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Regional modelling of vegetation distributions in Australia

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Reef & Rainforest RESEARCH CENTRE

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Prerequisites to success

- **A "proper" vegetation classification for the objectives**
- **An appropriate modelling method for the objectives**
- **Careful data selection for training/fitting including an appropriate range of environments and veg. types**
- **Careful verification and awareness of limitations**
- **Creative use of the model incorporating all ecological knowledge**

'It s better to have the right combination of ecological expertise, local knowledge and statistical skills in the team than to be using the current "best method"'.

Austin *et al.* 1995

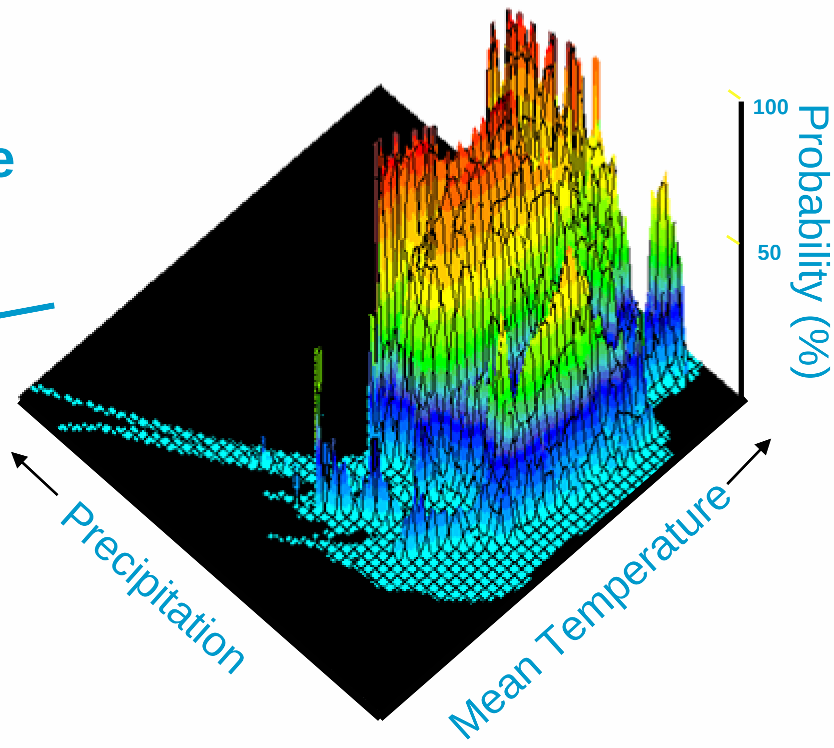
Empirical modelling method

spatial distributions of environmental variables

spatial distributions of vegetation classes, functional types or species

frequency distributions of vegetation in environmental space

modelling



generalized suitability of environments for each veg. type

vegetation map

Common modelling approaches

Generalised Linear Models (GLM), Generalised Additive Models (GAM), Classification and Regression Trees (CART), and Artificial Neural Networks (ANNs)

Uses –

pre-clearing vegetation

regional climate change impact assessment

palaeoecology

GAMs

Austin et al. 2000. Predicted Vegetation Cover in the Central Lachlan Region

Objective: pre-clearing vegetation map

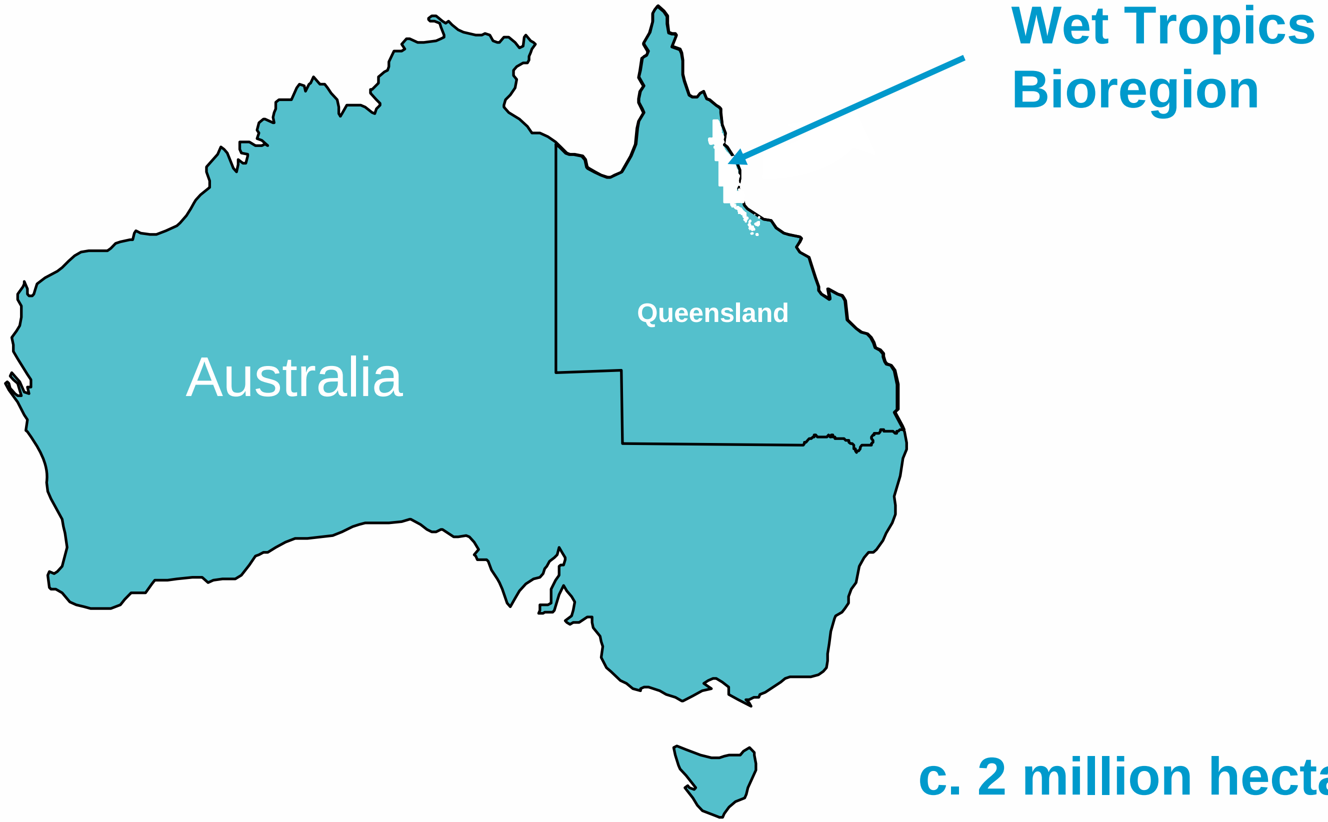
2530 plots, 223 species

1. **Vegetation classified into 75 “communities”**
2. **Statistical modelling – used GAM to predict % cover of 135 species based on climate, topography, geology and soil variables**
3. **Predicted species distributions**
4. **Used the predicted distributions and the classification to map the vegetation communities**

Wet Tropics of NE Queensland Artificial Neural Network example

- **Challenges – why an empirical (black box) approach?**
- **Value of a structural vegetation classification**
- **The Neural Net Classifier**
- **Testing**
- **Using all the information – various indices**
- **Applications/further testing**

The Wet Tropics Bioregion



c. 2 million hectares

Wet Tropics Bioregion

The Wet Tropics Bioregion has:

high relief (0-1600m)
recent volcanism
rich soils
very high rainfall
very high biodiversity









Modelling difficulties in rainforests

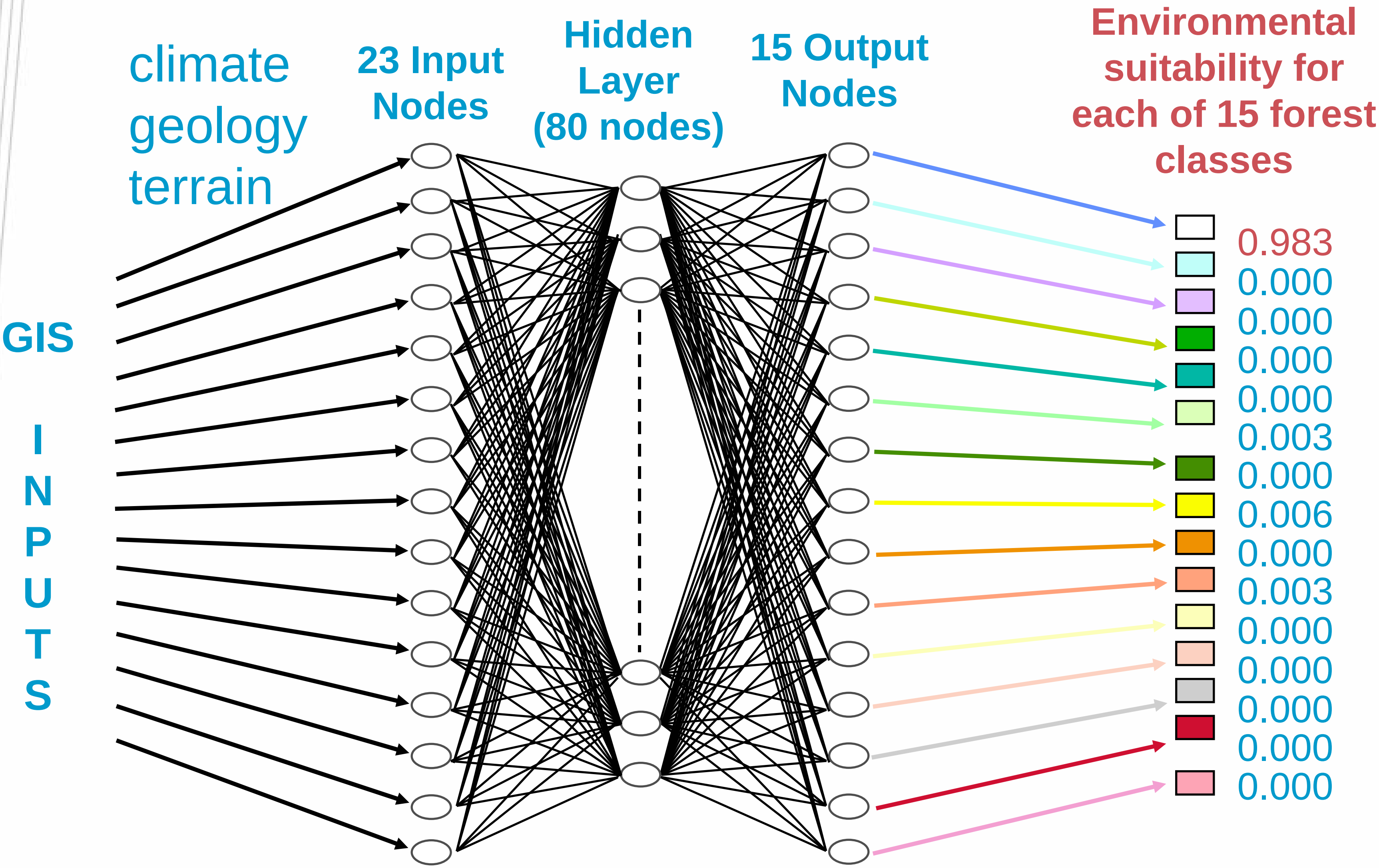
- > 800 species of tree species in c. 80 families
- Not all described and named
- Limited and often biased biogeographic information
- Very poor autecological knowledge even for the best studied, economically important species
- No useful plant functional type classification in rainforests
- Lack of predictive theoretical models
- **=> Mechanistic approaches are impossible - empirical approaches, focused on vegetation structure might be useful – used artificial neural network model (classifier)**

“Proper” classifications of vegetation is essential

- Len Webb’s physiognomic/structural classification of RF, Specht’s classification for sclerophyll forests
- Physiognomic and structural characteristics of forests in the Wet Tropics are controlled by local environments (climate, topography, soils)
- Largely, these features are not determined by floristics

- => useful in recent past and near future (-18kyr to +50yr)

ANN Structure **parametric and nonlinear**



Hilbert & van den Muysenberg 1999

Advantages on ANNs

- **Advantages = Disadvantages**
- **Not analytical, no hypothesis testing, no assumptions, very good predictors with sufficient data**

Data sampling is a key element
Supervised Training

Training Set

75 000 pixels, stratified random proportional to $\sqrt{A_f}$

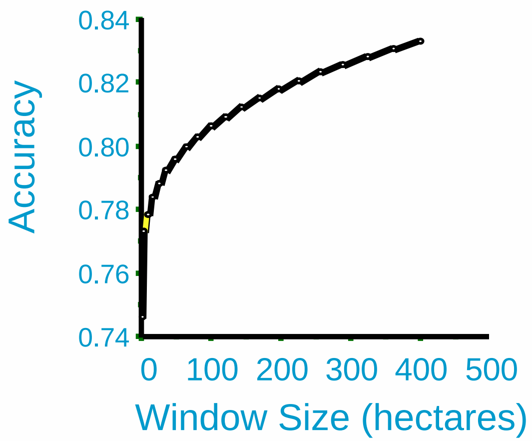
4.3% total forest area

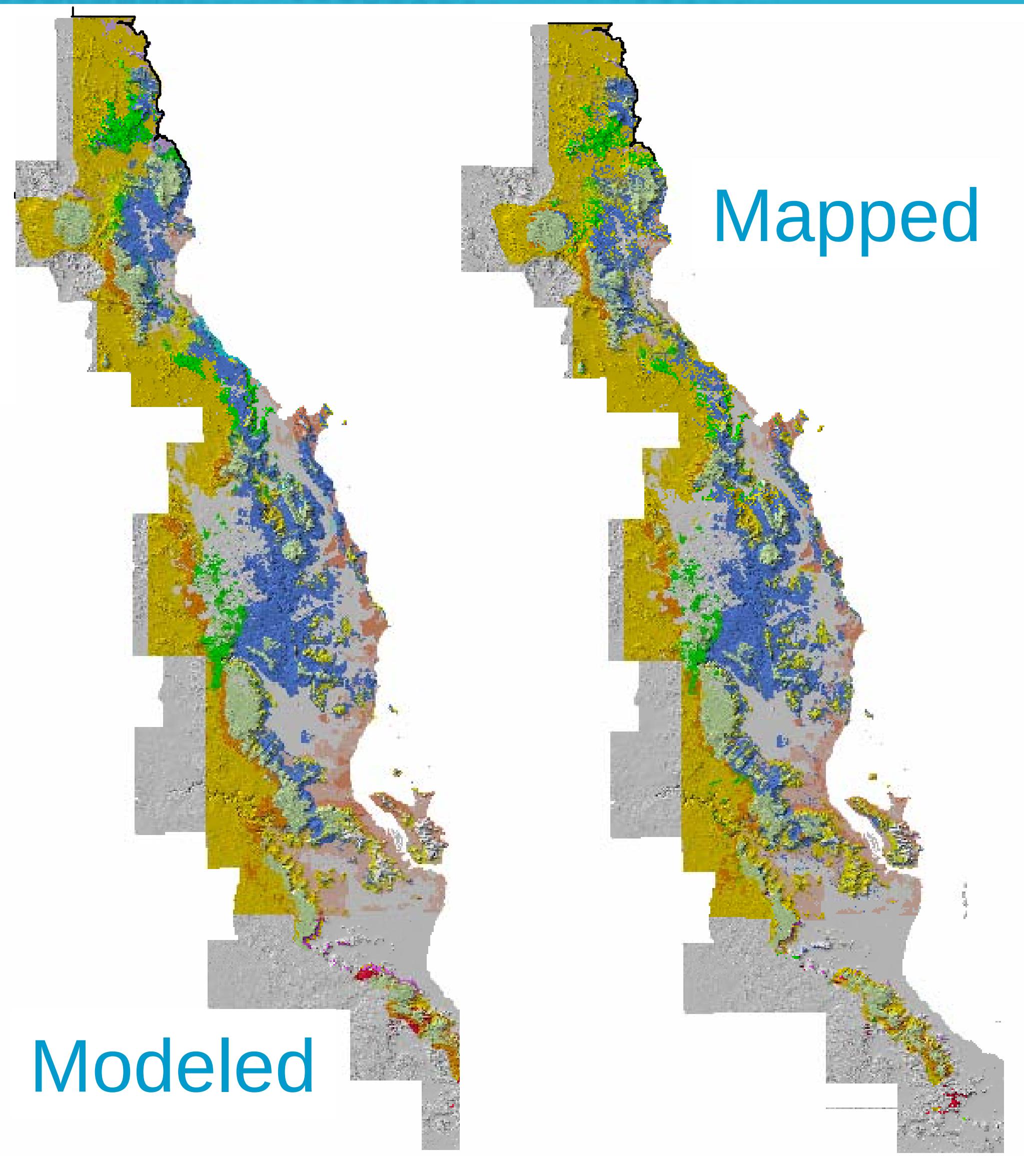
This equalized error among vegetation types with orders of magnitude differences in area

Accuracy

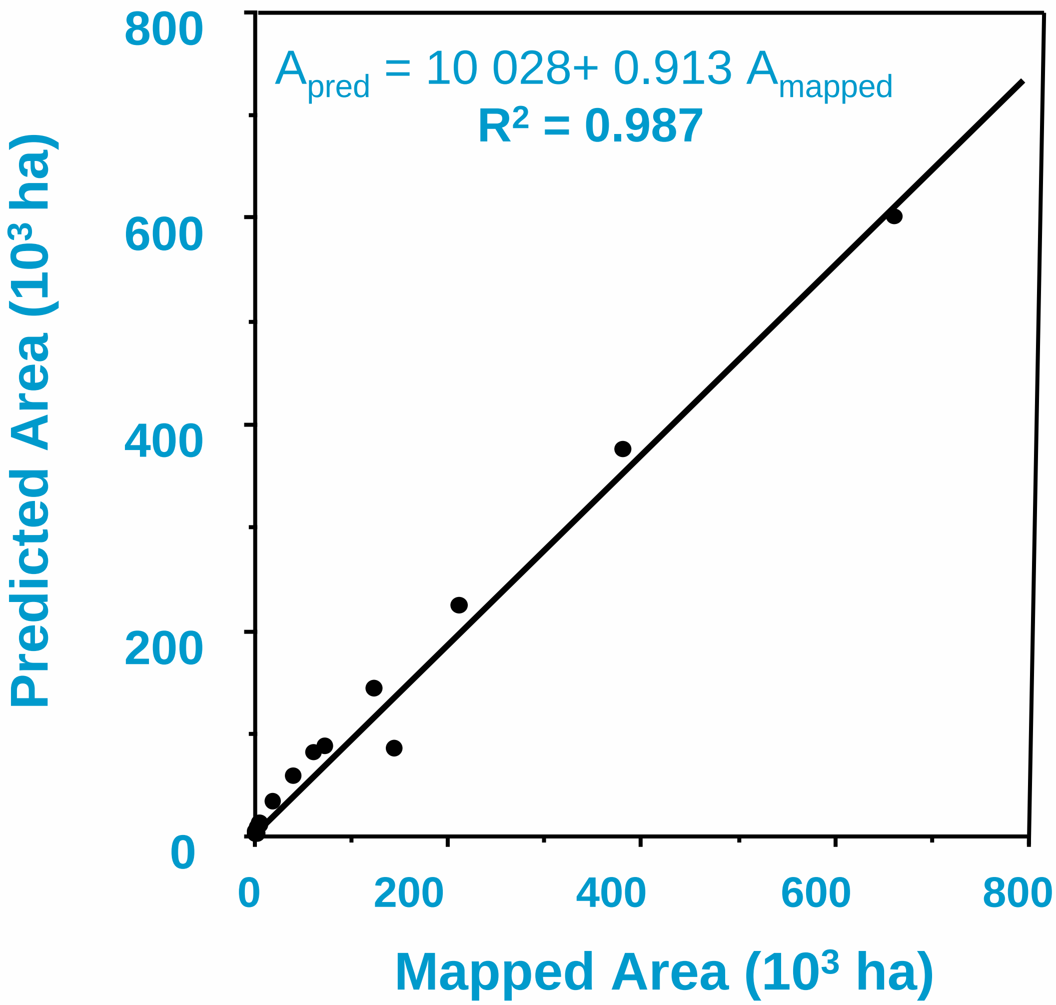
75%
at 1 hectare
resolution

Accuracy
increases at
coarser scales

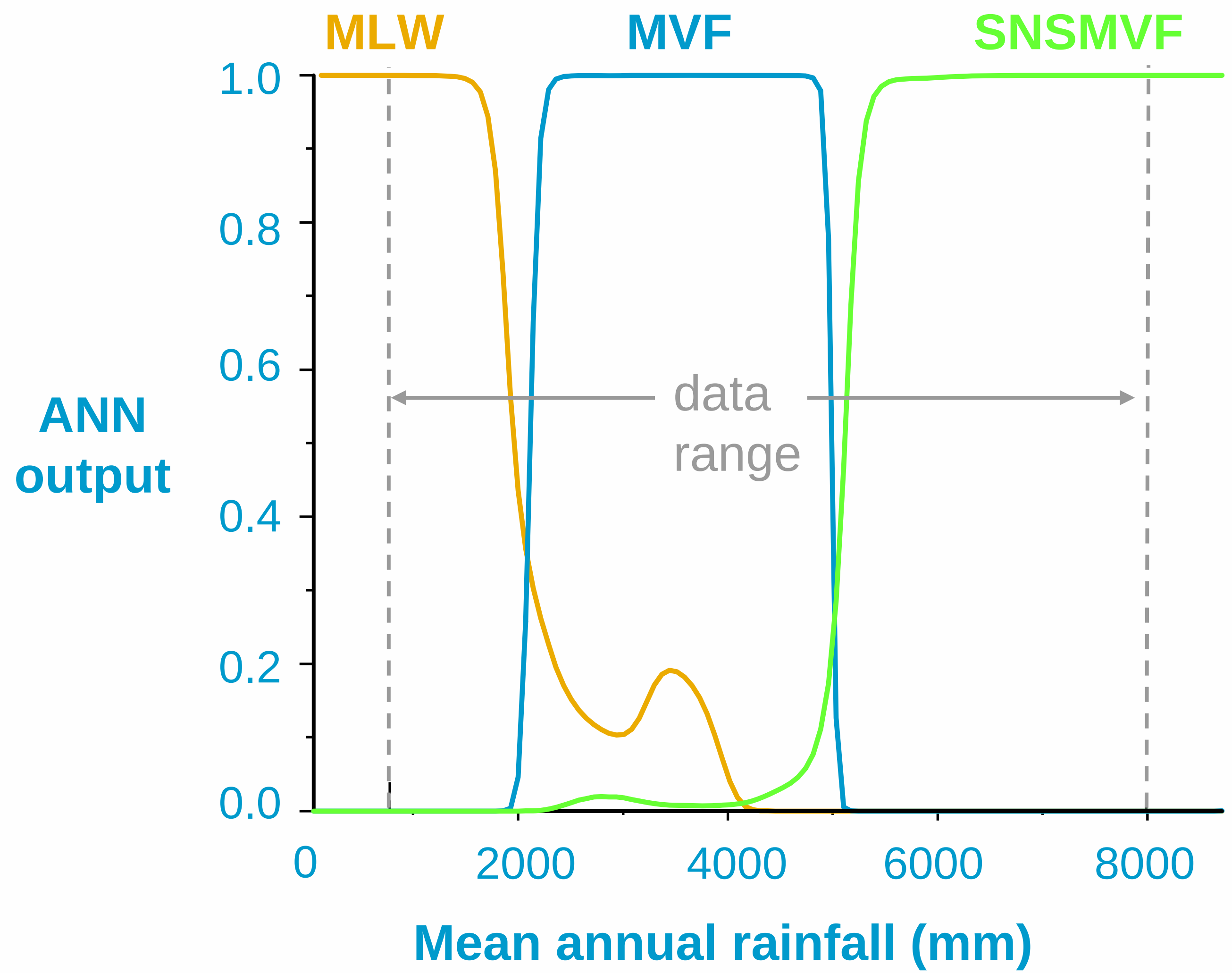




Total areas of each forest class are predicted very well



ANN Responses nonlinear, “well behaved”

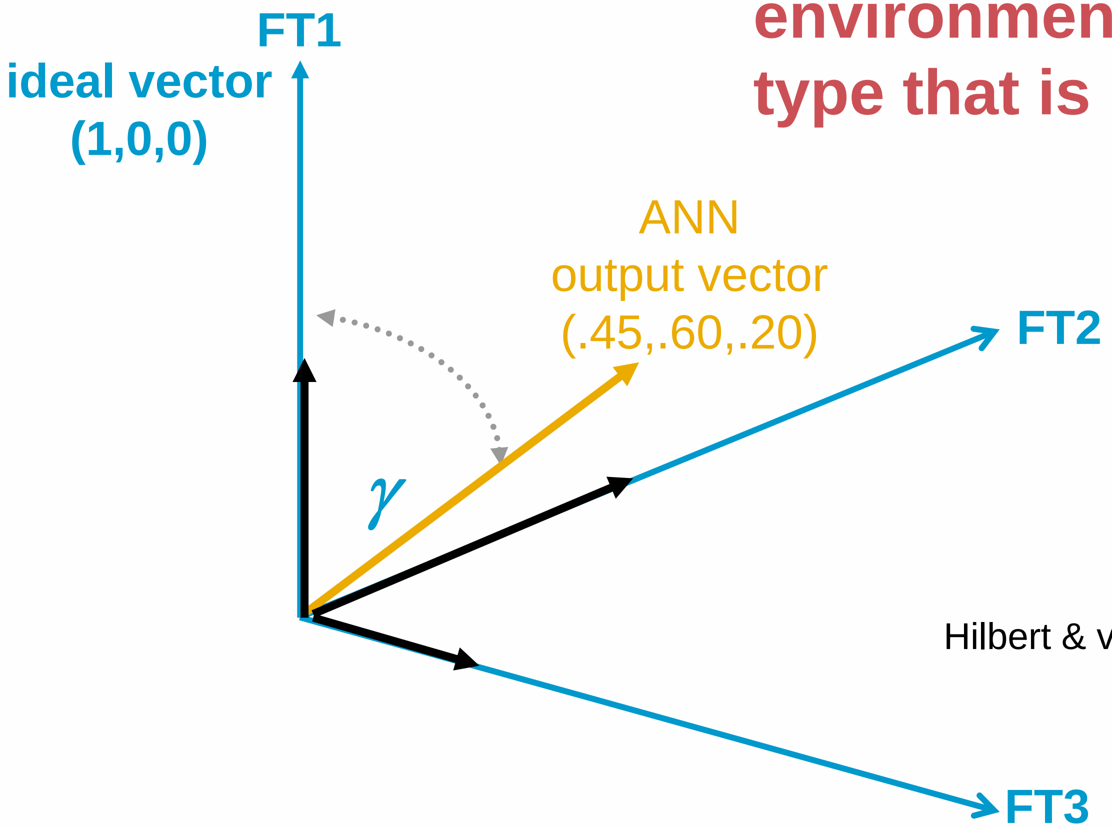


Additional, derived indices are useful

- **Dissimilarity – index of stress**
- **Probability of occurrence**
- **Conversion sensitivity – considering climate change uncertainty**

Index of Dissimilarity

How "ideal" is the local environment for the forest type that is mapped there?



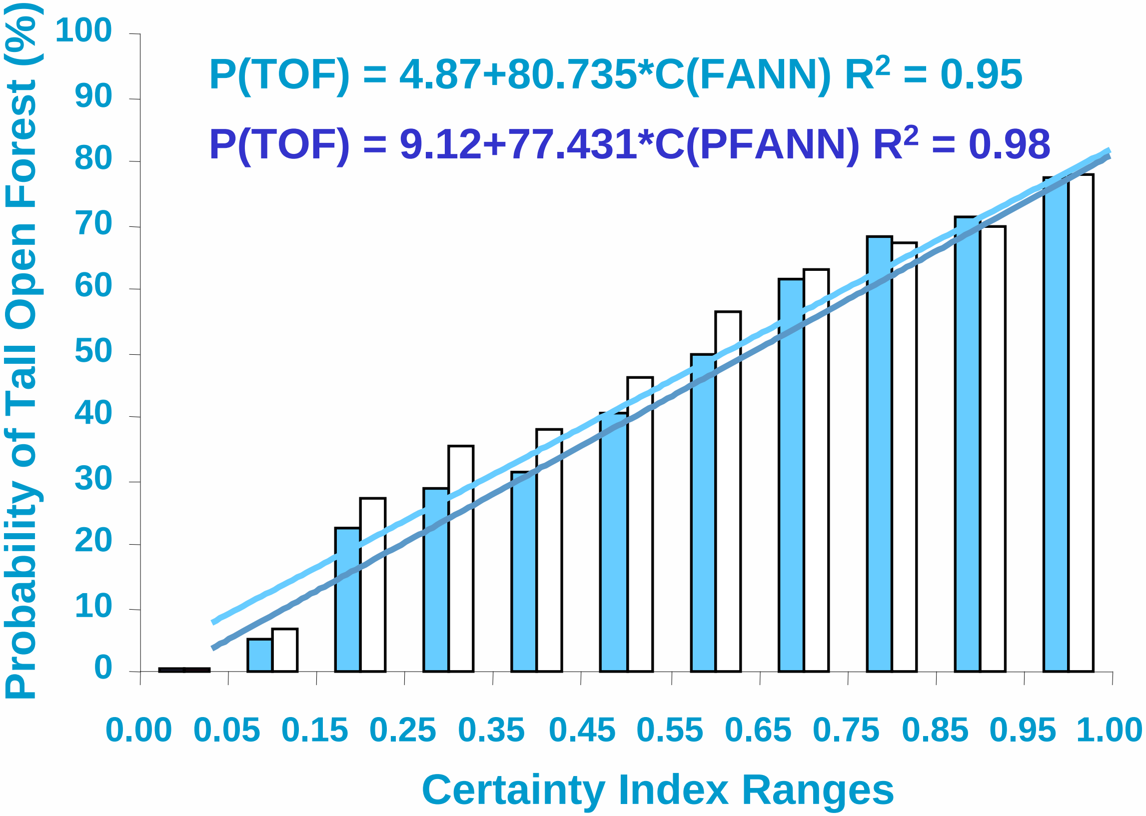
Hilbert & van den Muysenberg 199

the index of dissimilarity is γ divided by $\pi/2$ to normalize the index to the range [0,1]

Spatial estimates of the probability of finding a forest class

Certainty Index = ANN output TOF node x $\frac{\text{output TOF node}}{\text{sum all output nodes}}$

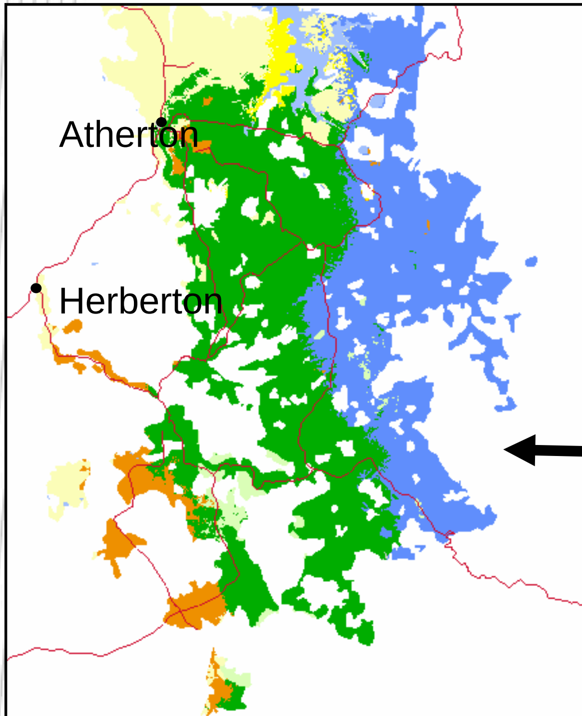
For a range of certainty values - number of pixels that are Tall Open Forest/ total number of pixels

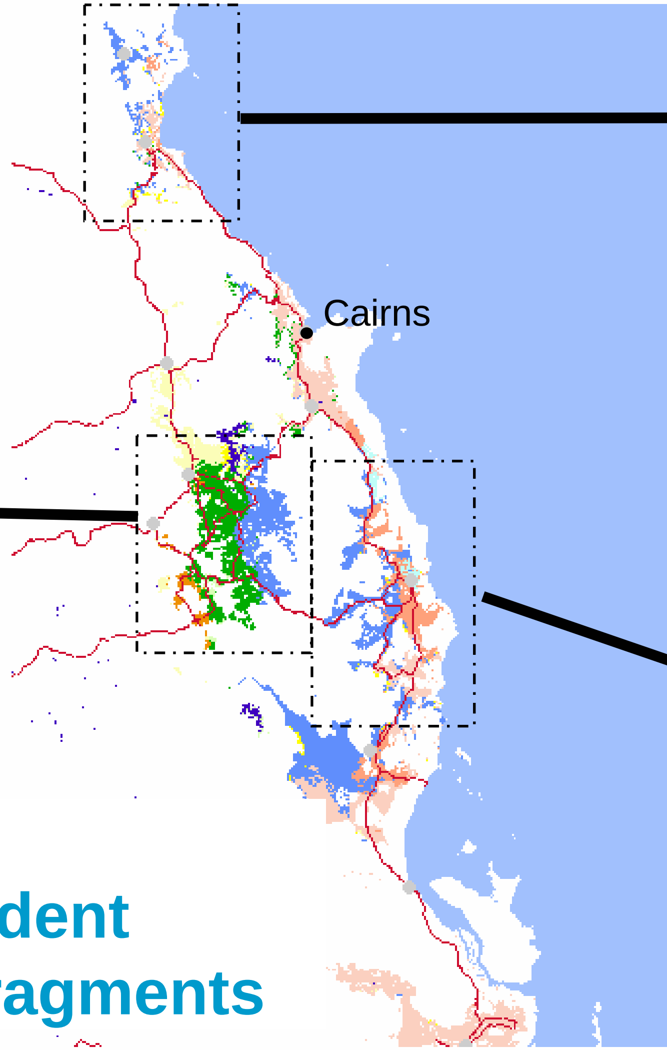


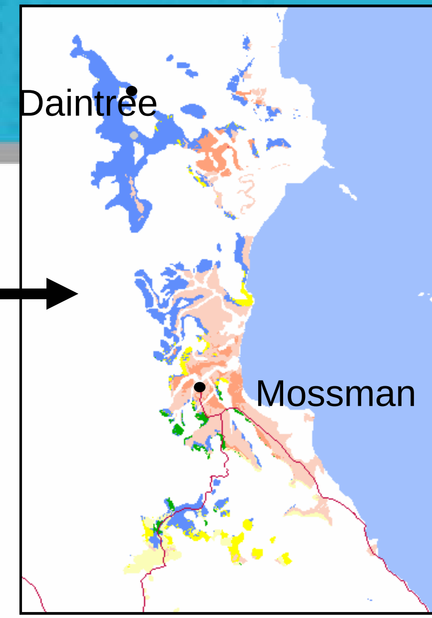
Applications

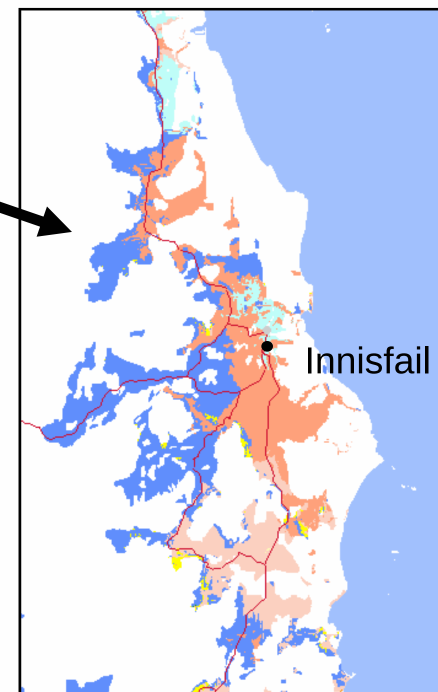
- Pre-clearing forest distributions
- Palaeo-distributions
- Landscape sensitivity – refugia
- Future climate change
- Linking with Cellular Automata

Pre-clearing





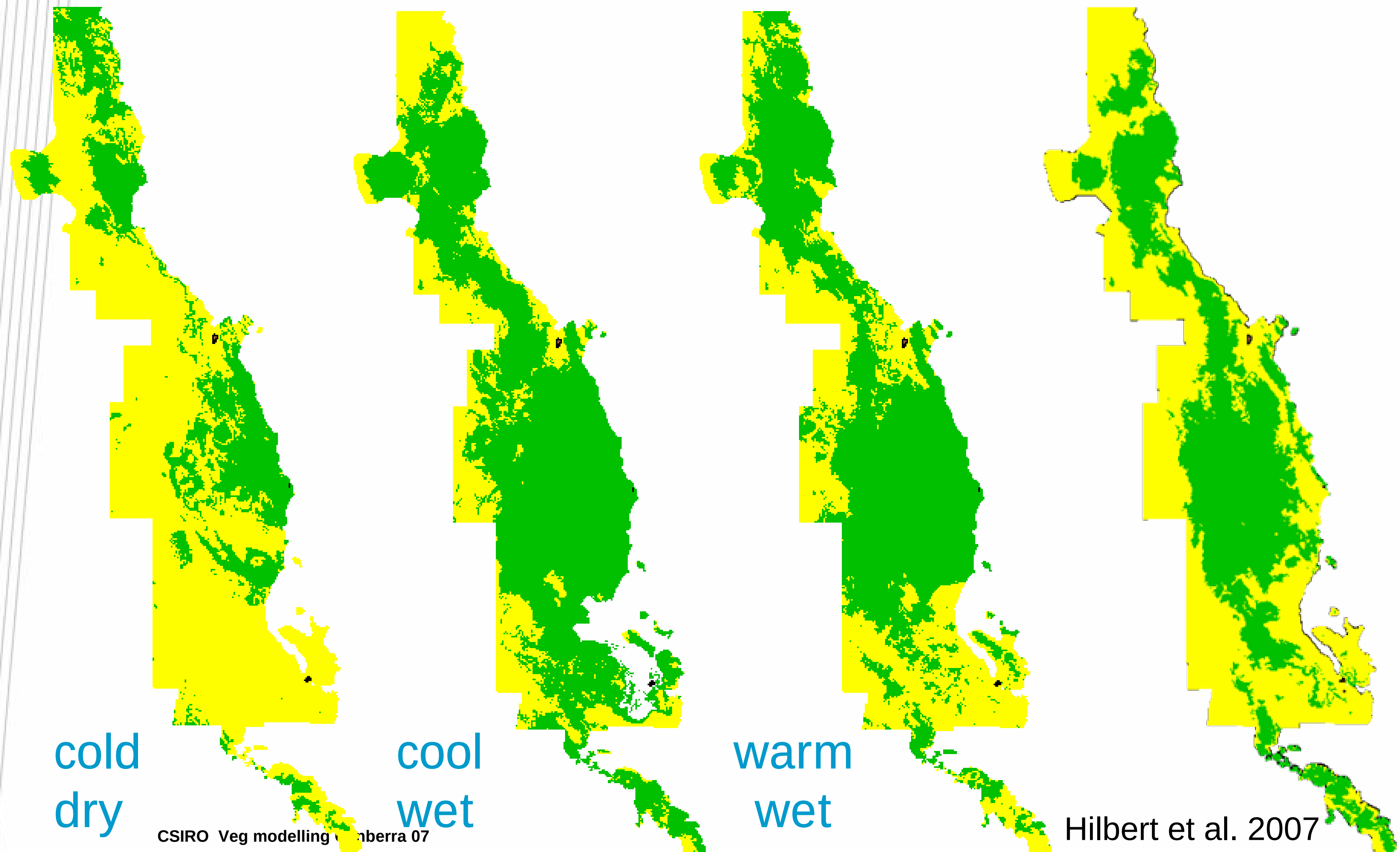




88% accuracy when tested with independent mapping of forest fragments

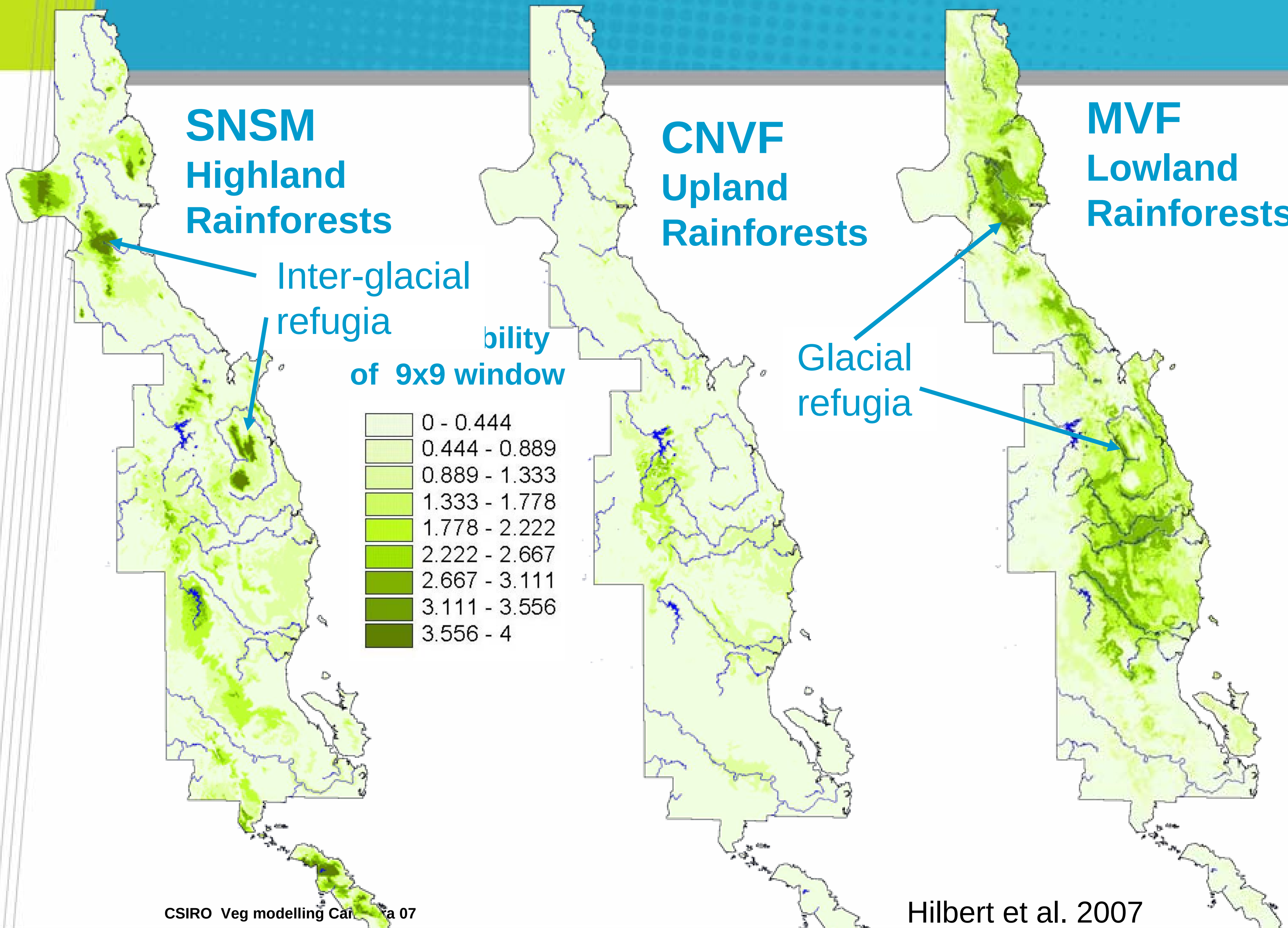
Hilbert (in press) 2007

Past distributions of rainforest



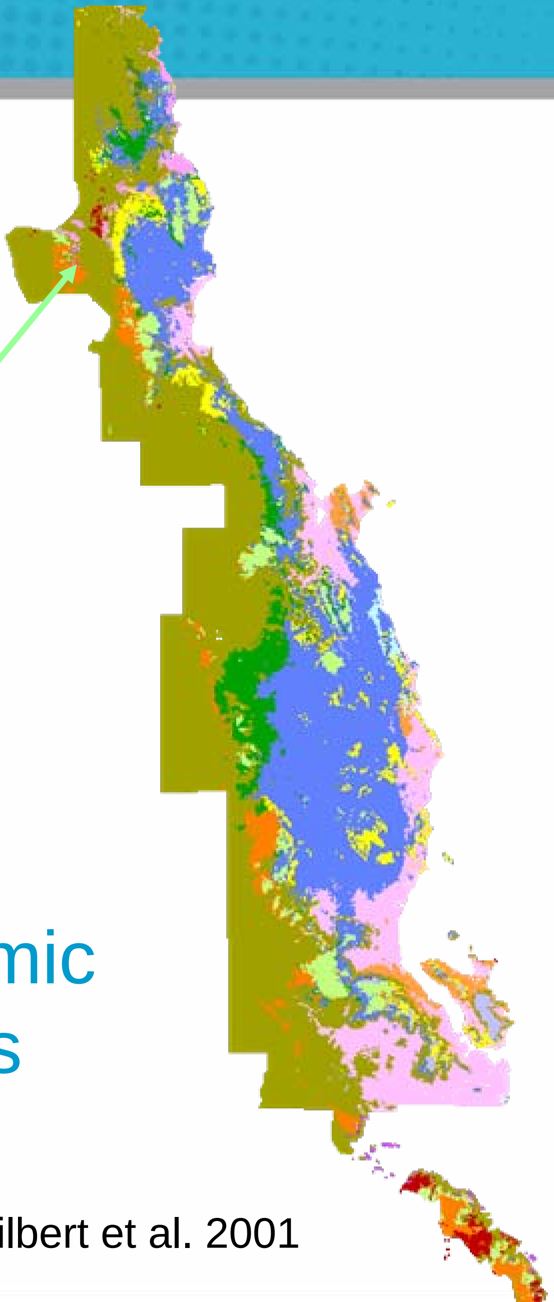
Hilbert et al. 2007

Landscape sensitivity to climate – refugia



Hilbert et al. 2007

Future climate change



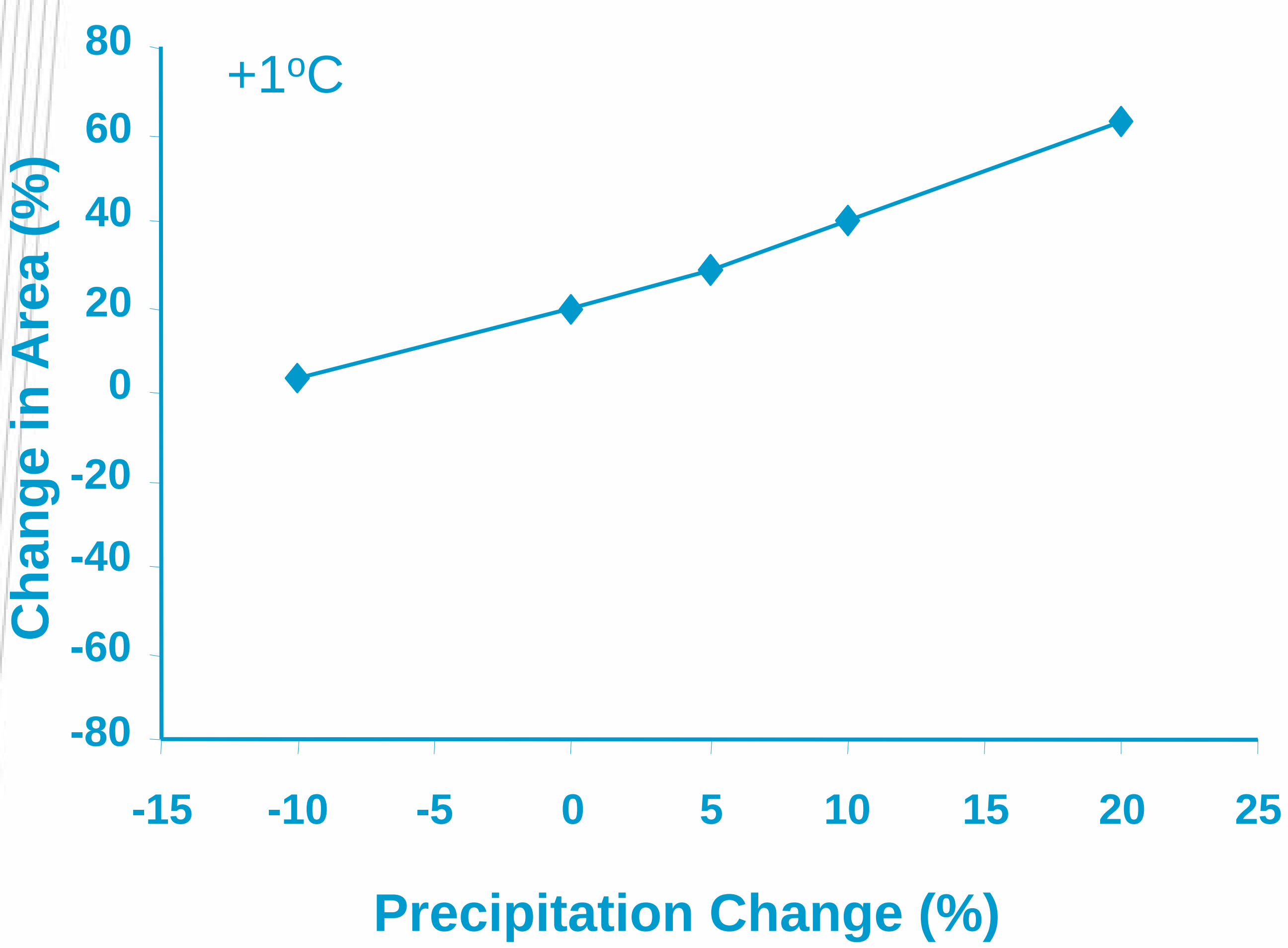
Highland Rainforests

Comparing potential today
with +1 ^{o}C, -10% rainfall

Potential loss of the rich, endemic flora and fauna in the highlands

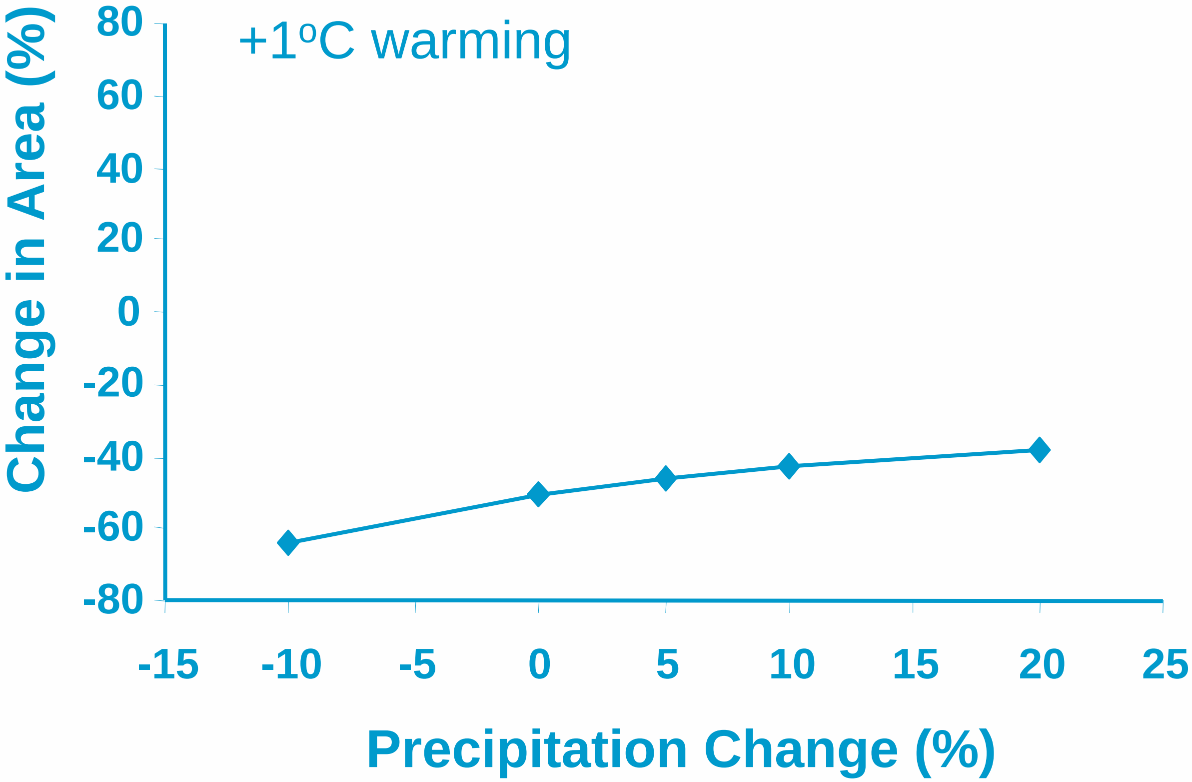
Hilbert et al. 2001

Lowland rainforest environments (MVF) will increase even if rainfall declines somewhat



Hilbert et al. 2001

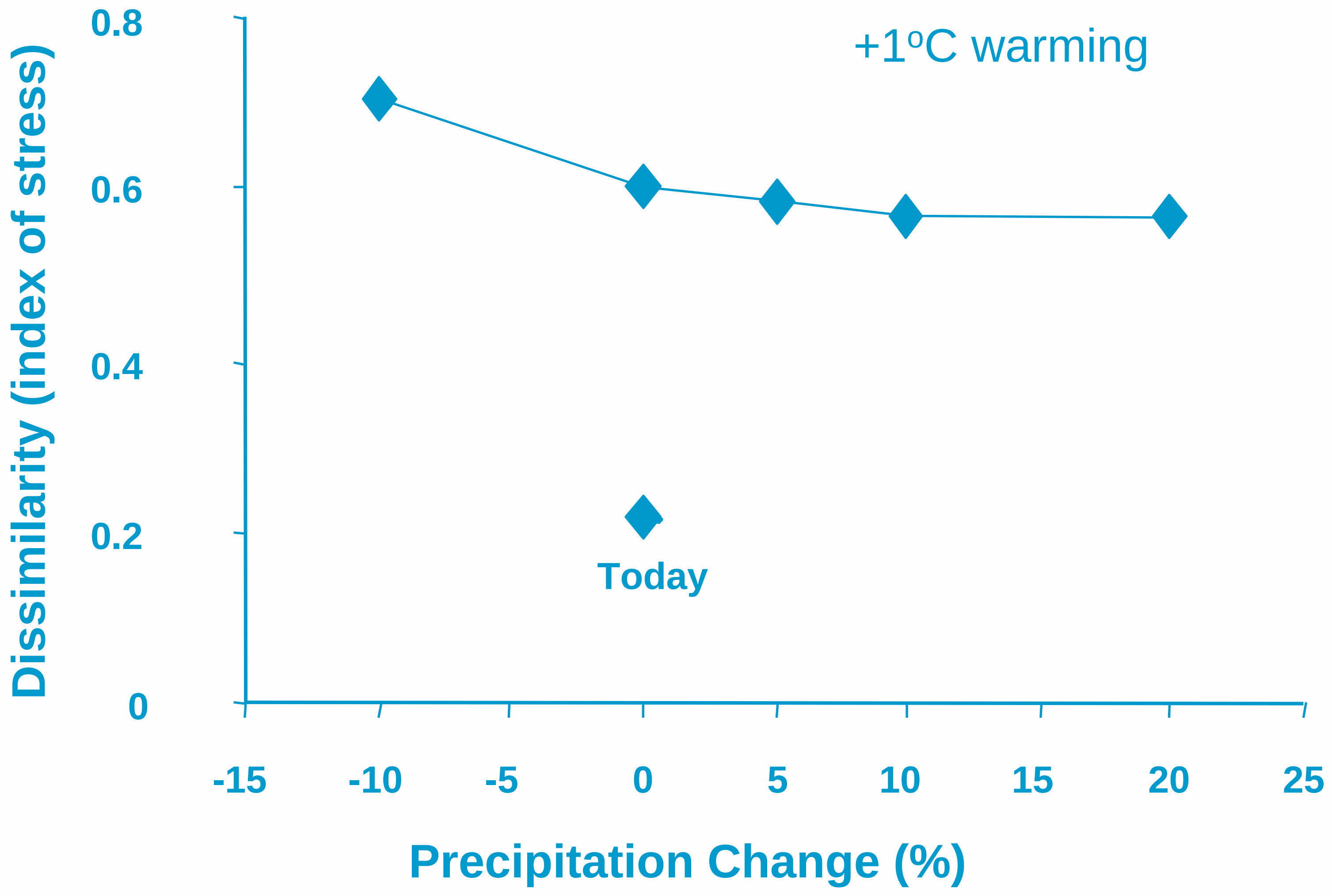
Highland rainforest environments will decline greatly with global warming, irrespective of changes in rainfall



Potentially devastating to high altitude fauna

Hilbert et al. 2001
Hilbert et al. 2004
Williams & Hilbert 2006

Highland rainforests will be highly stressed by global warming, irrespective of changes in rainfall

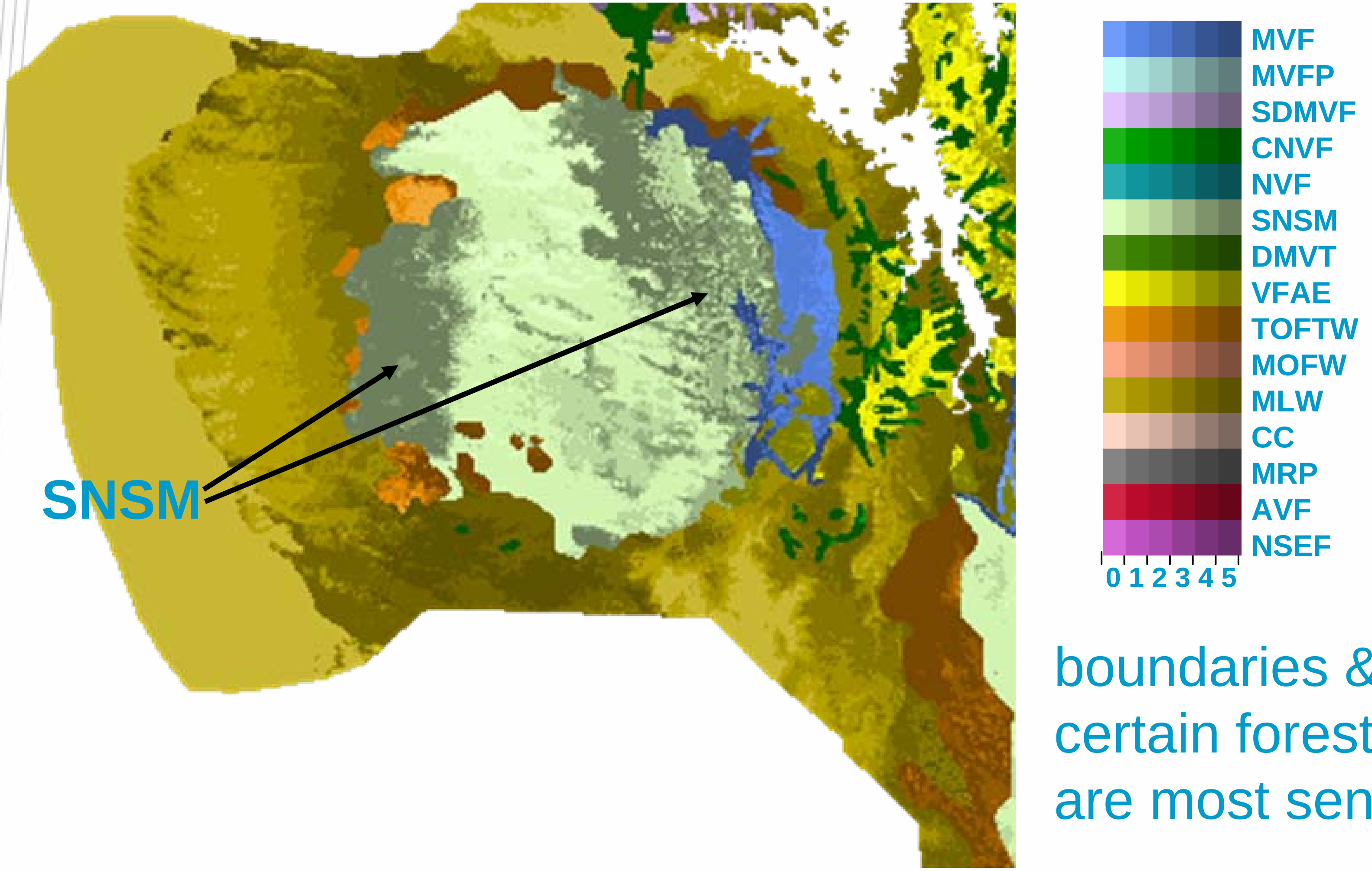


Hilbert et al. 2001

Spatial sensitivity to climate change Windsor Tableland

+1ºC warming
5 rainfall scenarios

Counts of change



boundaries & certain forest types are most sensitive

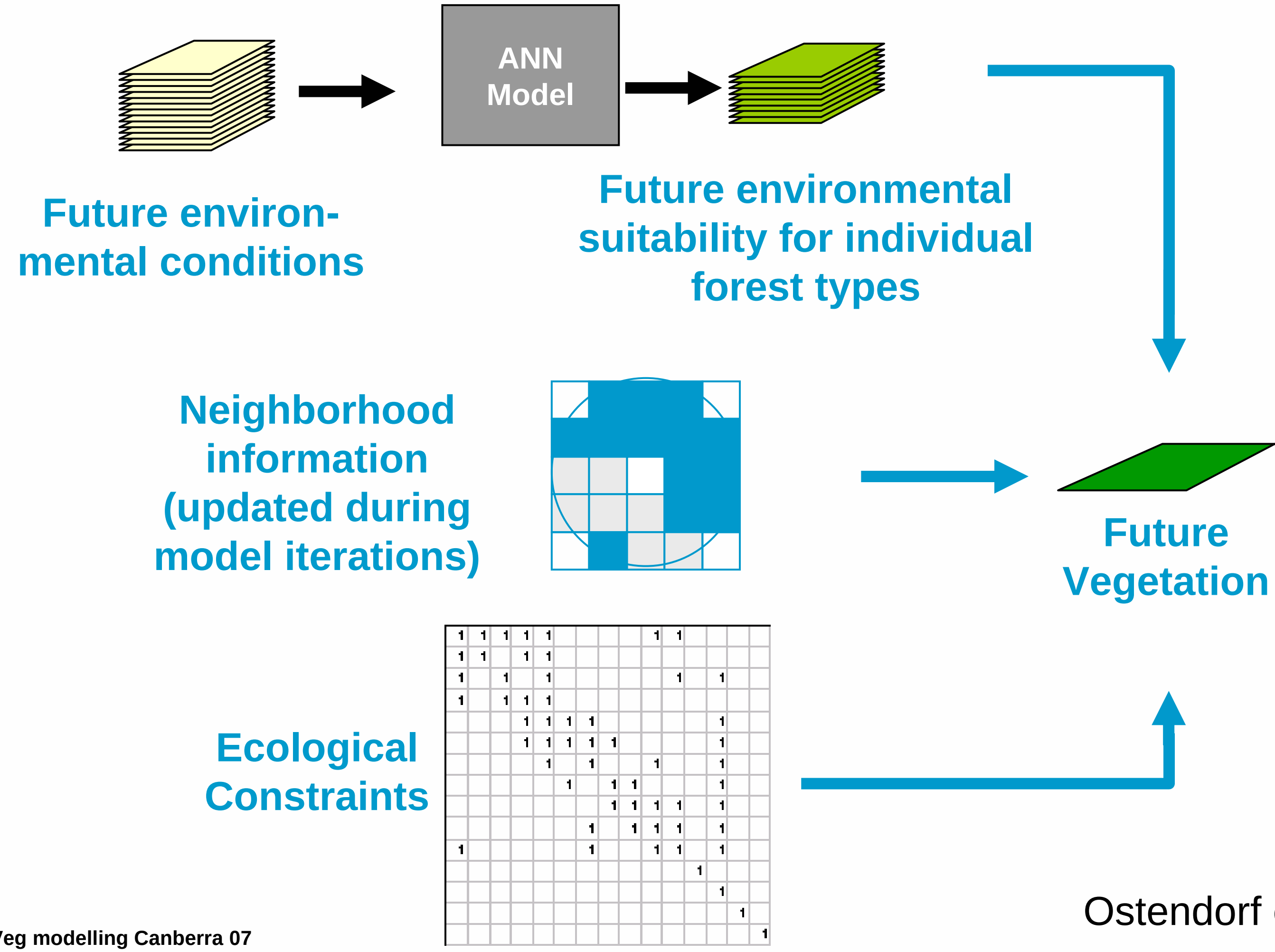
Hilbert et al. 2001

Moving forward

Can static, empirical approaches contribute to dynamics?

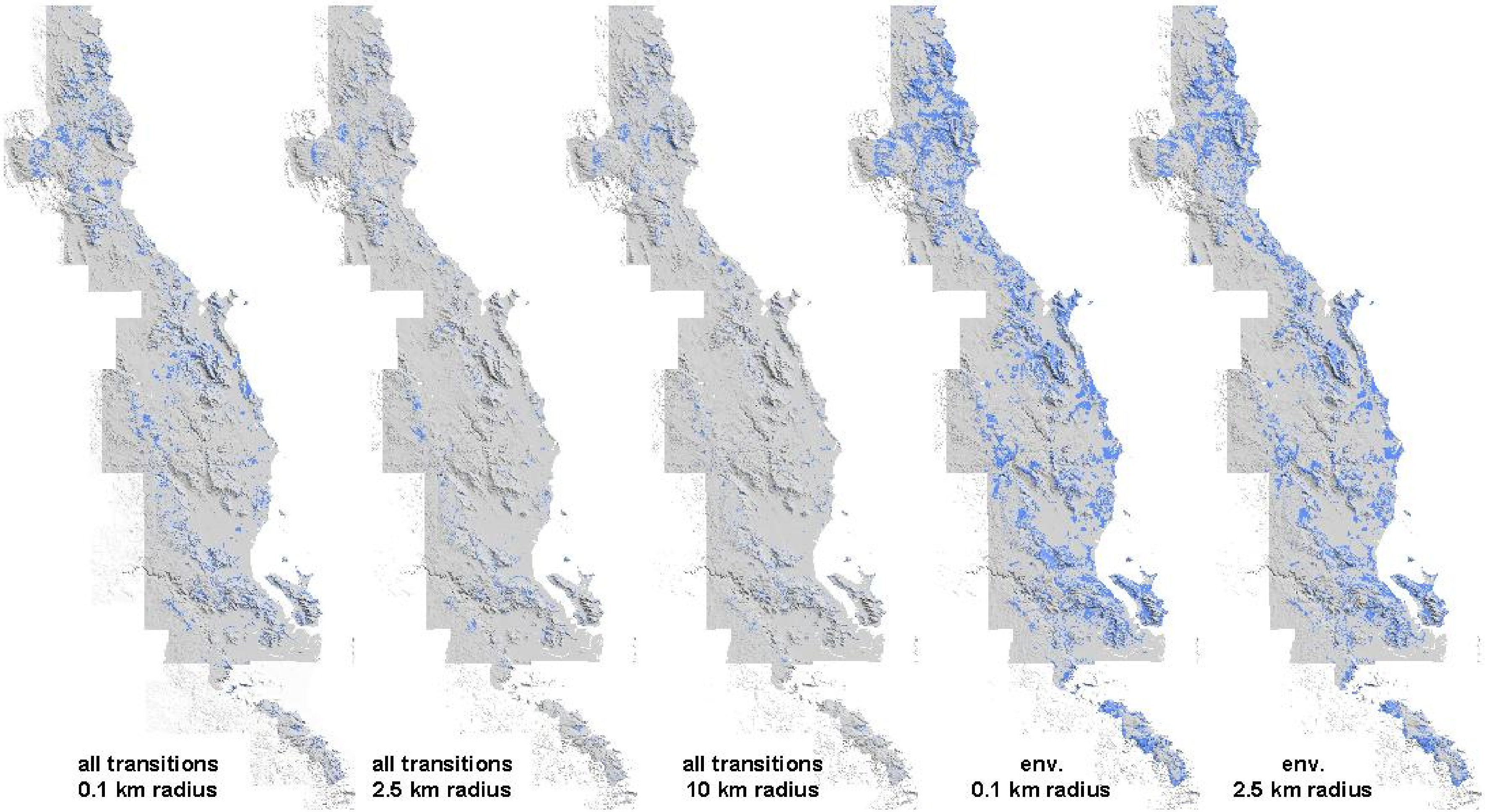
Linking with Cellular Automata

Combining the output of the ANN with spatial and ecological Information



Ostendorf et al. 2001

Differences between the ANN and CA/ANN model at equilibrium for +1 ^{o}C and - 10% precipitation scenario



Spatial Constraints Only

Spatial and Ecological Constraints

Conclusions

- **Regional modelling of vegetation distributions is usually empirical – often by necessity (scale issues and limited basic understanding).**
- **The specific modelling method is less important than the range of skills and data that are available.**
- **Careful empirical modelling, coupled with local ecological knowledge, good biogeographic data and creative analyses can be very informative, both scientifically and for management and policy development.**
- **"Black box" approaches have great value when coupled with ecological insight and are essential in the many circumstances where mechanistic models are not yet capable of addressing very important regional issues about climate change.**

This research has had very significant influence on regional, state and national policy

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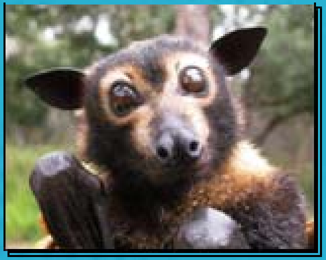
Questions or Comments ?



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