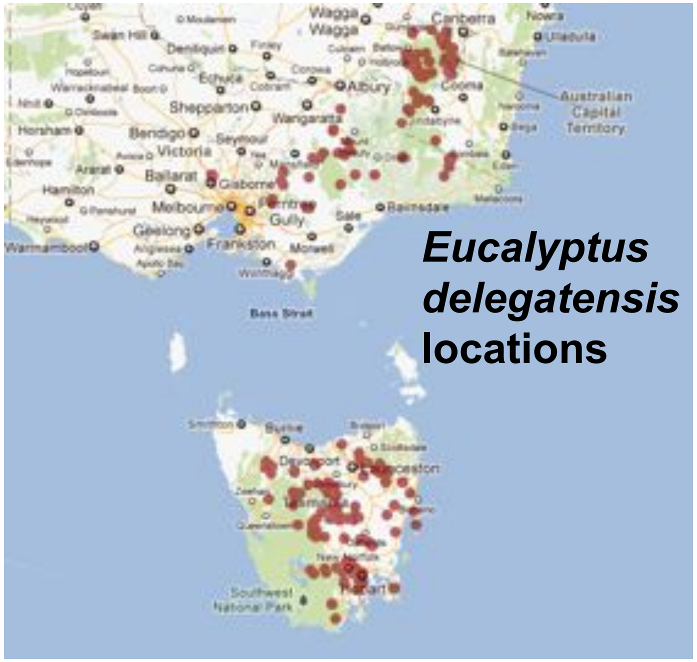
Ecological Model	• What ecological theory is assumed or tested?
Data Model	• Are there any limitations imposed by the nature of the data used?
Statistical Model	• Are the statistical procedures and methods used compatible with ecological theory?

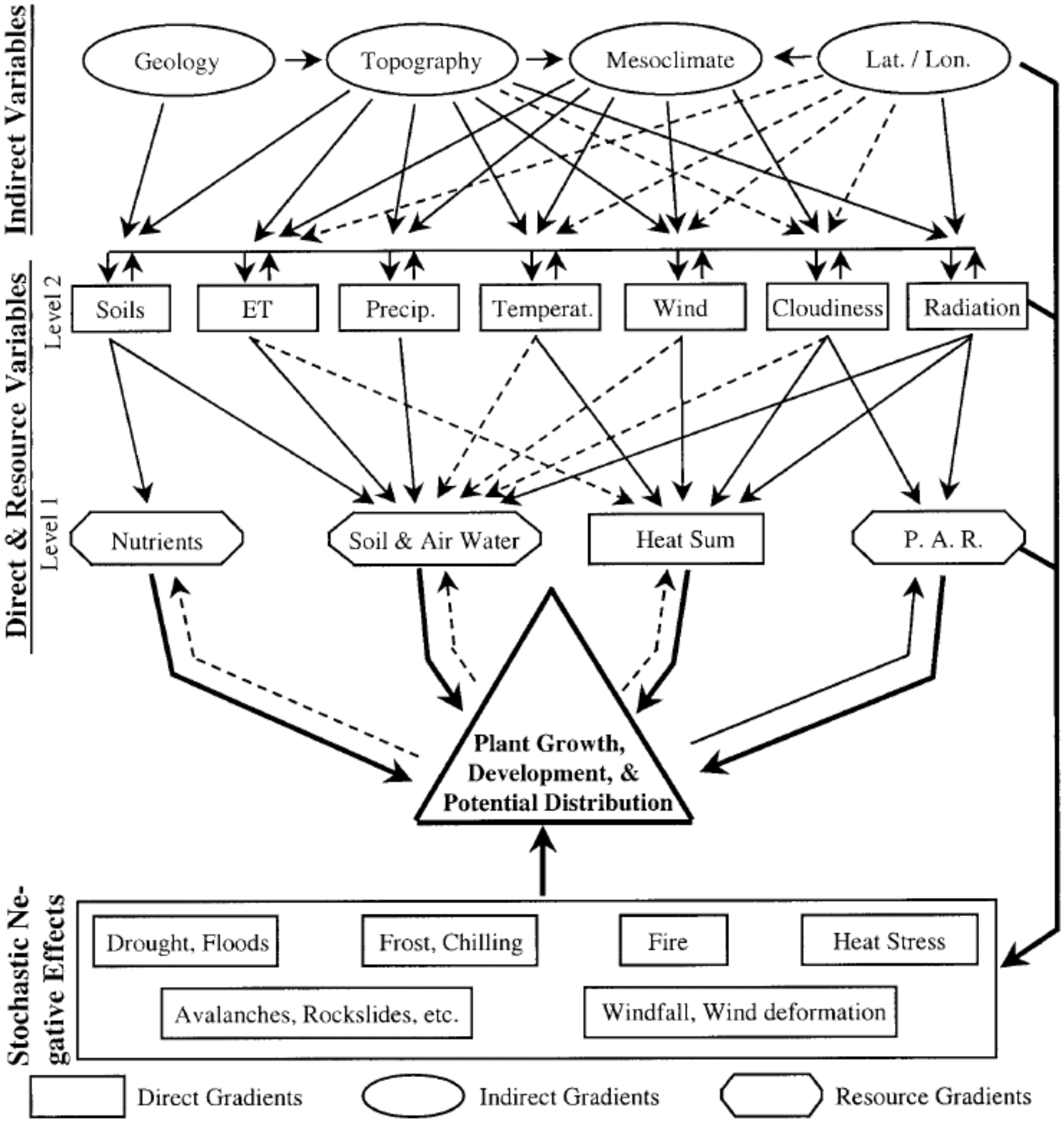
Austin, M. P. 2002. *Ecological Modelling, 157: 101-118.*
Austin, M. 2007. *Ecological Modelling, 200: 1-19.*

Basic components informing the choice of environmental layers for a data model

- Purpose (location, study species, response variable) – informs the extent and resolution of environmental layers to compile
- Applicable ecological theory – informs the scope and type of environmental layers to compile and evaluate
- Applicable statistical model – informs the format of layers and procedures for selecting environmental layers to include/test

Best demonstrated using a case study, plant species





Guisan & Zimmermann, *Ecological Modelling*, 135: 147 (2000), Fig. 3

An attempt to structure the problem for plants

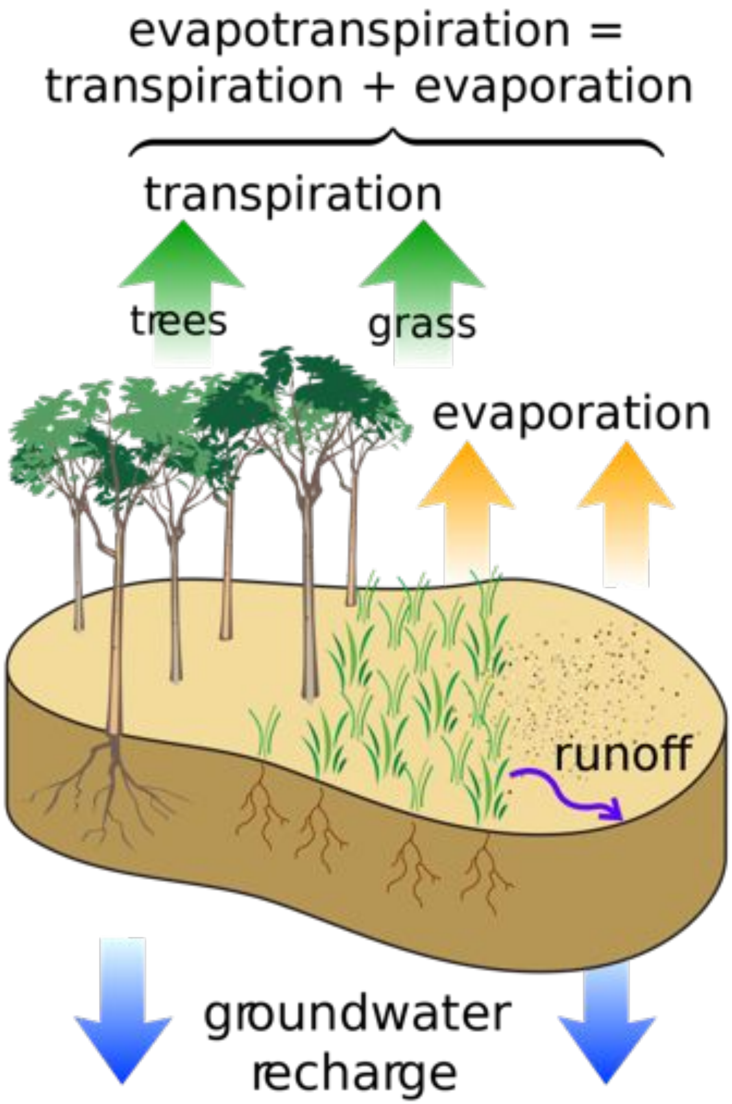
But lots of potential factors or their proxies to compile and consider in a model, including outputs from biophysical process models, with variable quality and correlations

Over 100 layers to choose from in the ALA

A wide range of National 1km gridded environmental variables in the ALA spatial portal

- Climate variables
  - Mean conditions of evaporation, precipitation, minimum and maximum temperature, wind, humidity, solar radiation (ANUCLIM derivatives)
- Disturbance regimes
  - Fire frequency and mean climatic extremes (proxies for drought, flood, frost, heat, etc)
- Soil variables
  - Soil depth, clay%, bulk density, hydraulic conductivity, structure, water holding capacity, calcrete, nutrient status, etc (derivatives of the Atlas of Australian soils)
- Geoscience variables
  - Geological age and inherent fertility (derivatives of the 1:1M National Geology), and geophysics - gravity and magnetics
- Terrain variables (DEM derivatives)
  - Slope, aspect, elevation diversity, topographic position, wetness indices, multi-resolution indices, etc

The role of biophysical process models: e.g., Environmental water predictors

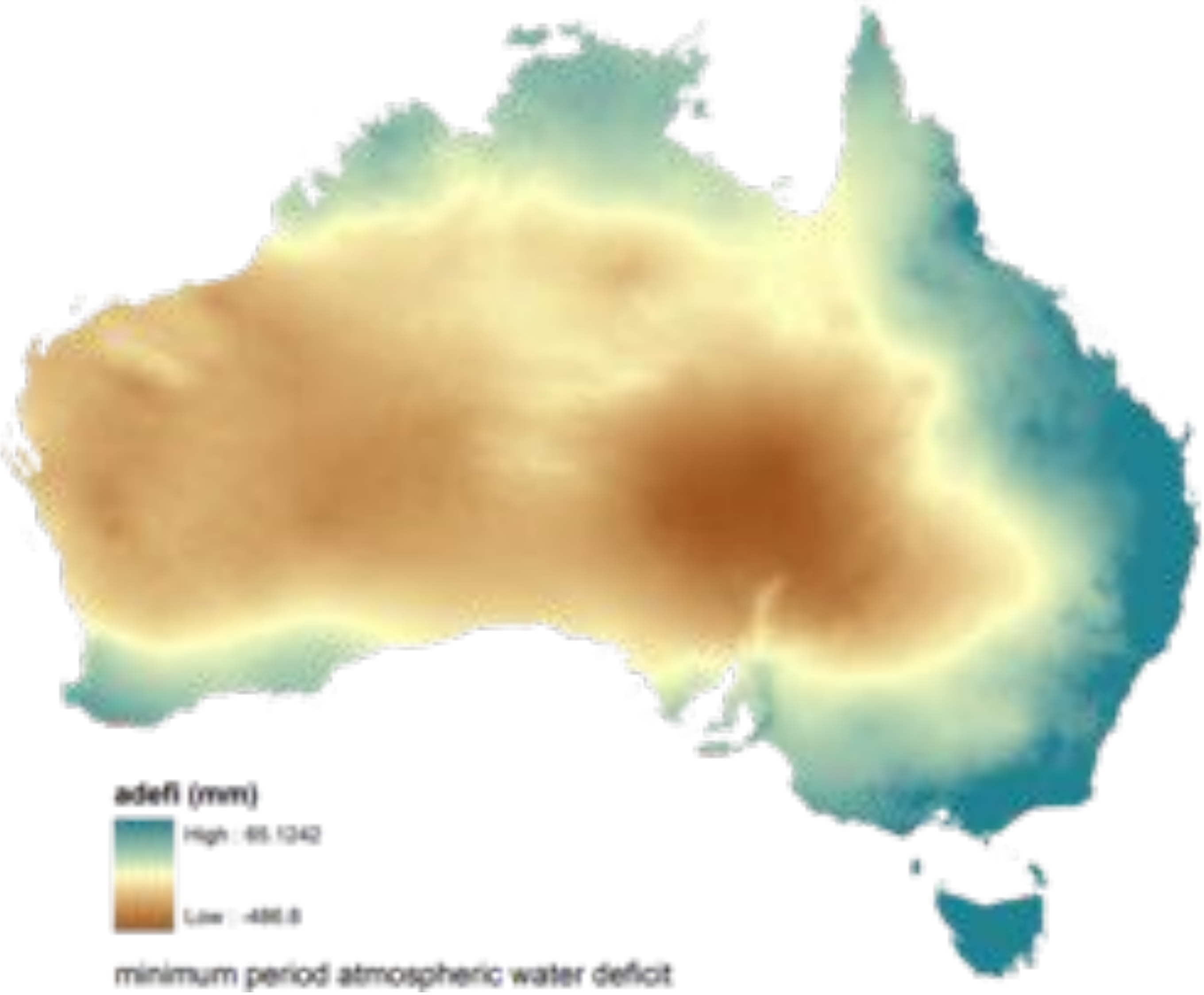


It is good practice to develop physiologically-relevant predictors

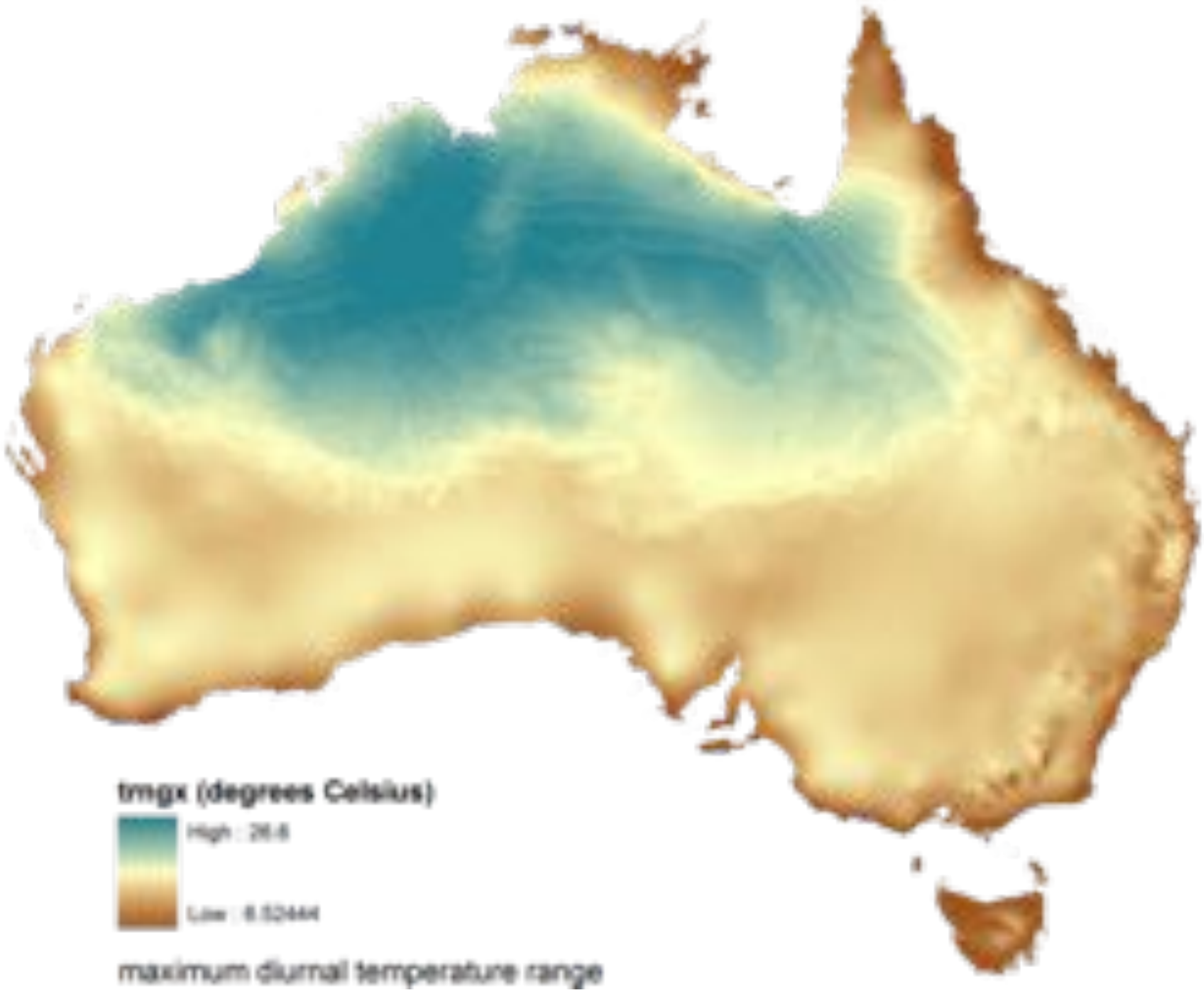
Water balance models potentially reduce a large number of predictors to just a few

But the outputs can be confounded by poor resolution and inaccuracy of soil parameters

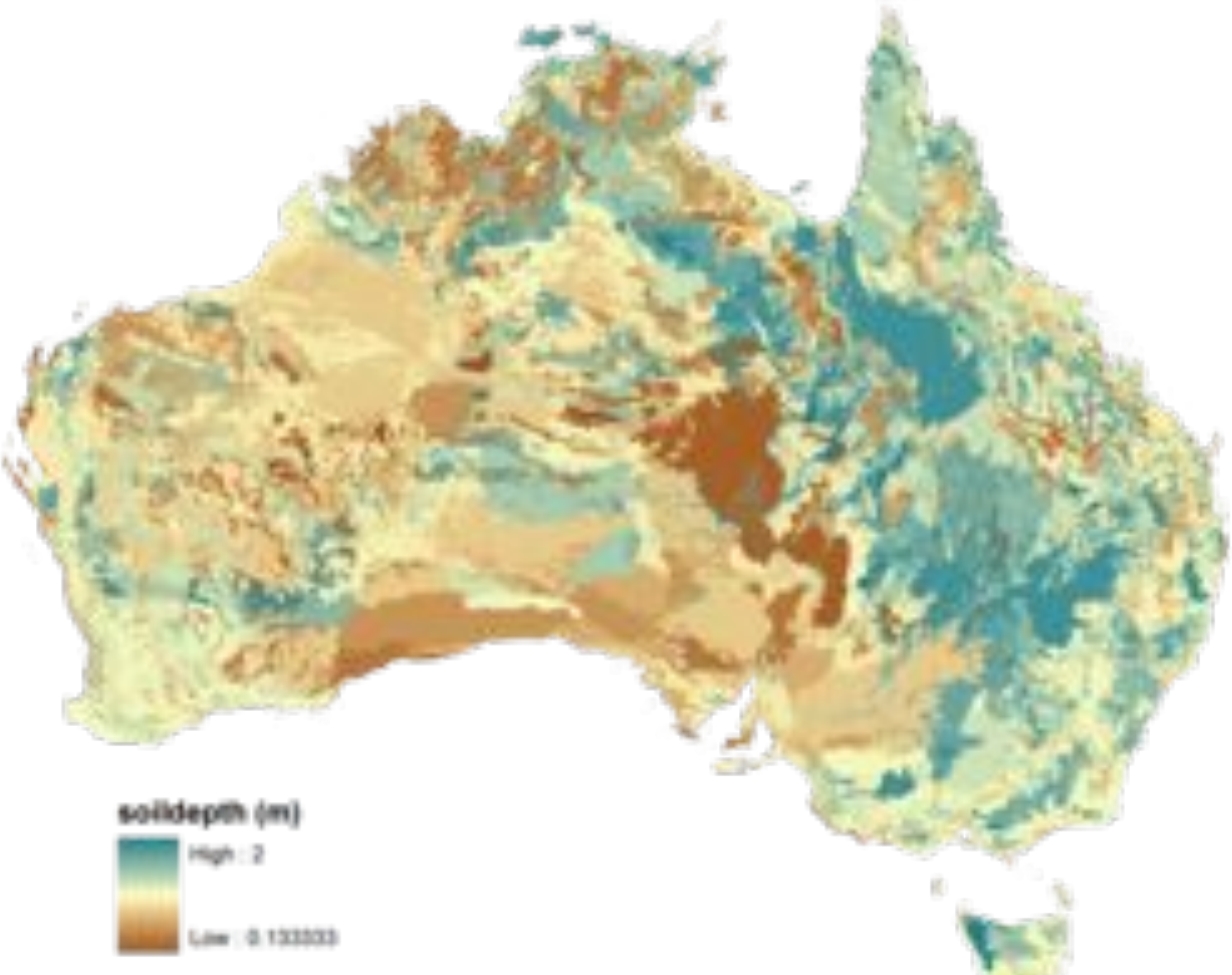
Example variables: water (P-E)



Example variables: diurnal temperature range

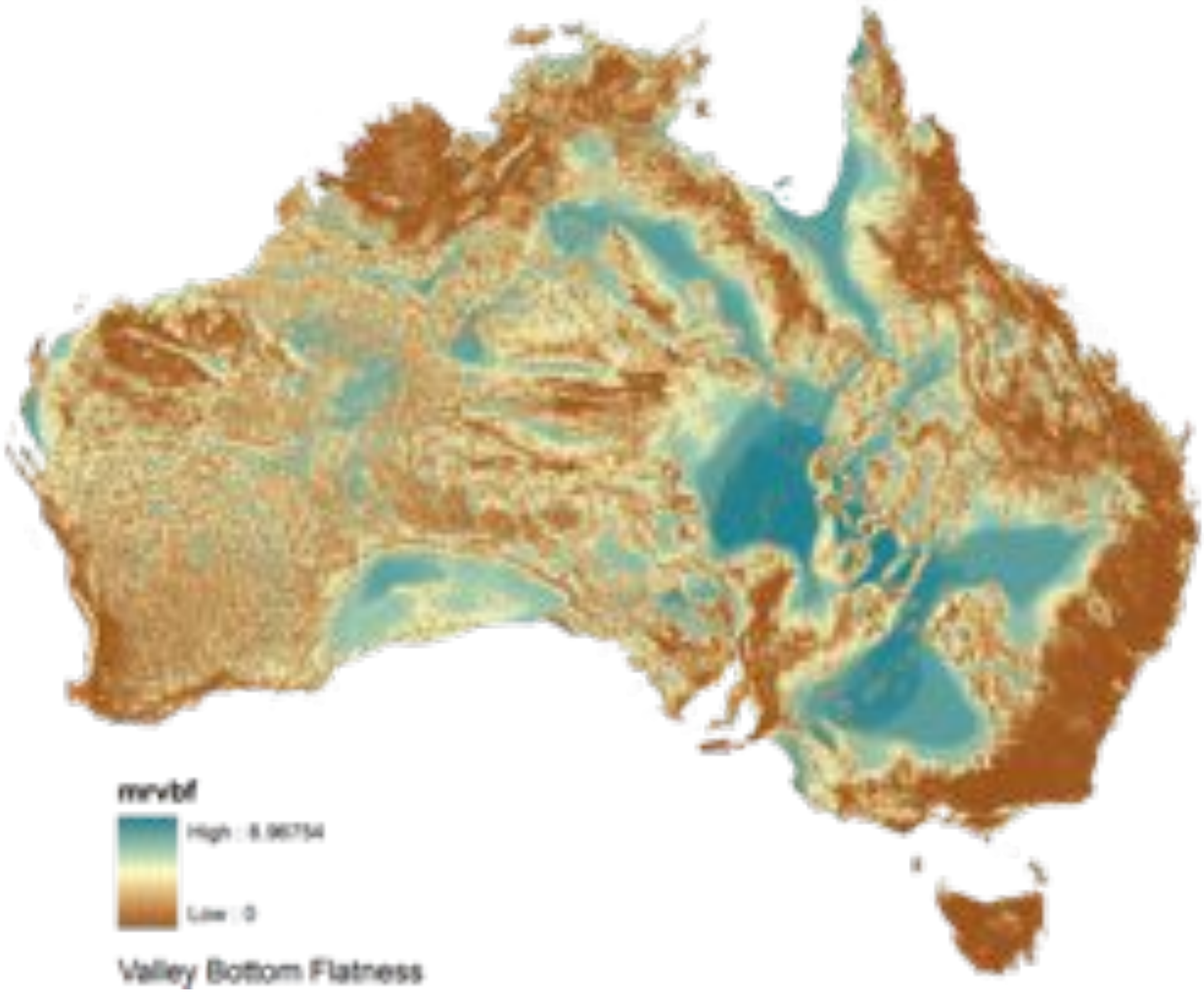


Example variables: soil depth

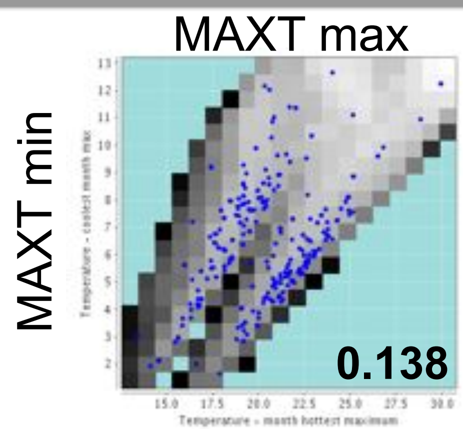


solum depth (Atlas Australian Soils)

Example variables: DEM multi-resolution indices

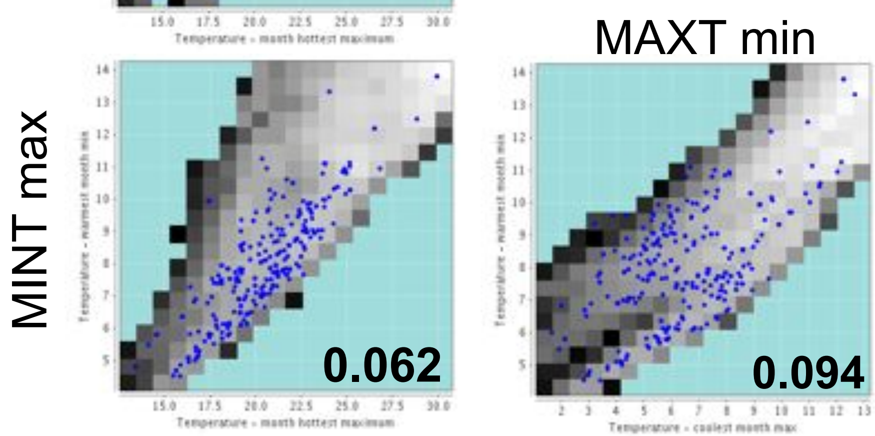


Example scatter plots from ALA spatial portal – minimum and maximum temperatures



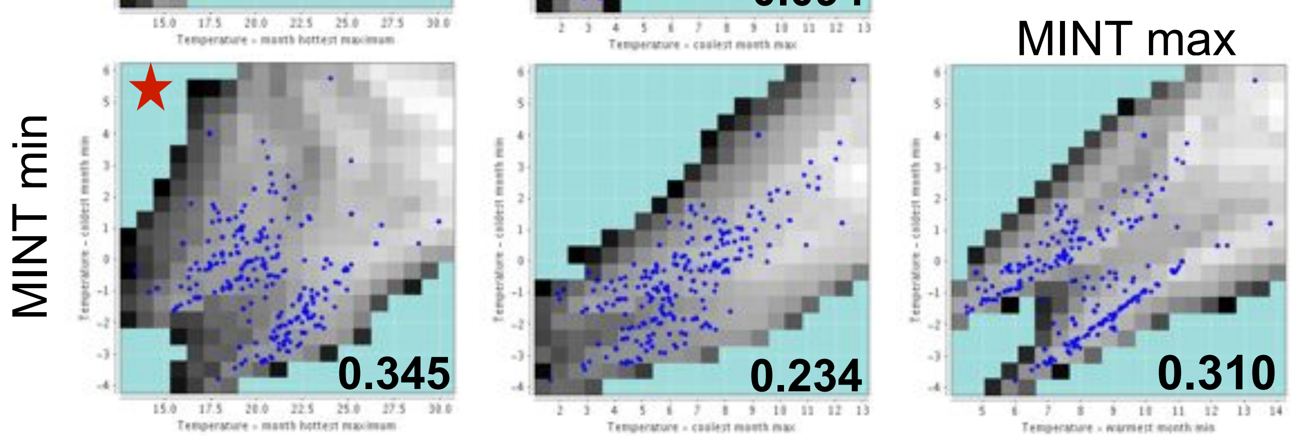
Blue points: species (*Eucalyptus delegatensis*)

Grey scale: extent of environment in Australia
(white grids correspond to a large area, black grids represent a small area)



Blue space: beyond background environments

Numbers: inter-layer association
0 = identical, 1 = entirely different



* Extreme ends of the gradient are more independent

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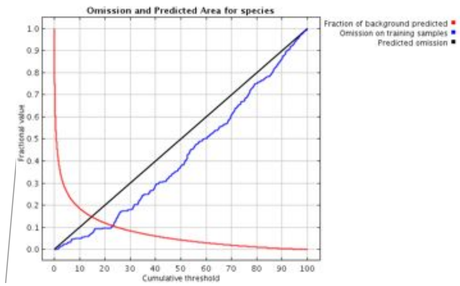
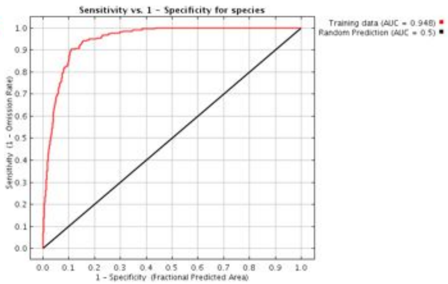
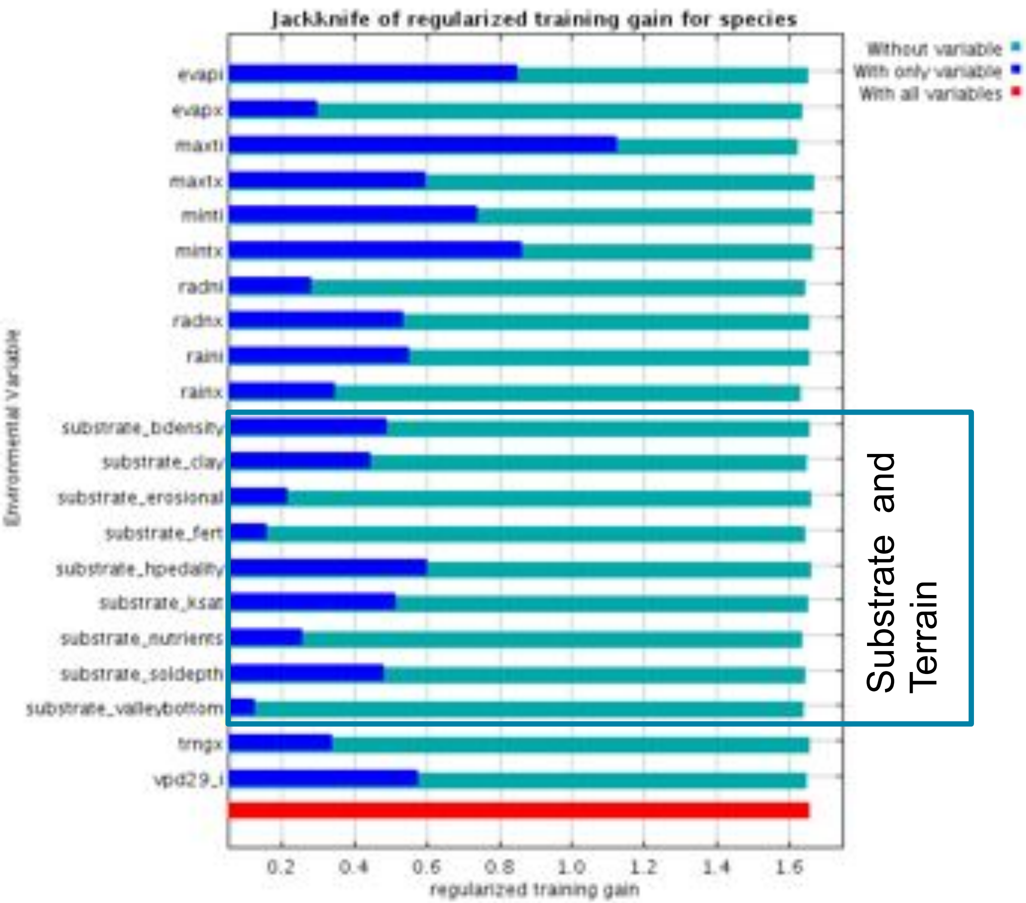
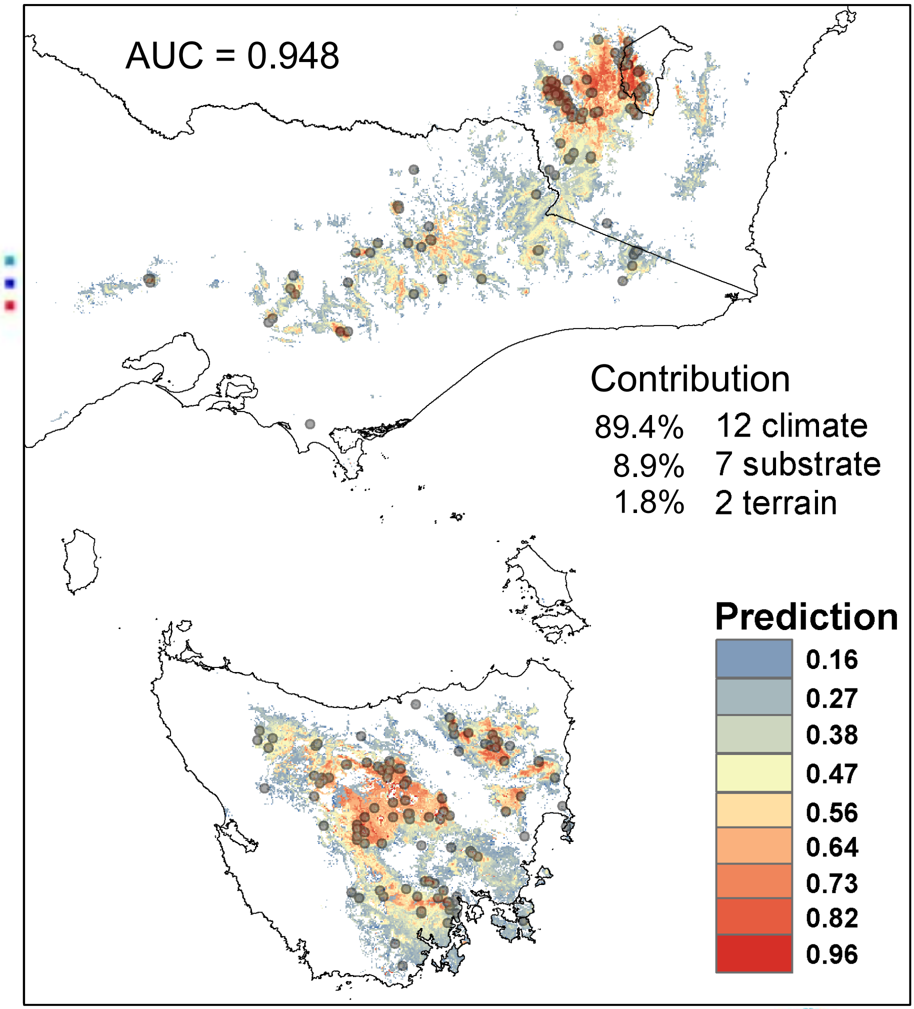
Example ALA output: MaxEnt model prediction







Maxent model: *E. delegatensis*



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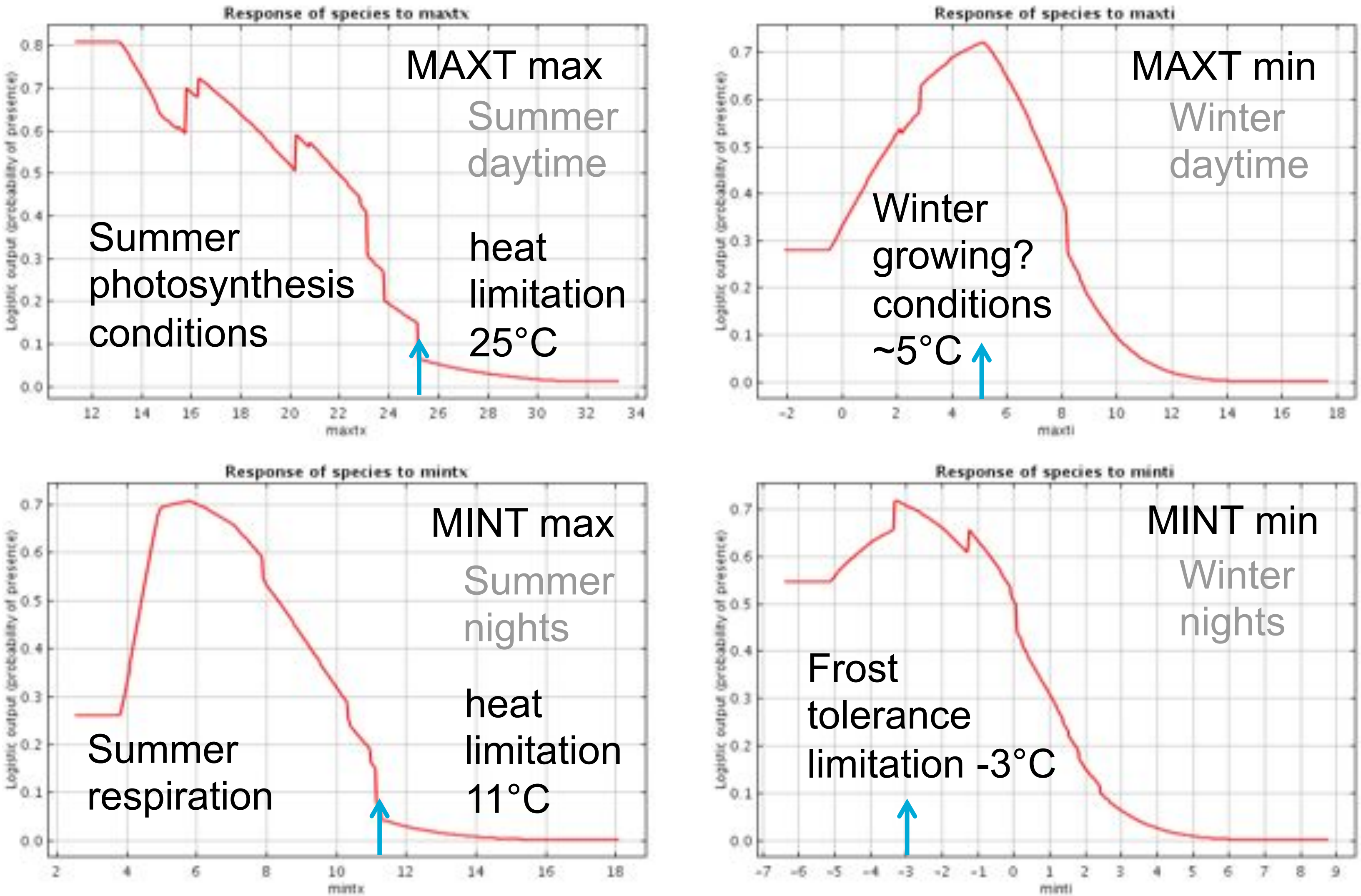
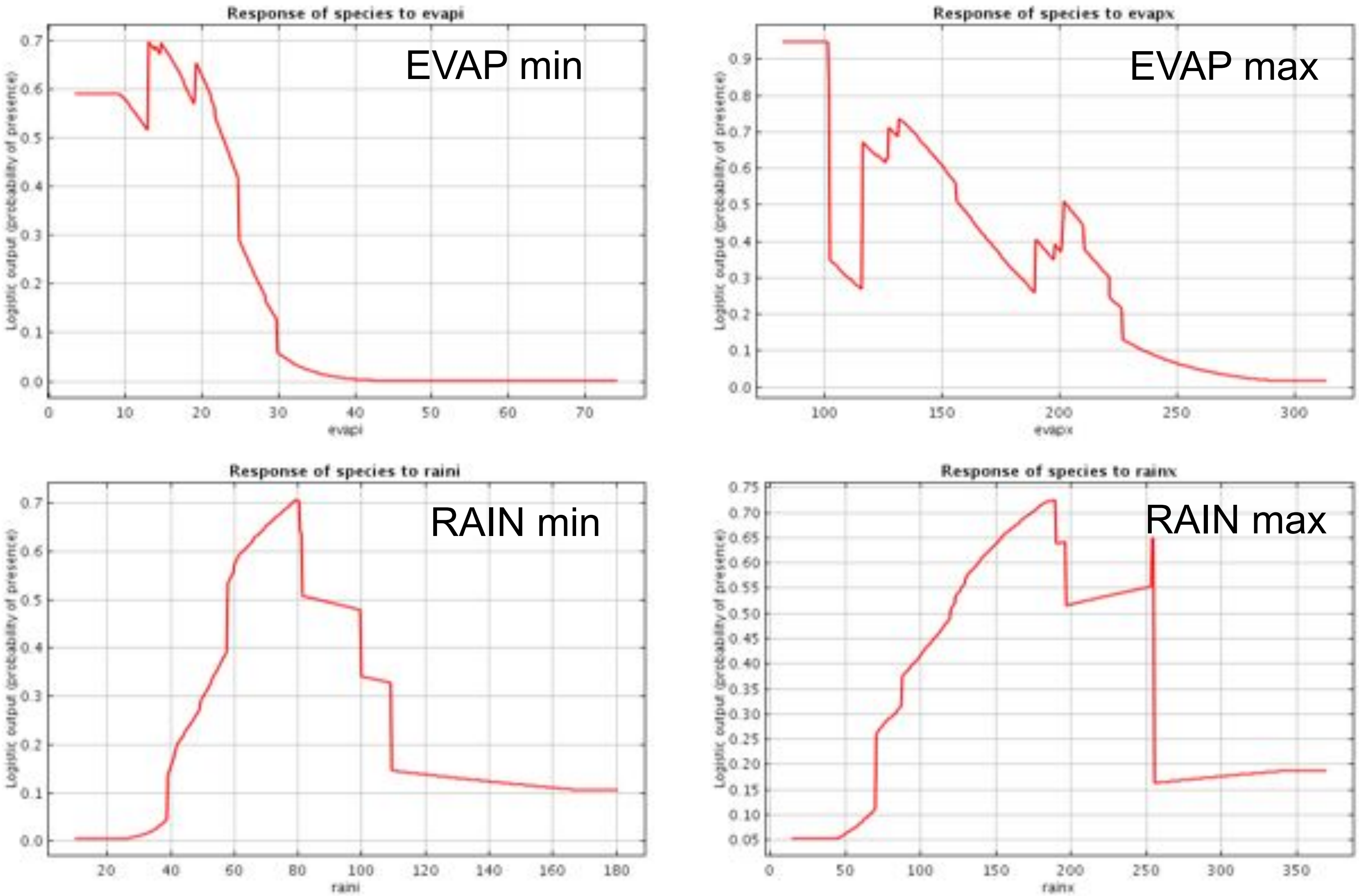
Indicative physiological parameters?



Maxent models created using only the corresponding variable

Rainfall and evaporation? Would atmospheric water deficit be more ecologically meaningful?



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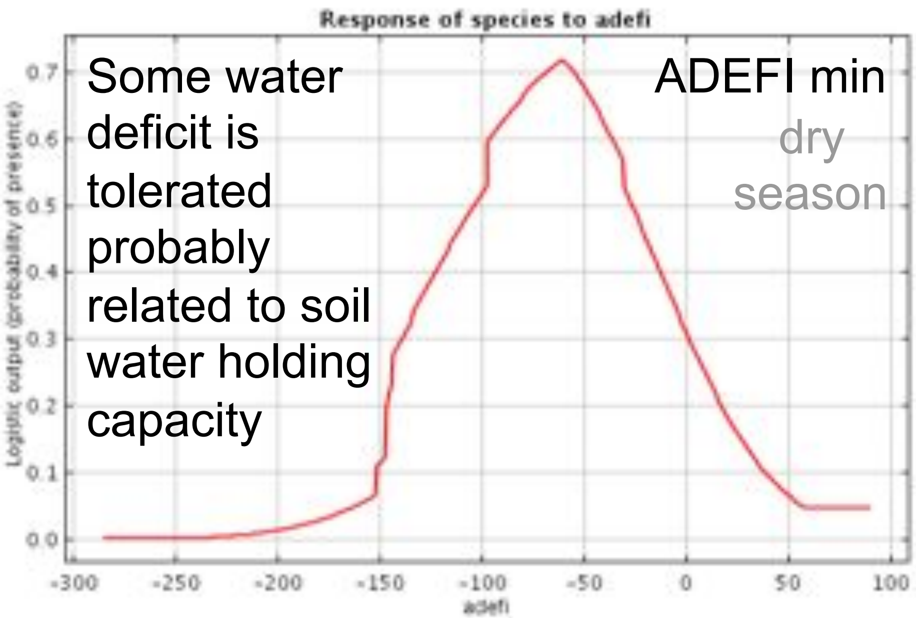

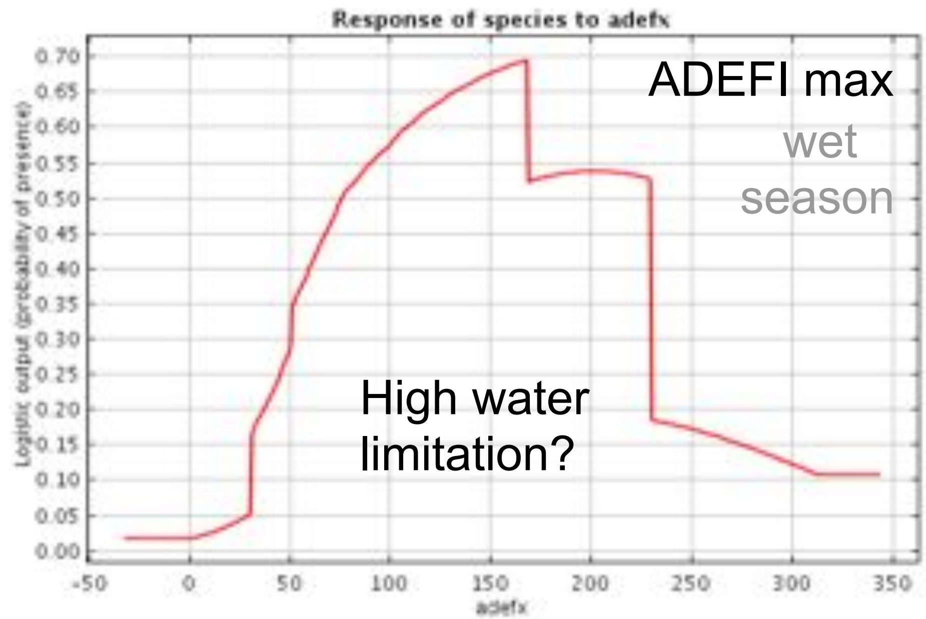

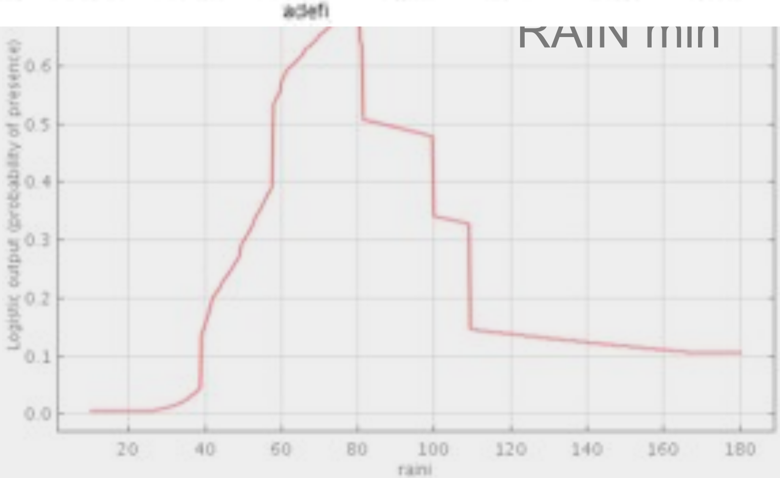

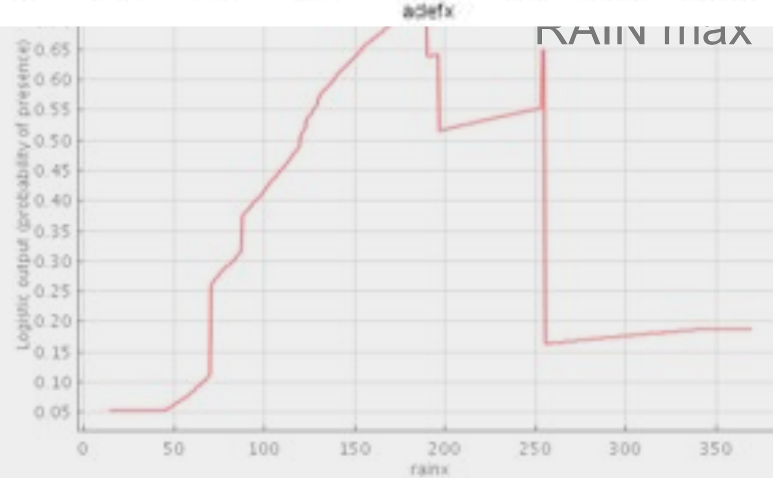

Maxent models created using only the corresponding variable

Principles for selecting environmental layers

- Adopt explicit ecological rationale based on theory (purpose)
- Note whether the variable is a direct or indirect driver of distribution patterns, proximal or distal to physiological process
- Use logic and scatter plots to explore correlation patterns between variables to understand origins and which are relatively independent
- Develop a hypothesis-driven framework for successively including variables in a model (initial set and supplementary to test residuals)
- Avoid combining variables that are self-excluding alternative sets (e.g. rainfall and evaporation, atmospheric water deficit)
- Iteratively revise your understanding of the environmental layers through the practice of model building, note effective combinations
- Visualise results in both environmental and geographic space and link to ecological rationale (potential physiological optima and limits)

Conclusions

- No simple solutions, but ecological theory adds structure to the process of identifying, evaluating and selecting layers
- Biophysical process models improve reality (more proximal predictors), but gains may be offset by inaccurate, incomplete or low resolution input parameters: use simple, interpretable variables
- Scatter plots and model testing with explicit subsets in a hierarchical or structured way, is an iterative learning process
- Above all – know how your layers were generated (metadata), critically evaluate their utility and encourage new developments
- This presentation has focused on terrestrial environments, but the same applies to other environments: marine and freshwater, etc

CSIRO Ecosystem Sciences
Kristen Williams
Ecological Geographer

Phone: 02 6246 4213
Email: kristen.williams@csiro.au
Web: www.csiro.au

Eucalyptus delegatensis canopy

www.csiro.au

Thank you

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