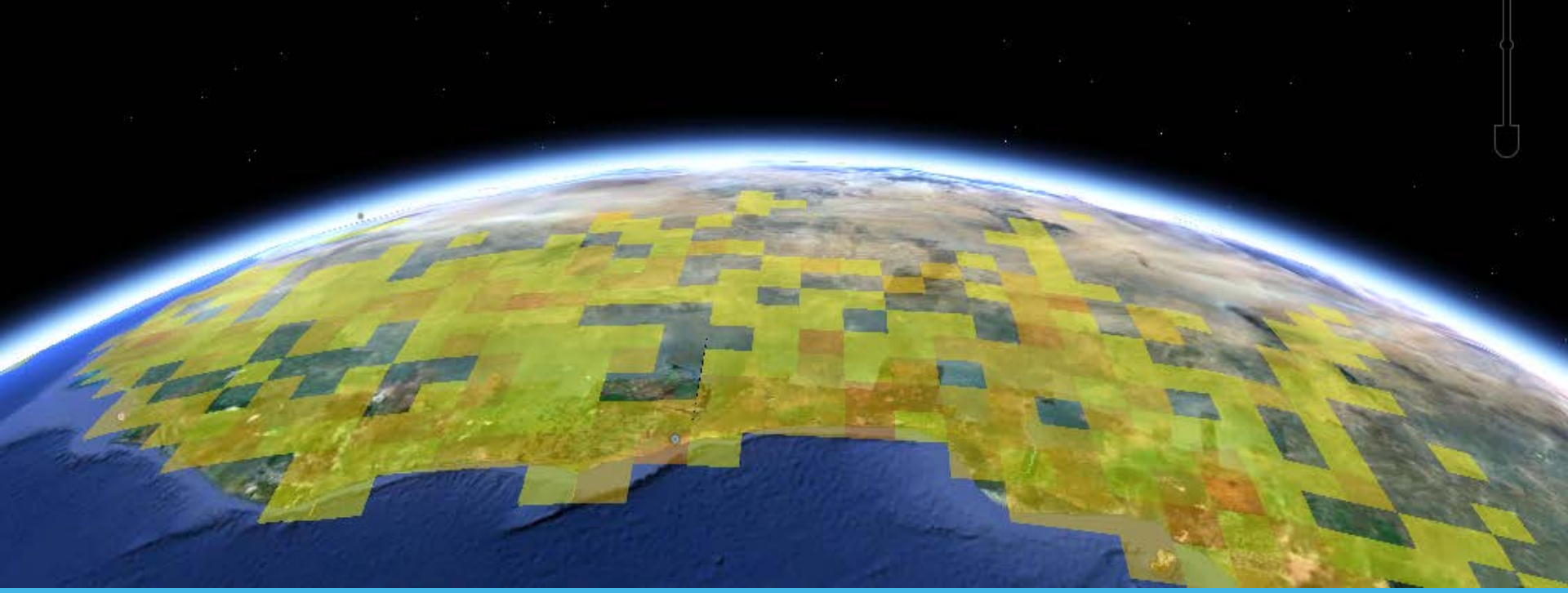


Compositional-turnover modelling: an applied perspective

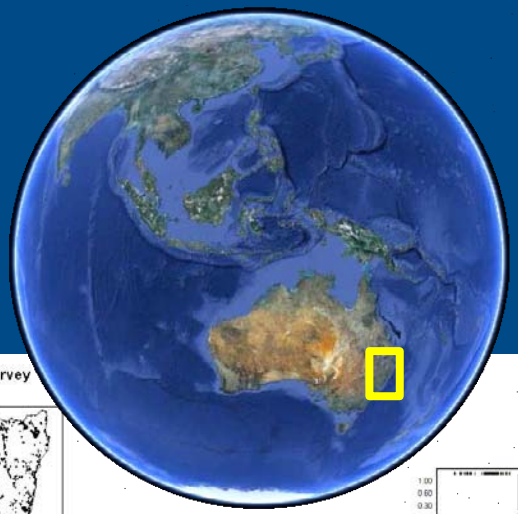
Simon Ferrier

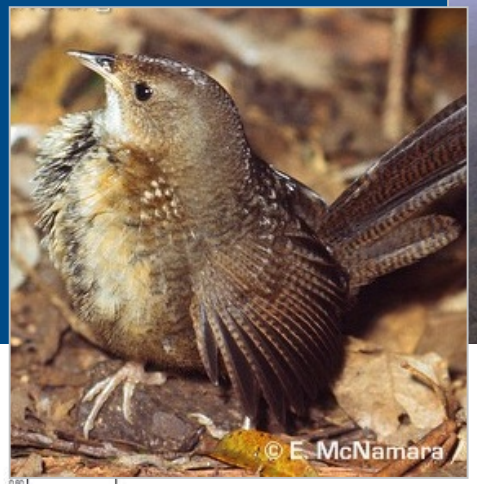
Tom Harwood, Karel Mokany, Kristen Williams, Andrew Hoskins, Renee Catullo
Glenn Manion (NSW OEH), Dan Rosauer (ANU)

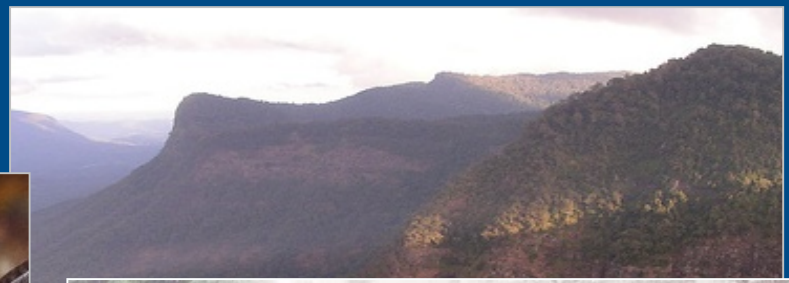
CSIRO LAND & WATER FLAGSHIP
www.csiro.au

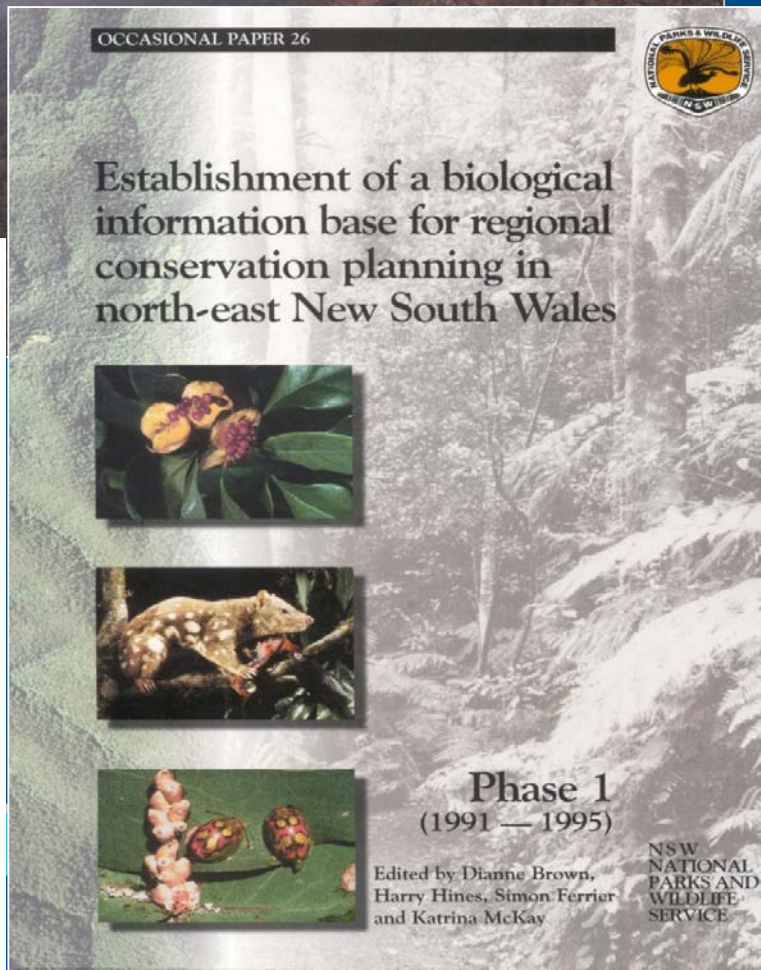
A long time ago ...

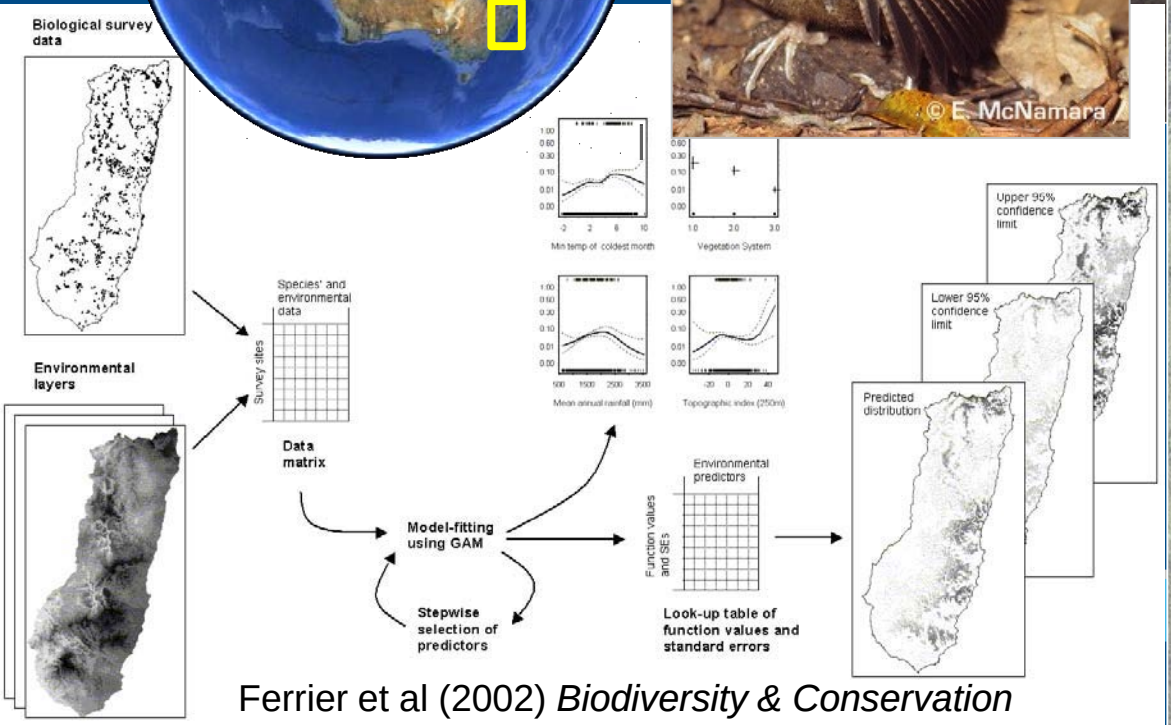
Ferrier (1984) ***The status of the Rufous Scrub-bird: habitat, geographical variation & abundance*****.**
PhD Thesis.





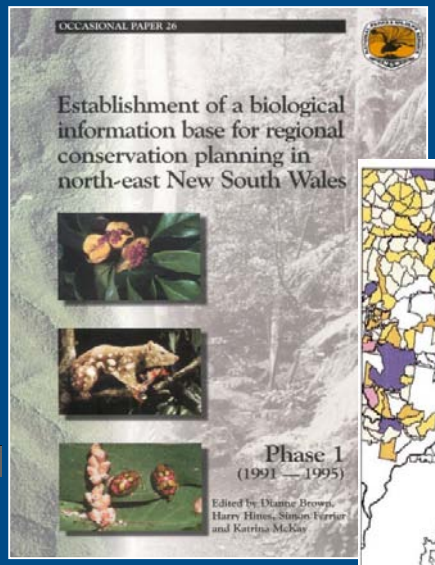


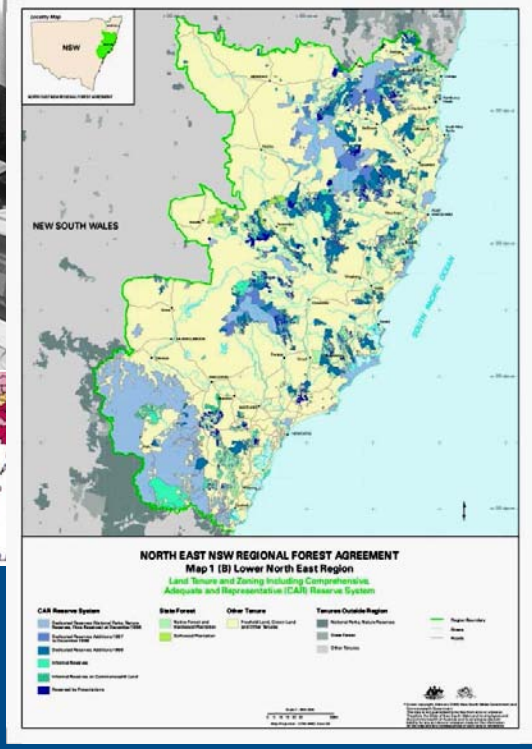




Ferrier et al (2002) *Biodiversity & Conservation*

Regional conservation planning in north-east NSW forests throughout the 1990s





Modelled species distributions & vegetation communities

Protection targets

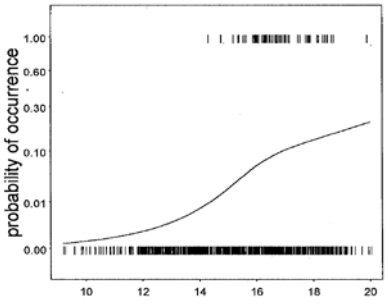
Conservation prioritisation (irreplaceability analysis)

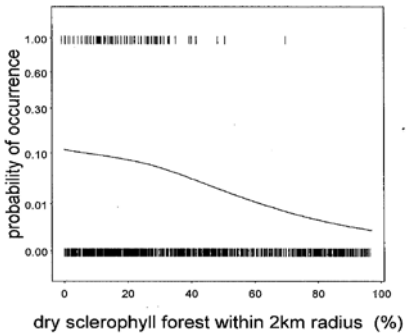
Timber resource assessment

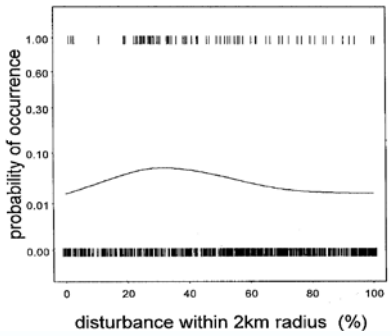
Negotiation & selection of new reserves

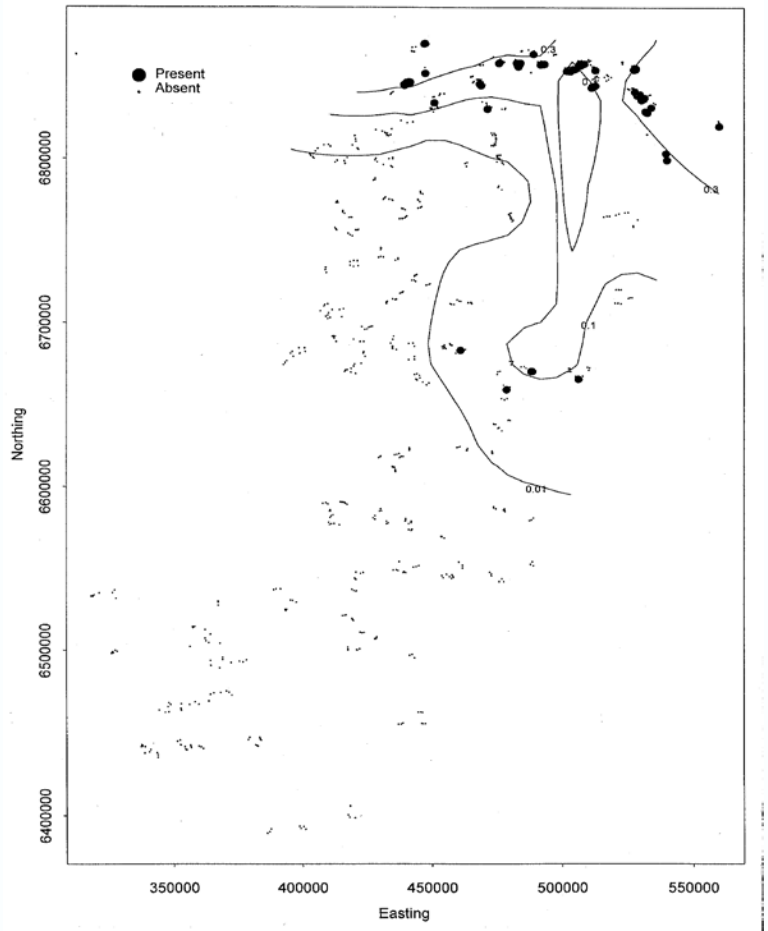
Ferrier, S et al (2000) *Biological Conservation* 93: 303-325

Innovations in SDM application during that period - incorporating geographical space





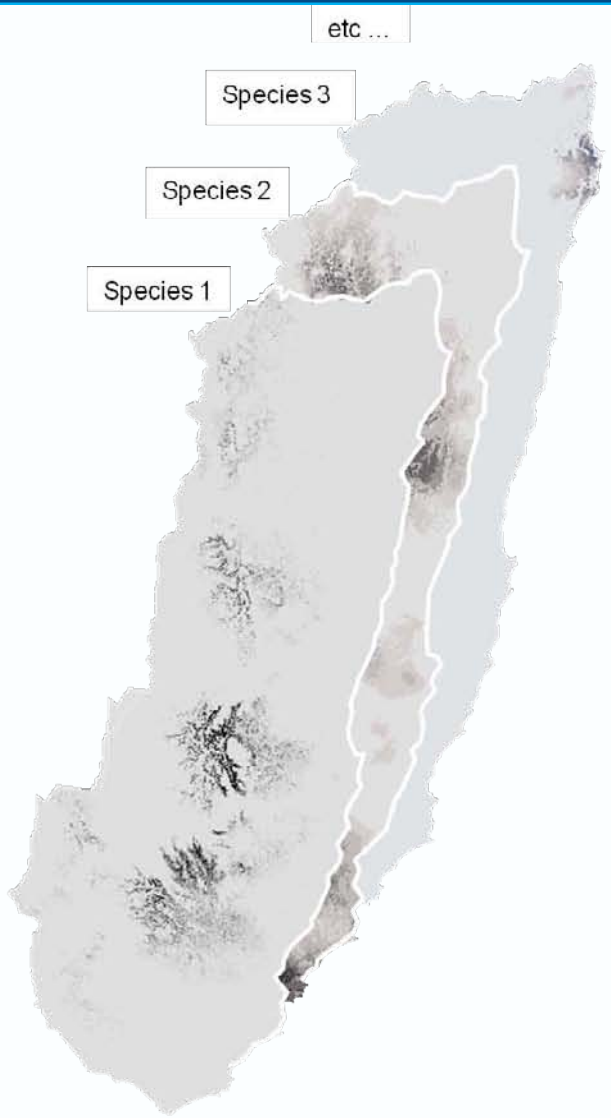


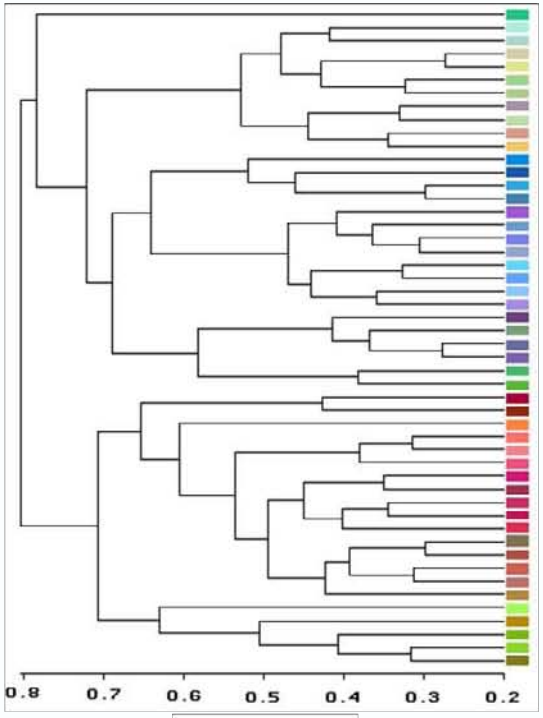


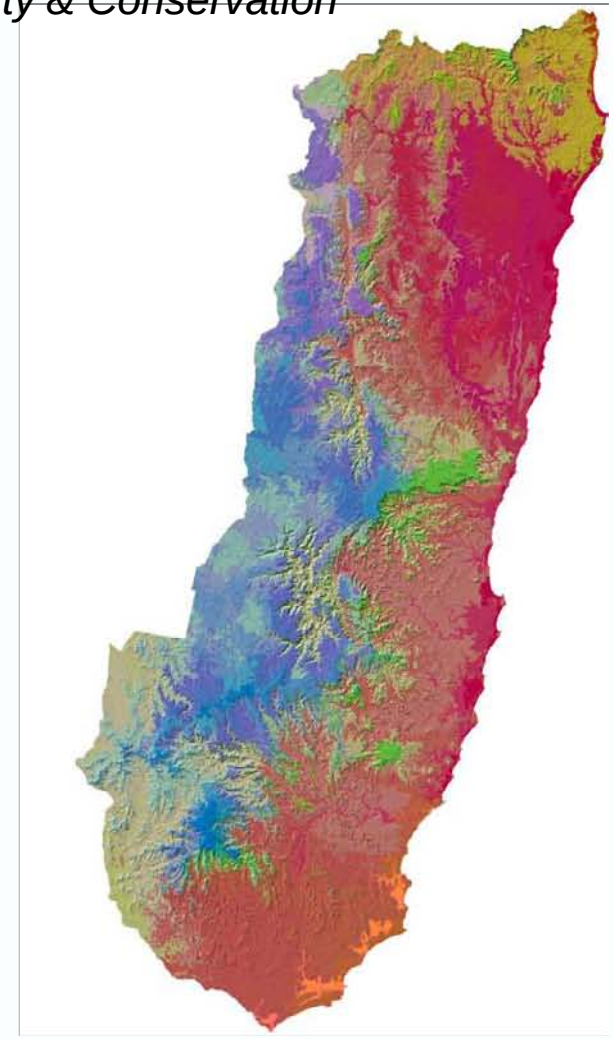
Ferrier et al (2002)
Biodiversity & Conservation

Innovations in SDM application during that period - “stacked” predict-then-assemble approaches

Ferrier et al (2002) *Biodiversity & Conservation*





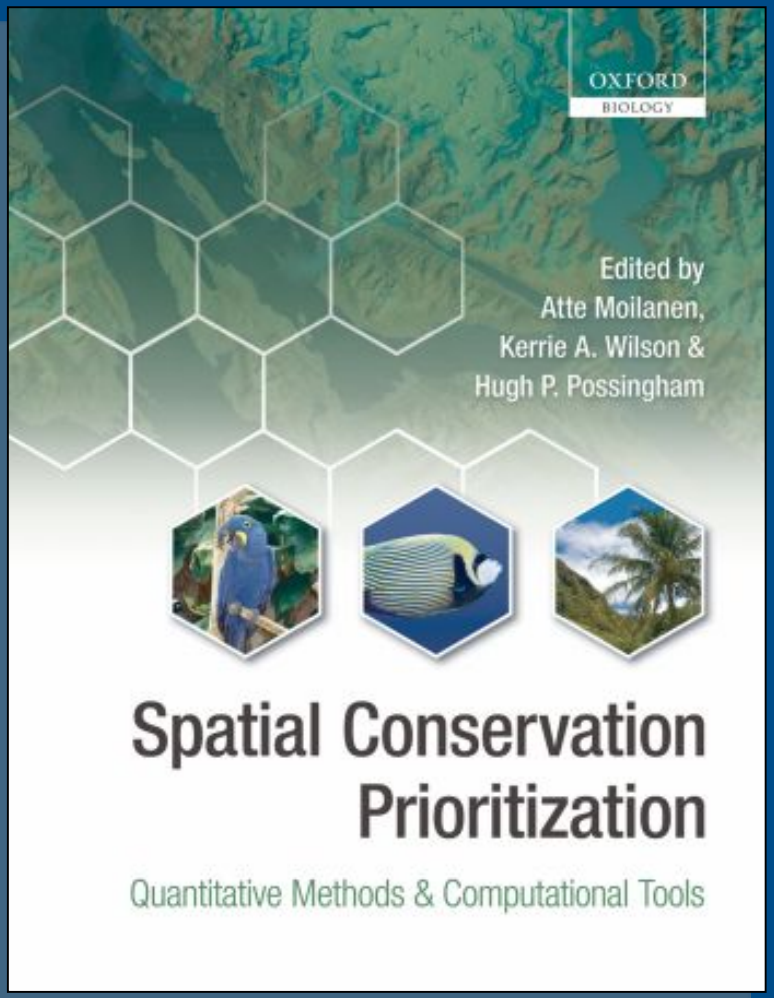


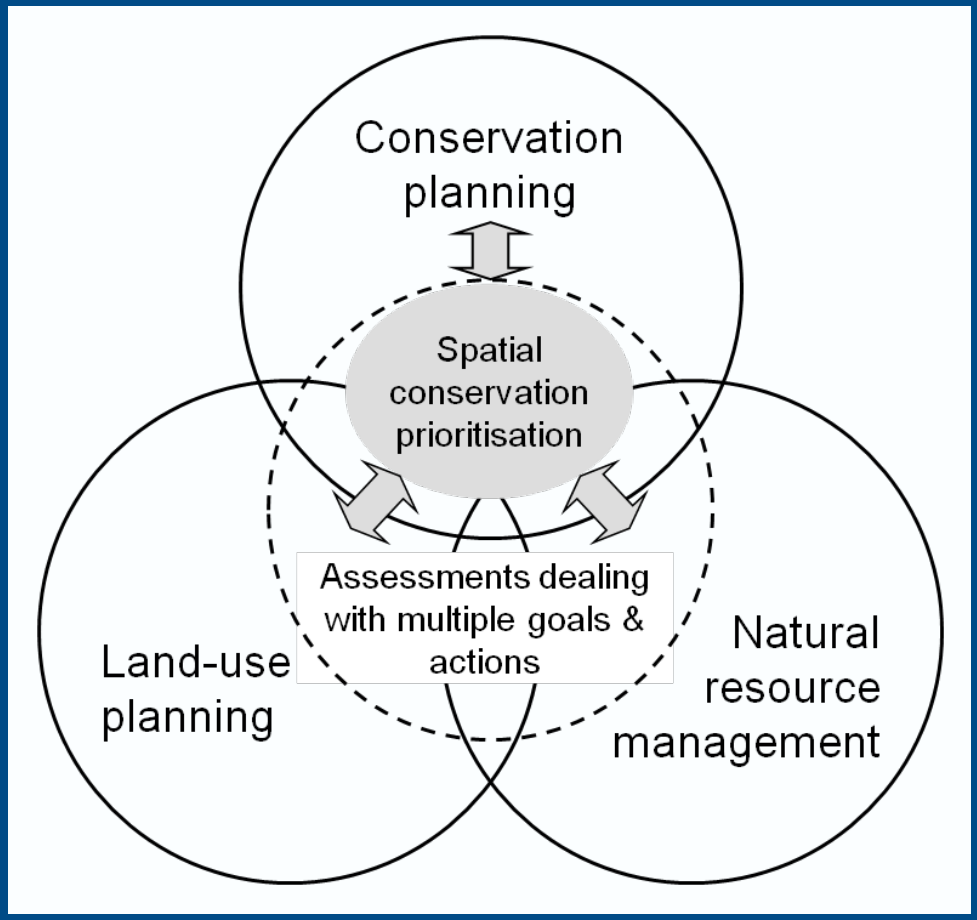
Modelled distributions for 208 canopy tree species

Numerical classification of grid-cells into 50 ‘communities’

Mapped communities

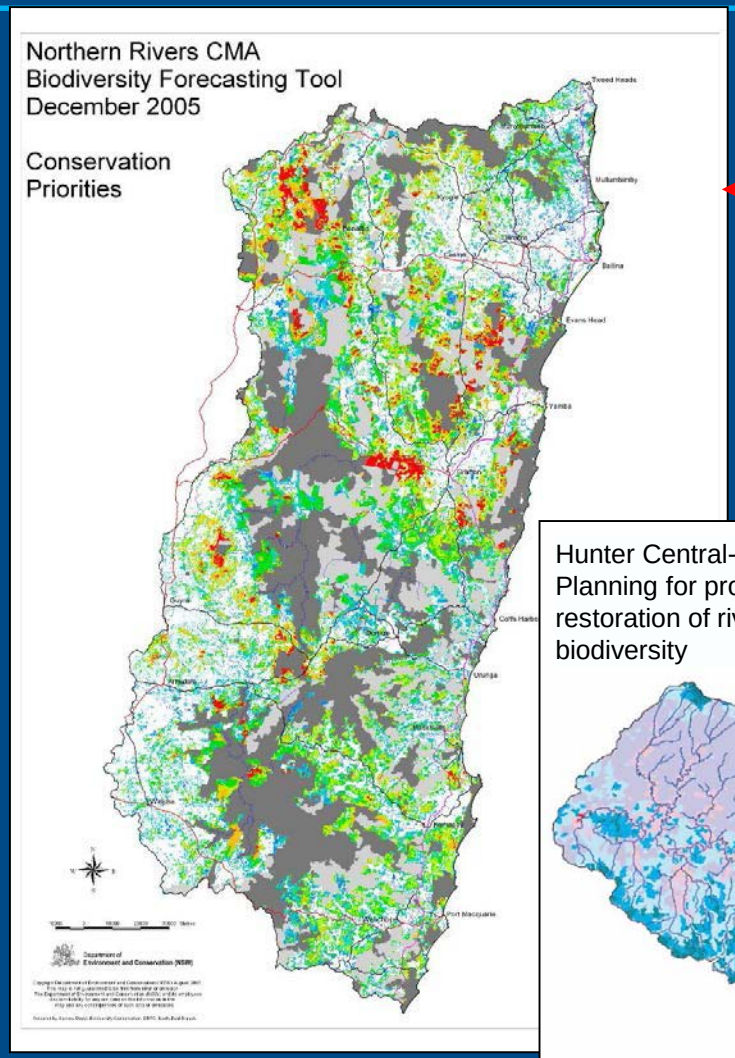
Late 1990s onwards: focus shifted to whole-landscape decision-making processes

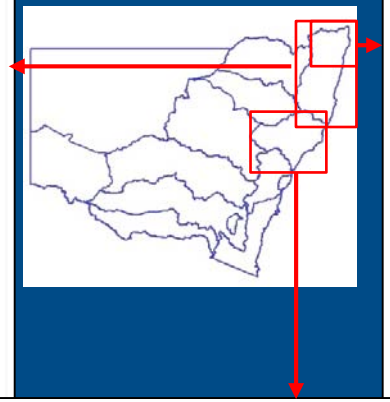


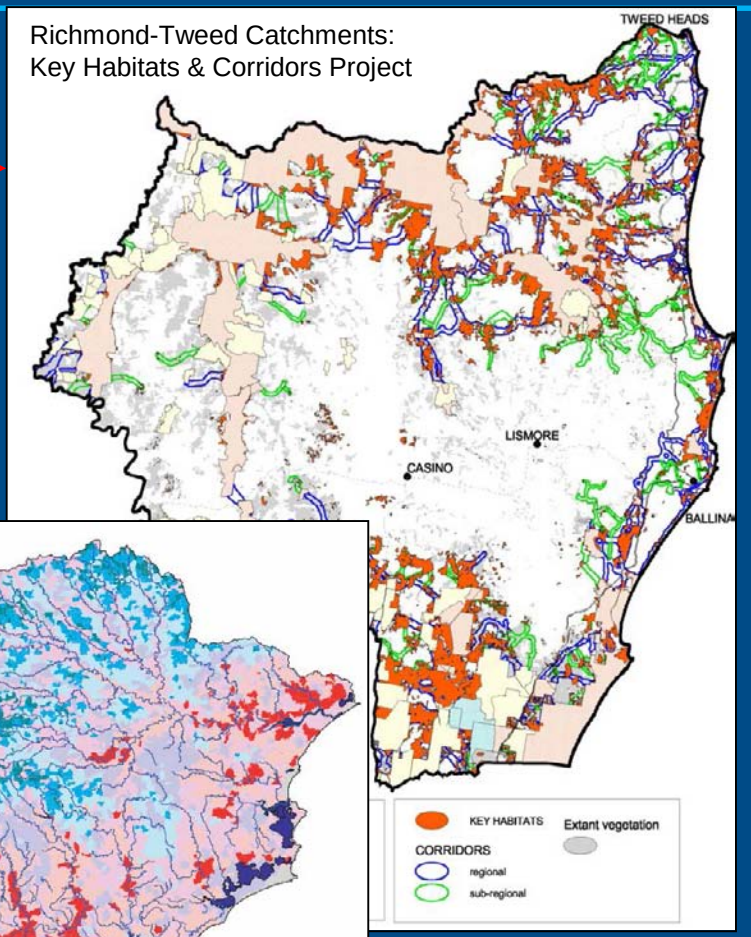


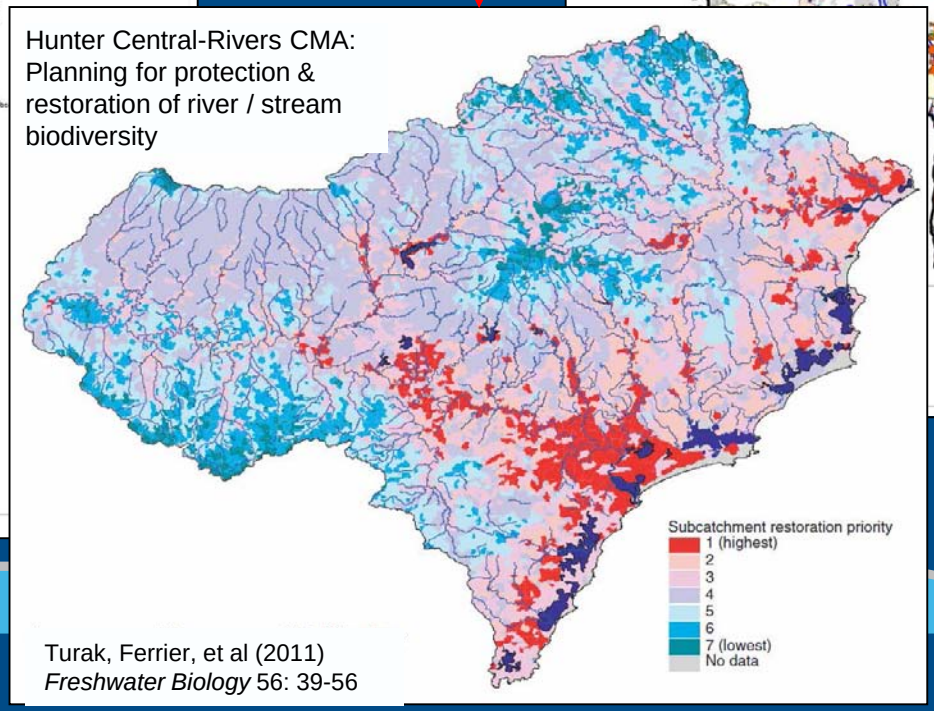
Ferrier, S & Wintle, B (2009) Quantitative approaches to spatial conservation prioritisation: matching the solution to the need. In *Spatial Conservation Prioritisation*. OUP

Late 1990s onwards: focus shifted to whole-landscape decision-making processes





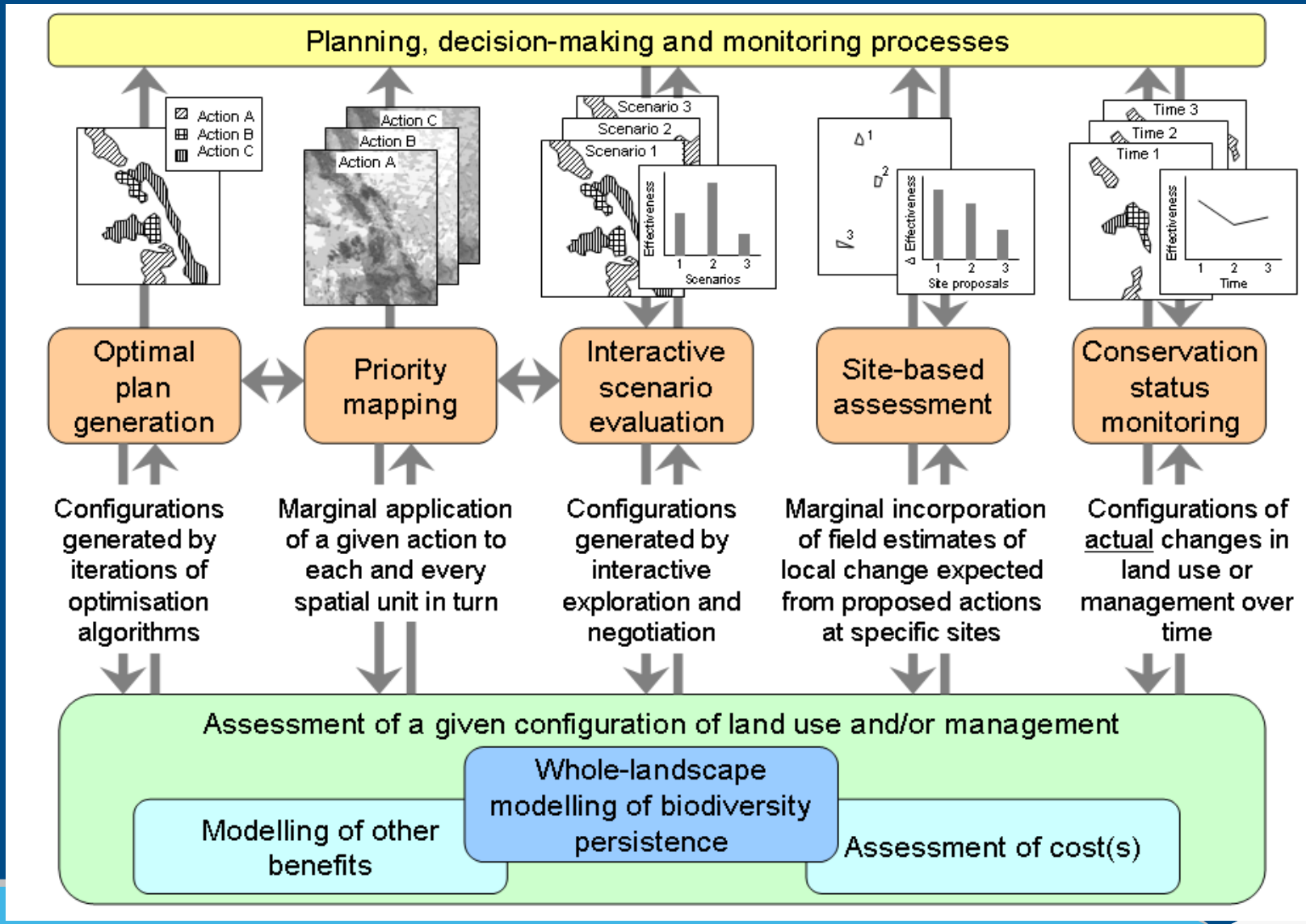




NSW GOVERNMENT Environment, Climate Change & Water

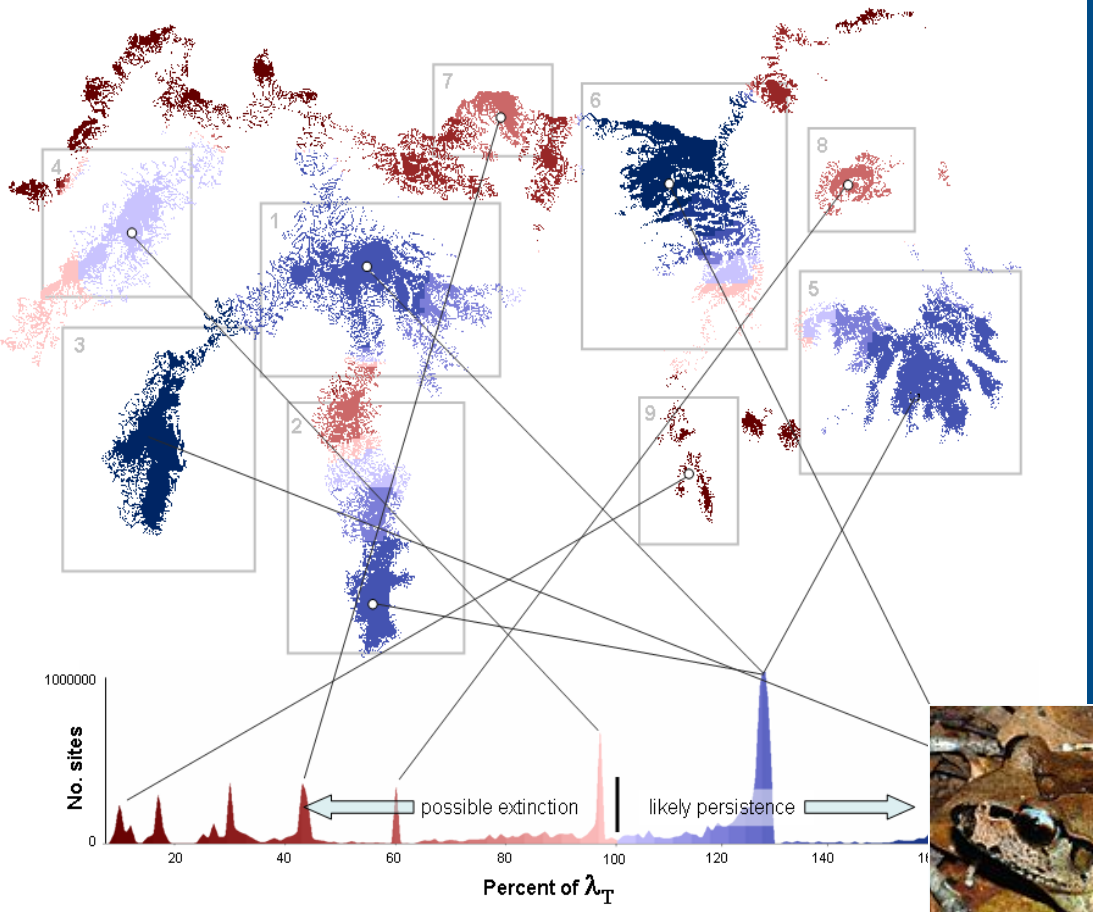
CSIRO

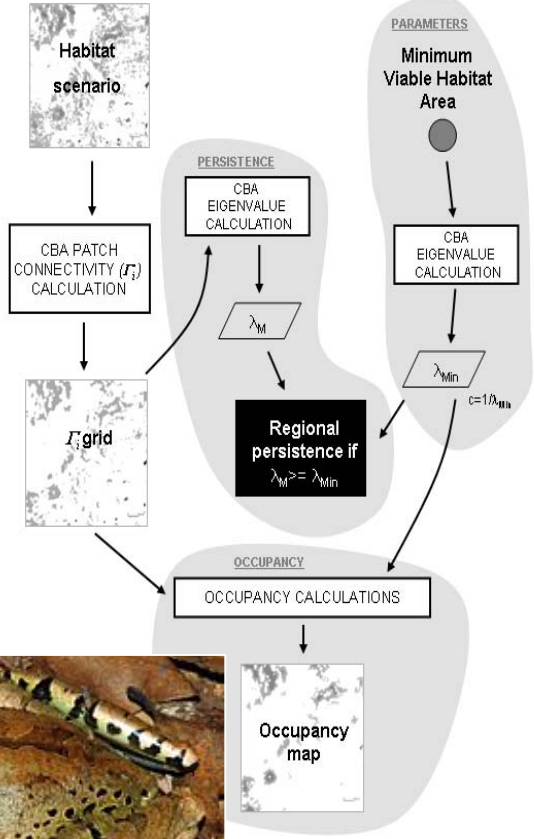
Whole-landscape modelling of biodiversity persistence as a foundation for multiple forms of higher-level assessment



Ferrier, S & Drielsma, M (2012) *Diversity & Distributions* 16: 386-492

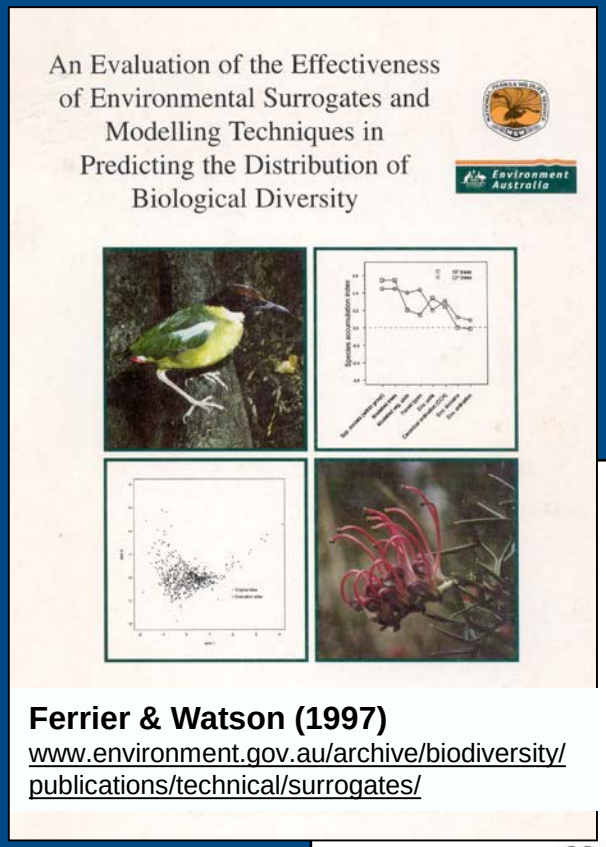
Resulted in further innovations in species modelling – e.g. linking SDMs to dynamic metapopulation models



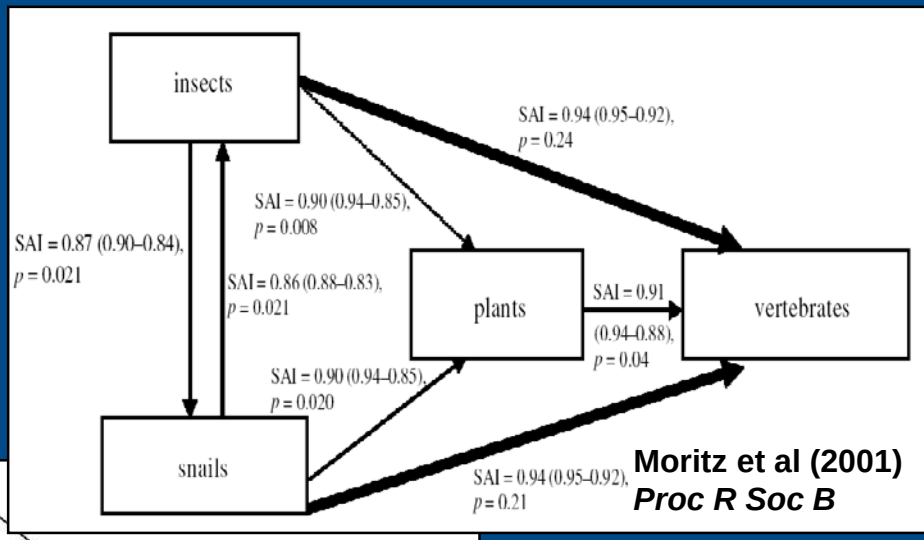


Drielsma, M & Ferrier, S (2009) *Biological Conservation* 142: 529-540

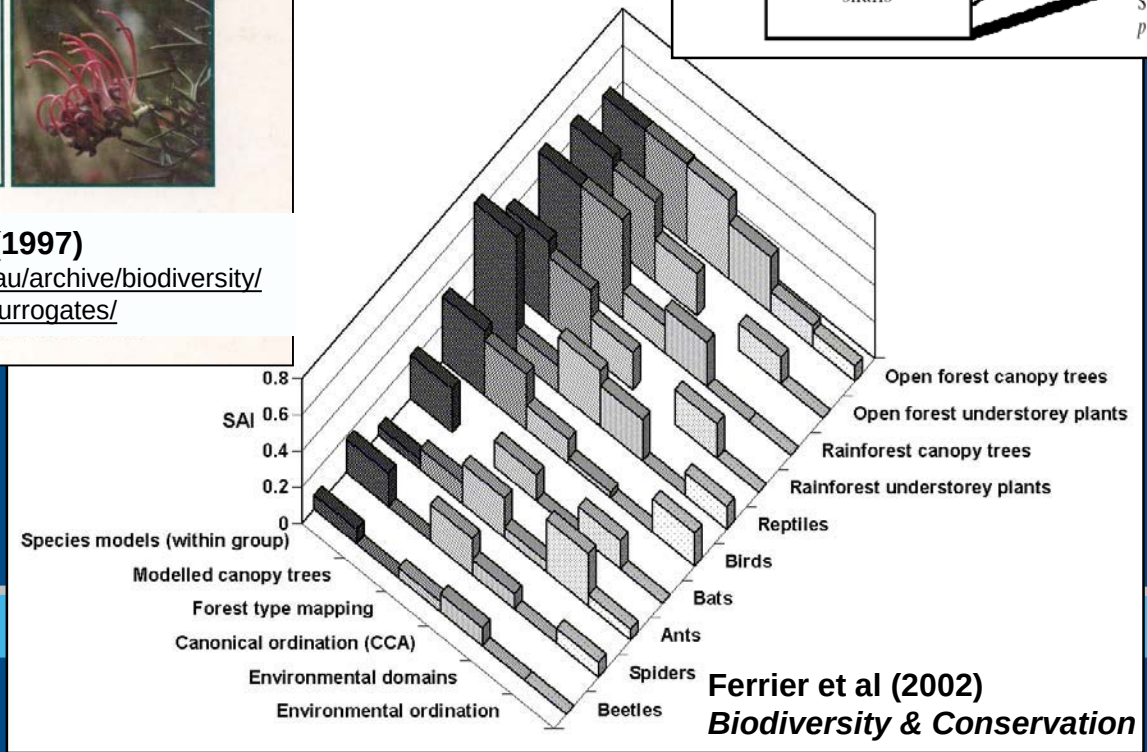
But what about “the other 99%” of compositional diversity?



Ferrier & Watson (1997)
www.environment.gov.au/archive/biodiversity/publications/technical/surrogates/



Moritz et al (2001)
Proc R Soc B



Ferrier et al (2002)
Biodiversity & Conservation

Spectrum of distributional modelling strategies

Ferrier & Guisan (2006) *Journal of Applied Ecology*

- interested in individual species of particular concern
- reasonable number of records per species

Individual species distribution (niche) modelling

"Predict first, assemble later" techniques

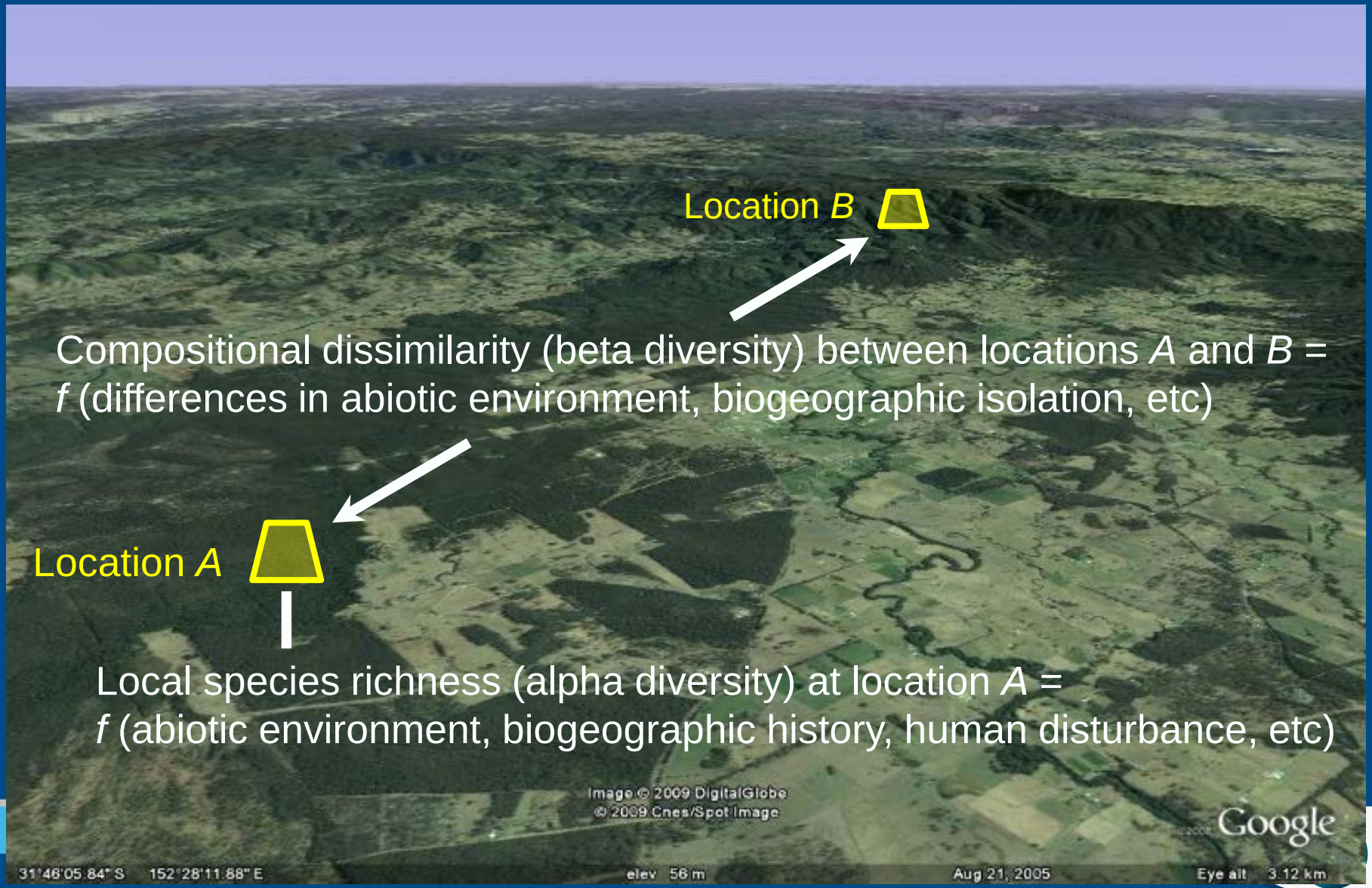
Simultaneous multi-response modelling of multiple species

"Assemble first, predict later" techniques

Macroecological modelling of collective biodiversity properties (richness, compositional turnover etc)

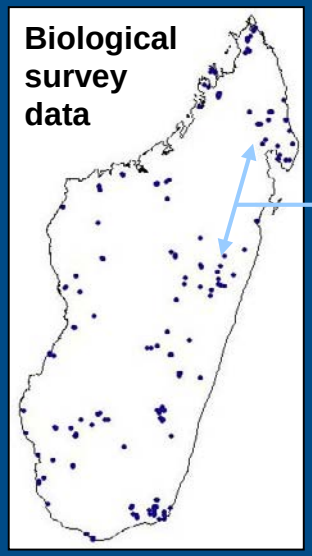
- interested in biodiversity as a whole
- huge number of species, each with few (or no) records

Modelling of compositional turnover (dissimilarity) across space



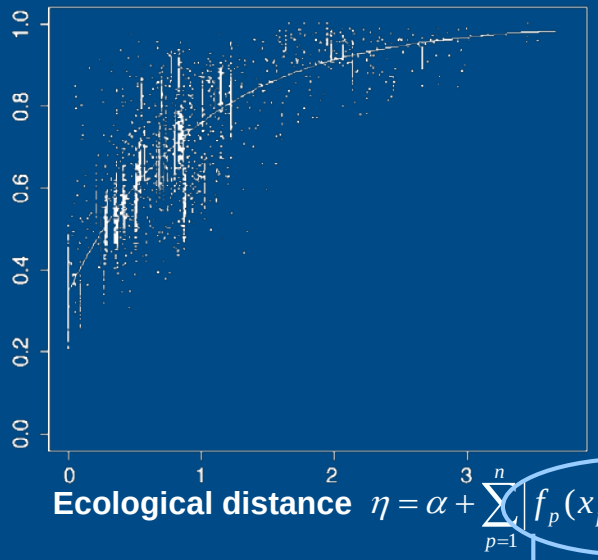
Statistical modelling of compositional turnover e.g. generalised dissimilarity modelling (GDM)

Ferrier, S et al (2007) *Diversity & Distributions*

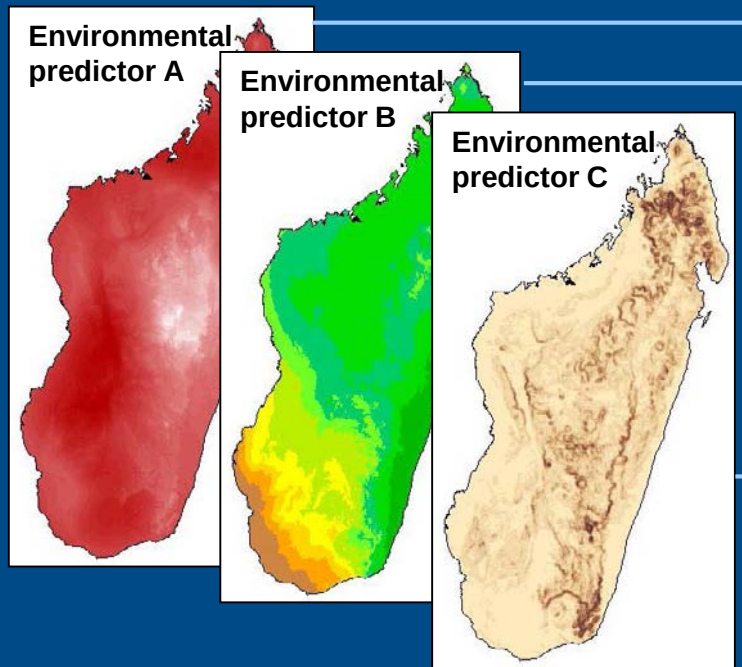


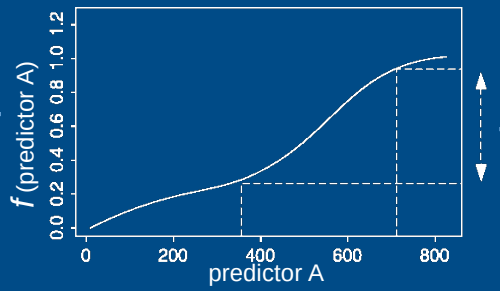
Compositional dissimilarity

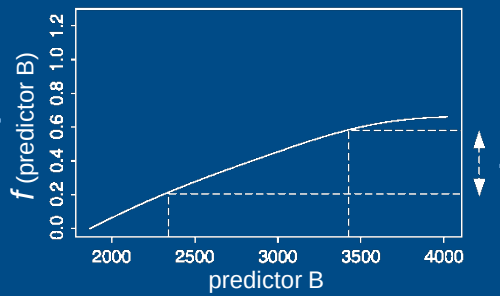
$$d_{ij} = 1 - e^{-\eta}$$

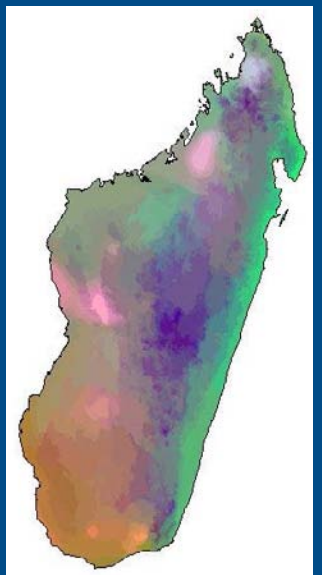


$$\eta = \alpha + \sum_{p=1}^{n} \left| f_p(x_{pi}) - f_p(x_{pj}) \right|$$







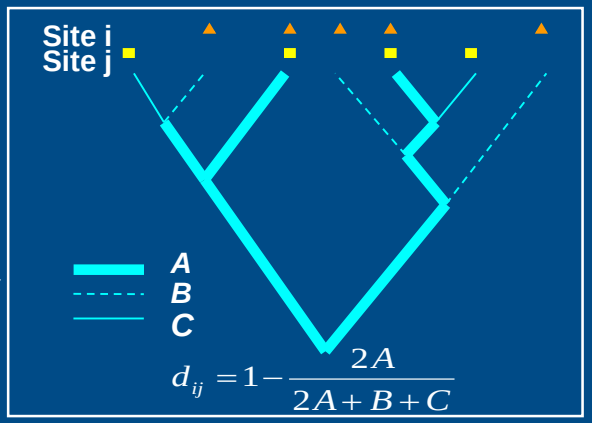


Flexibility in types of response and predictor variables

Response:

Dissimilarity in species composition
or
Phylogenetic dissimilarity
or
Intraspecific genetic distance
or
Metagenomic distance

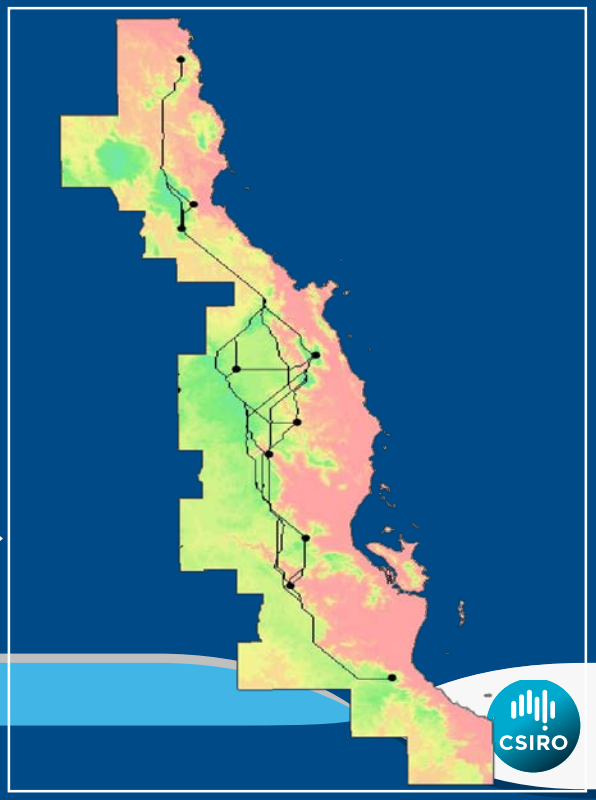
e.g.



Predictors:

Multiple environmental gradients
and / or
Geographic separation
and / or
Biogeographic isolation

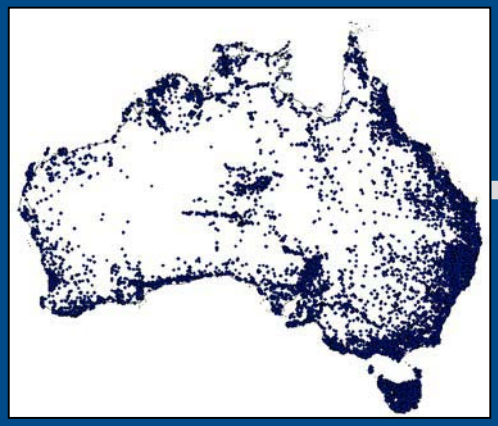
e.g.



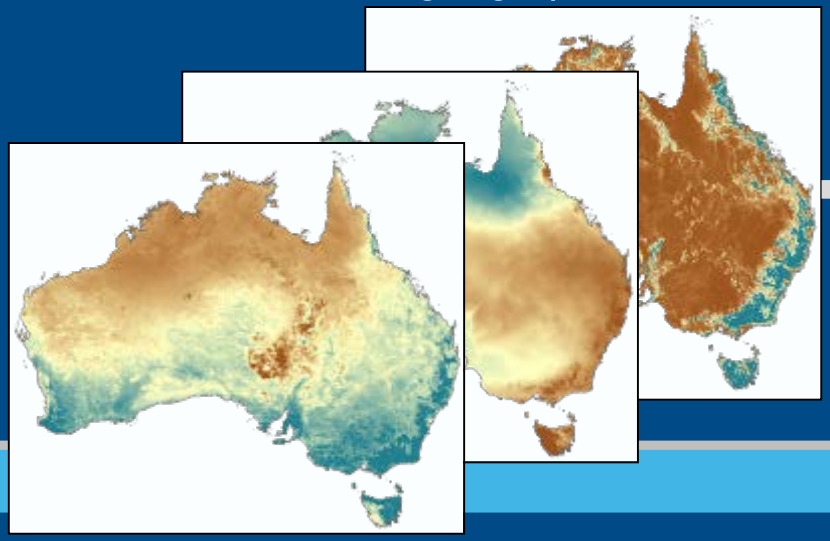
Ferrier, S et al (2007) *Diversity & Distributions*

Modelling dissimilarity in species composition

77,000 records of 2,700 land-snail species

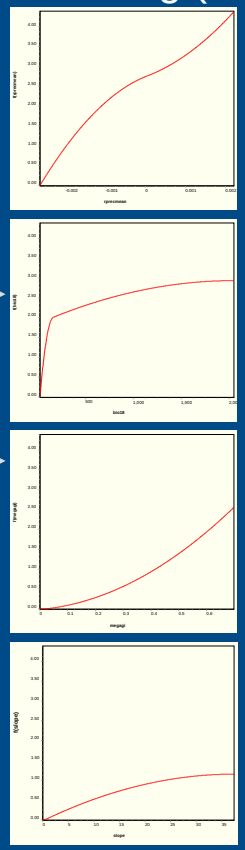


Remotely derived environmental variables:
climate, terrain, soils, geographic isolation etc



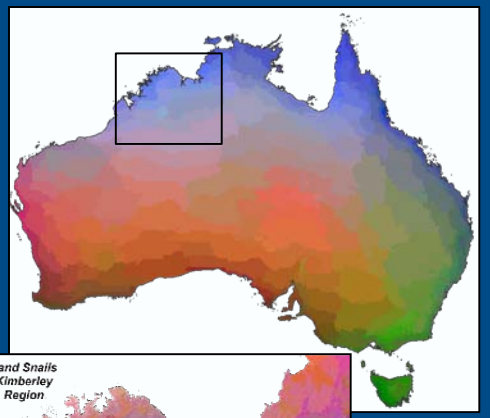
etc ...

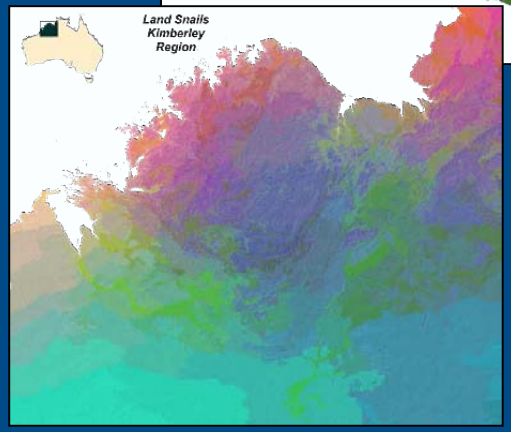
Generalised dissimilarity modelling (GDM)



etc ...

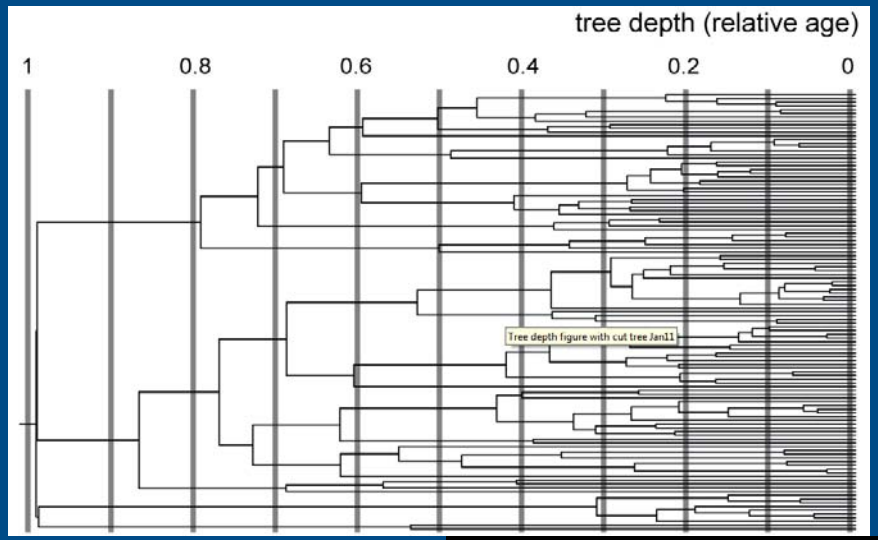
Spatial pattern in compositional turnover

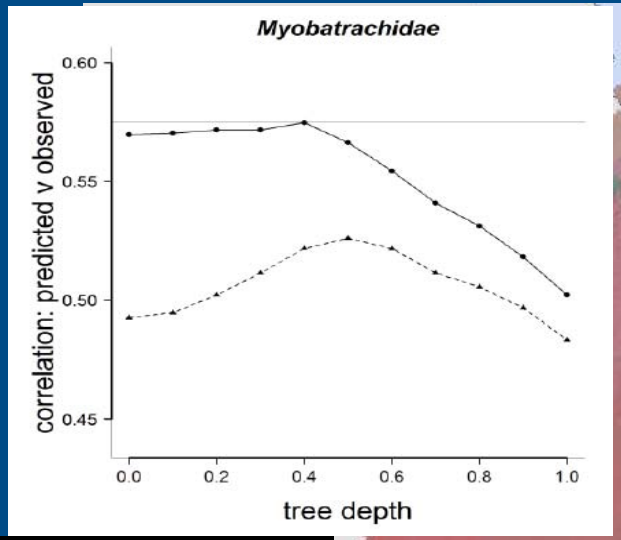


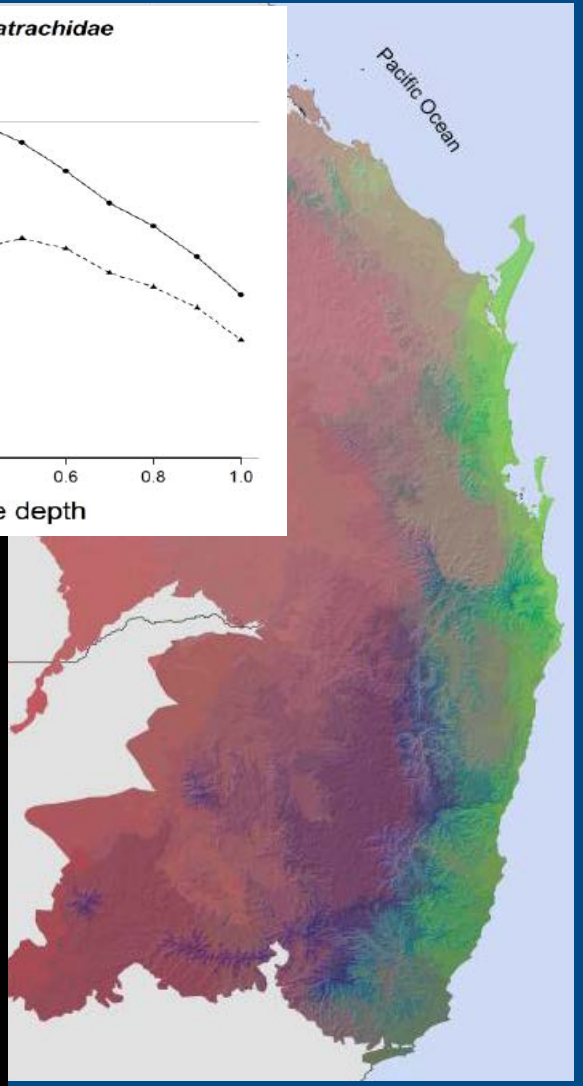


Funded by Aust. Department of Environment

Modelling phylogenetic dissimilarity







Rosauer, D et al (2013) *Ecography*

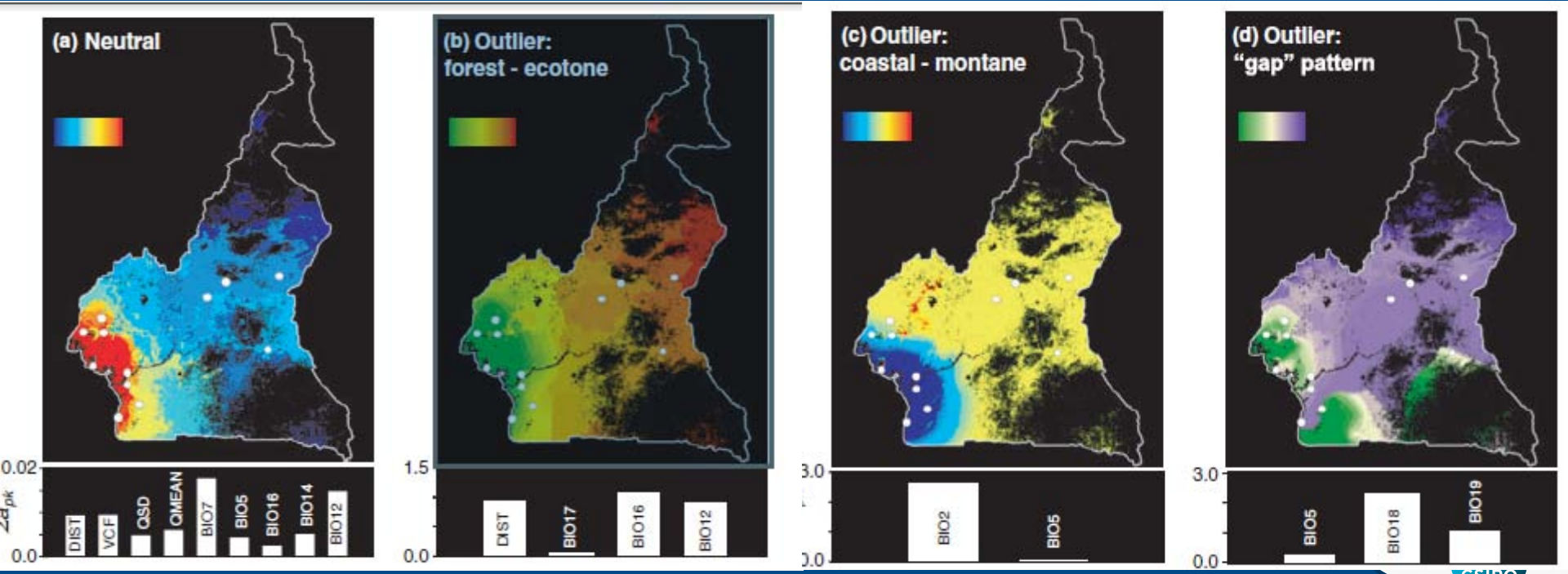
Modelling intraspecific genetic variation

MOLECULAR ECOLOGY

Molecular Ecology (2010) 19, 3773–3788 doi: 10.1111/j.1365-294X.2010.04684.x

Genomic signals of diversification along ecological gradients in a tropical lizard

ADAM H. FREEDMAN,*† HENRI A. THOMASSEN,† WOLFGANG BUERMANN†‡ and THOMAS B. SMITH*†



Modelling intraspecific genetic variation

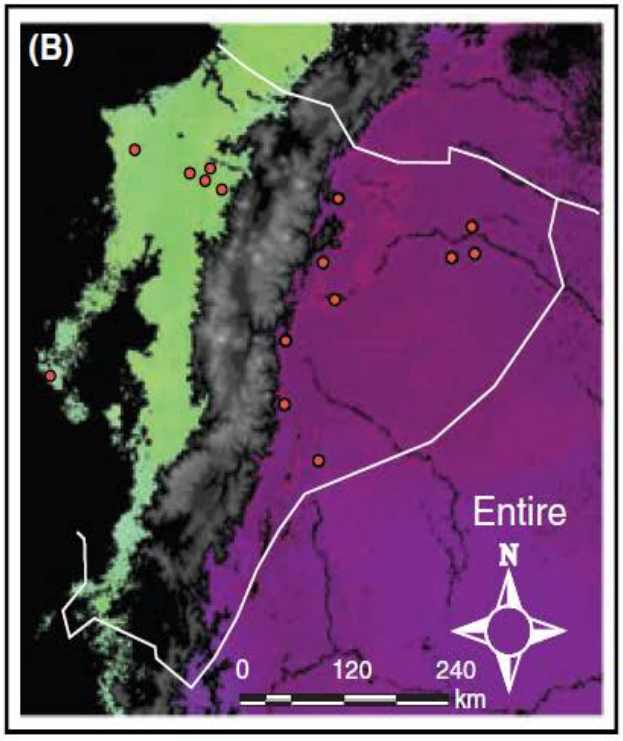
Evolutionary Applications www.evolutionaryapplications.org

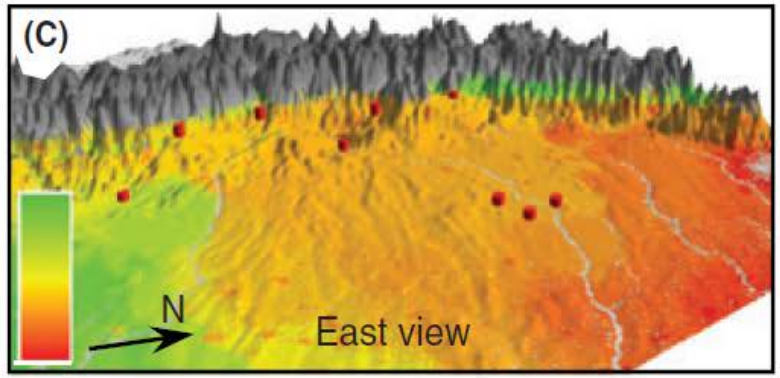
Evolutionary Applications ISSN 1752-4571

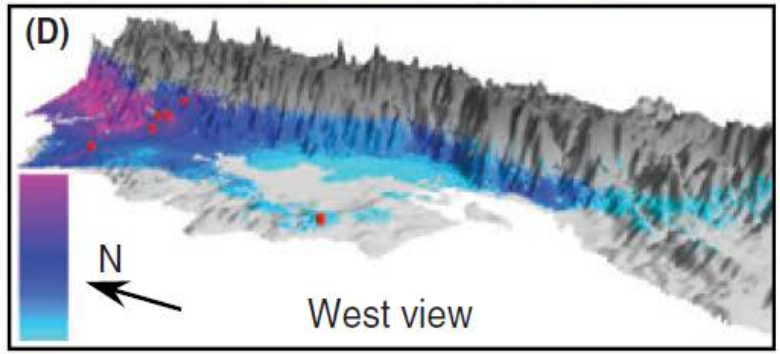
ORIGINAL ARTICLE

Modeling environmentally associated morphological and genetic variation in a rainforest bird, and its application to conservation prioritization

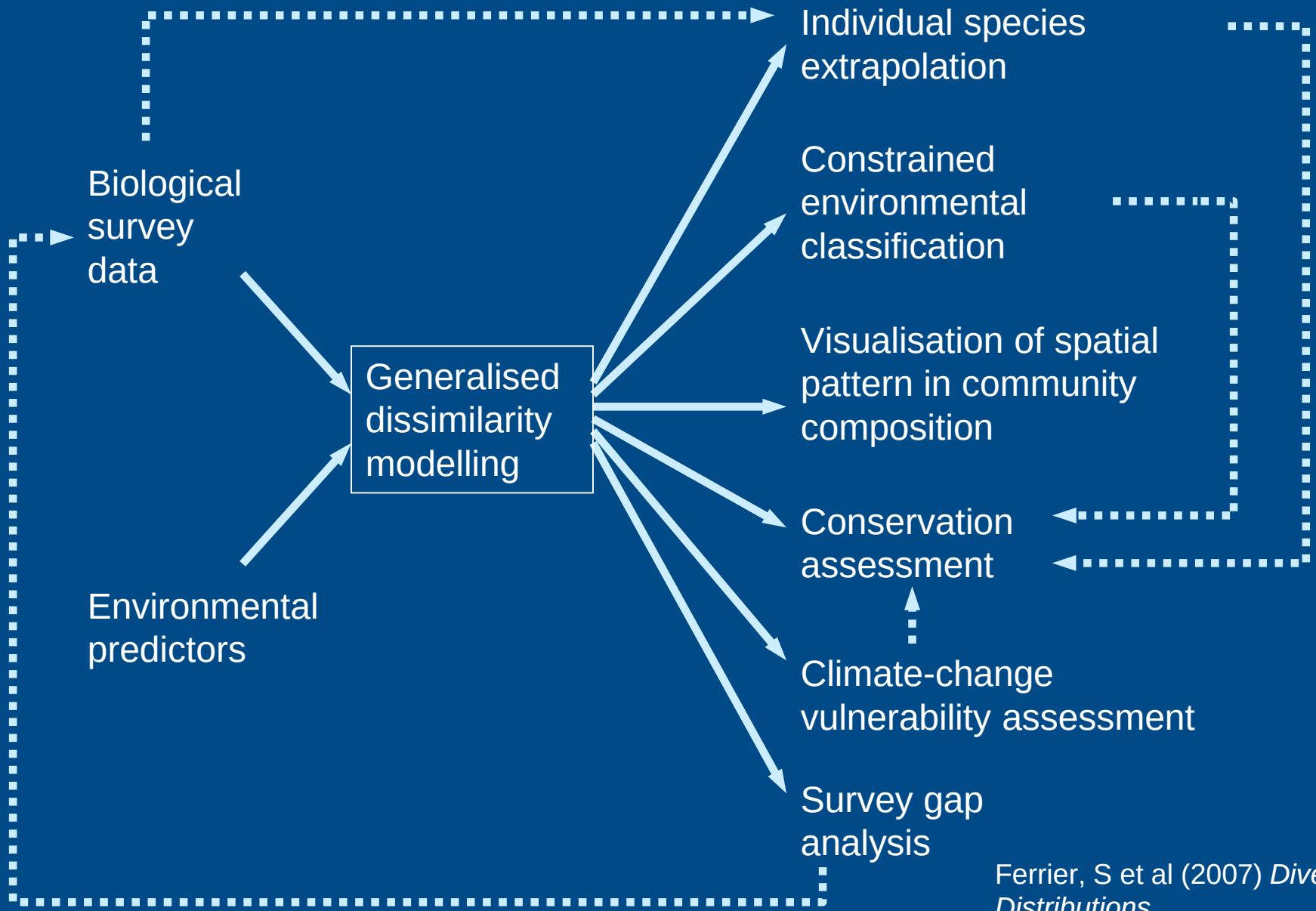
Henri A. Thomassen,[1] Wolfgang Buermann,[1] Borja Milá,[1,2] Catherine H. Graham,[3] Susan E. Cameron,[4] Christopher J. Schneider,[5] John P. Pollinger,[1,6] Sassan Saatchi,[1,7] Robert K. Wayne[1,6] and Thomas B. Smith[1,6]





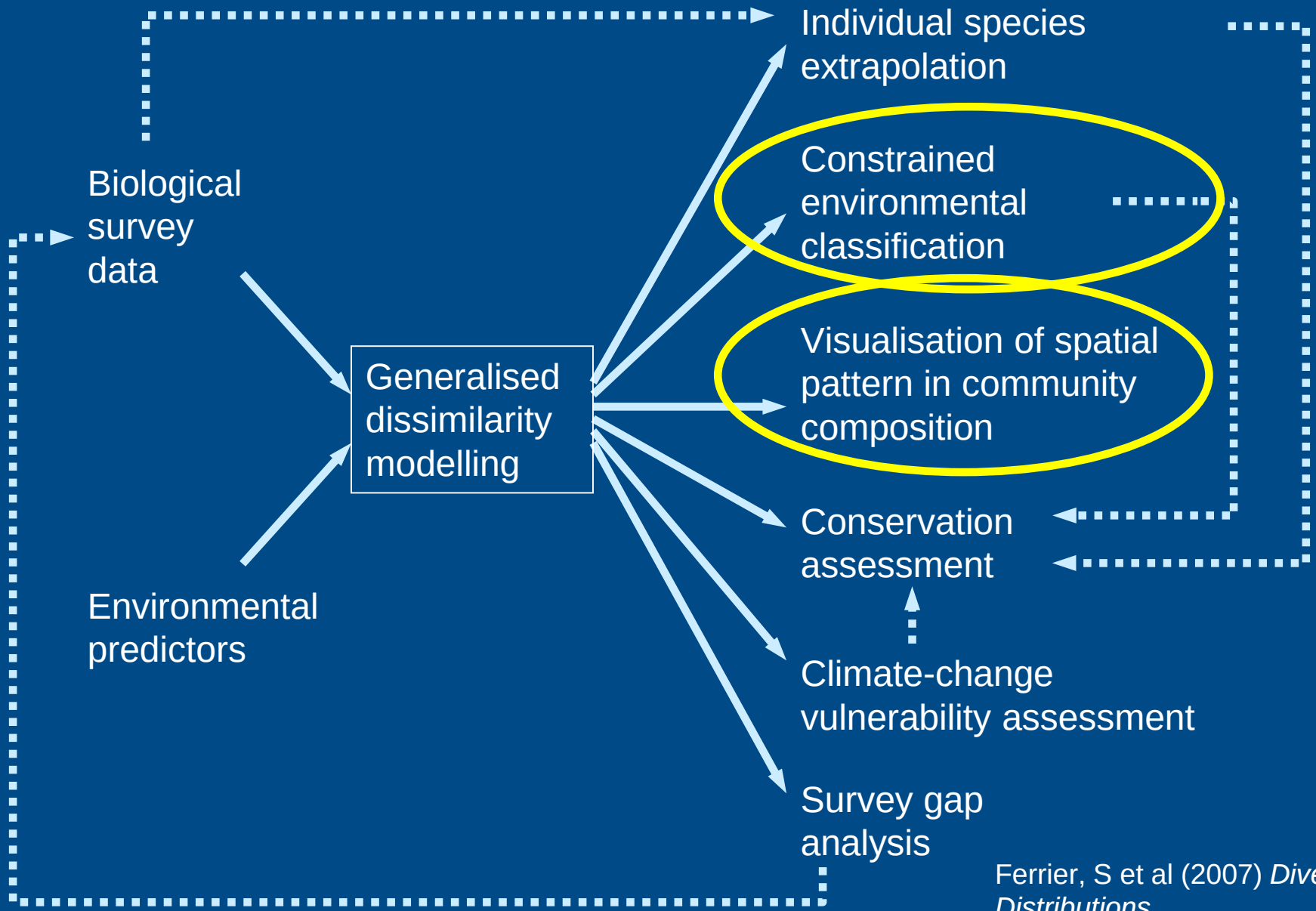


Perspective on potential roles of GDM, *circa* 2007



Ferrier, S et al (2007) *Diversity & Distributions*

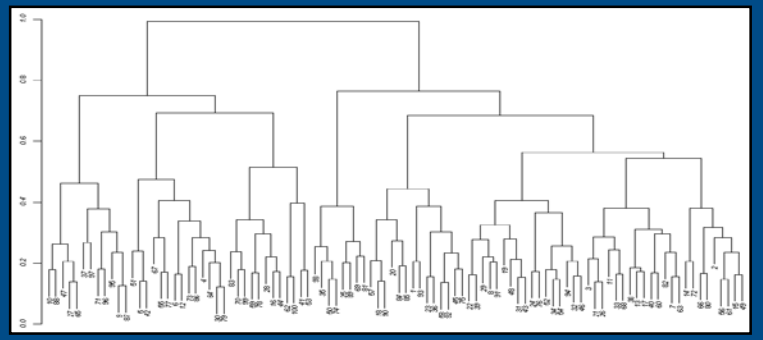
Perspective on potential roles of GDM, *circa* 2007

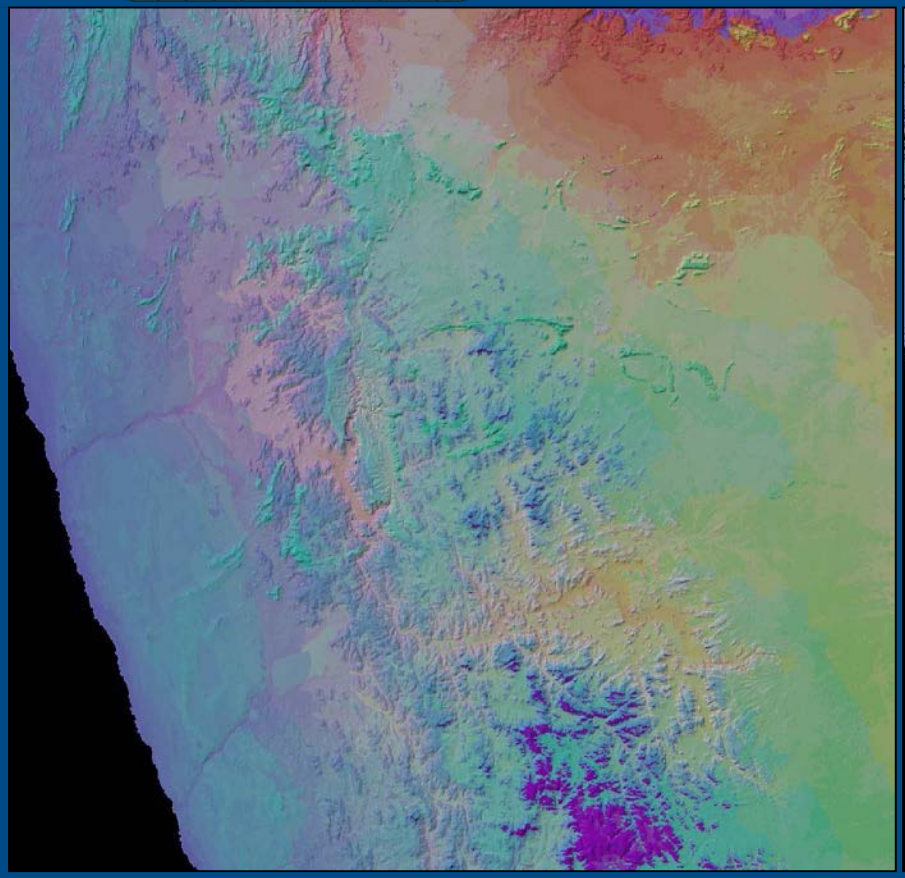


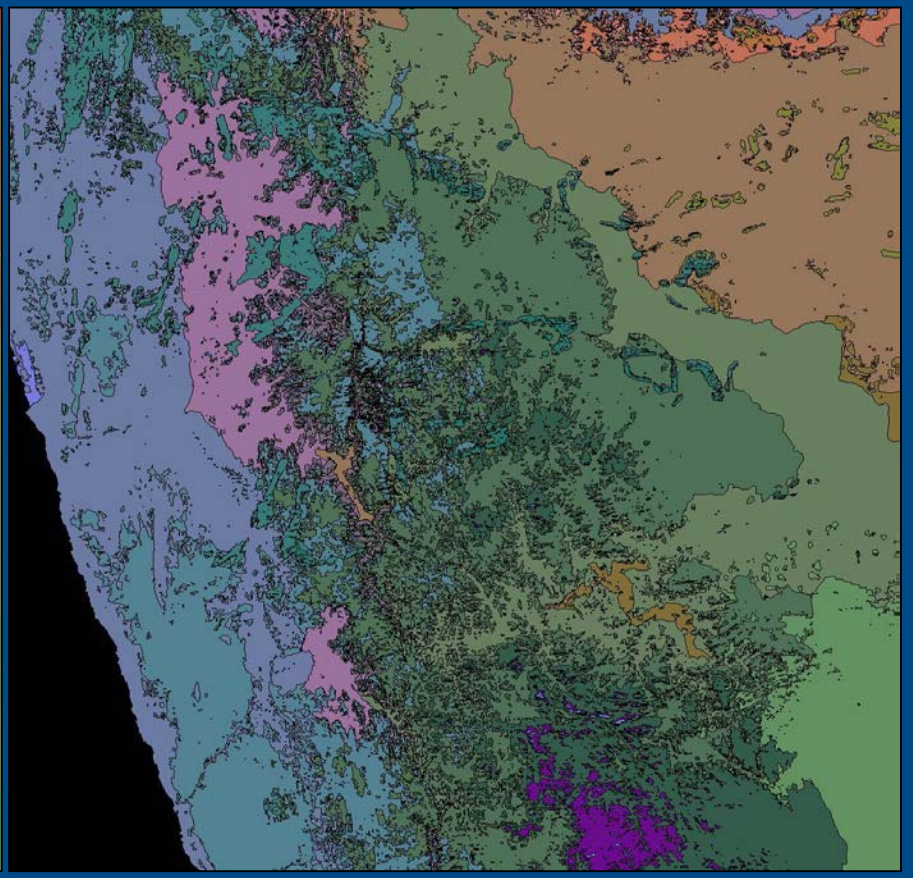
Ferrier, S et al (2007) *Diversity & Distributions*

Visualisation and classification of spatial pattern in compositional turnover

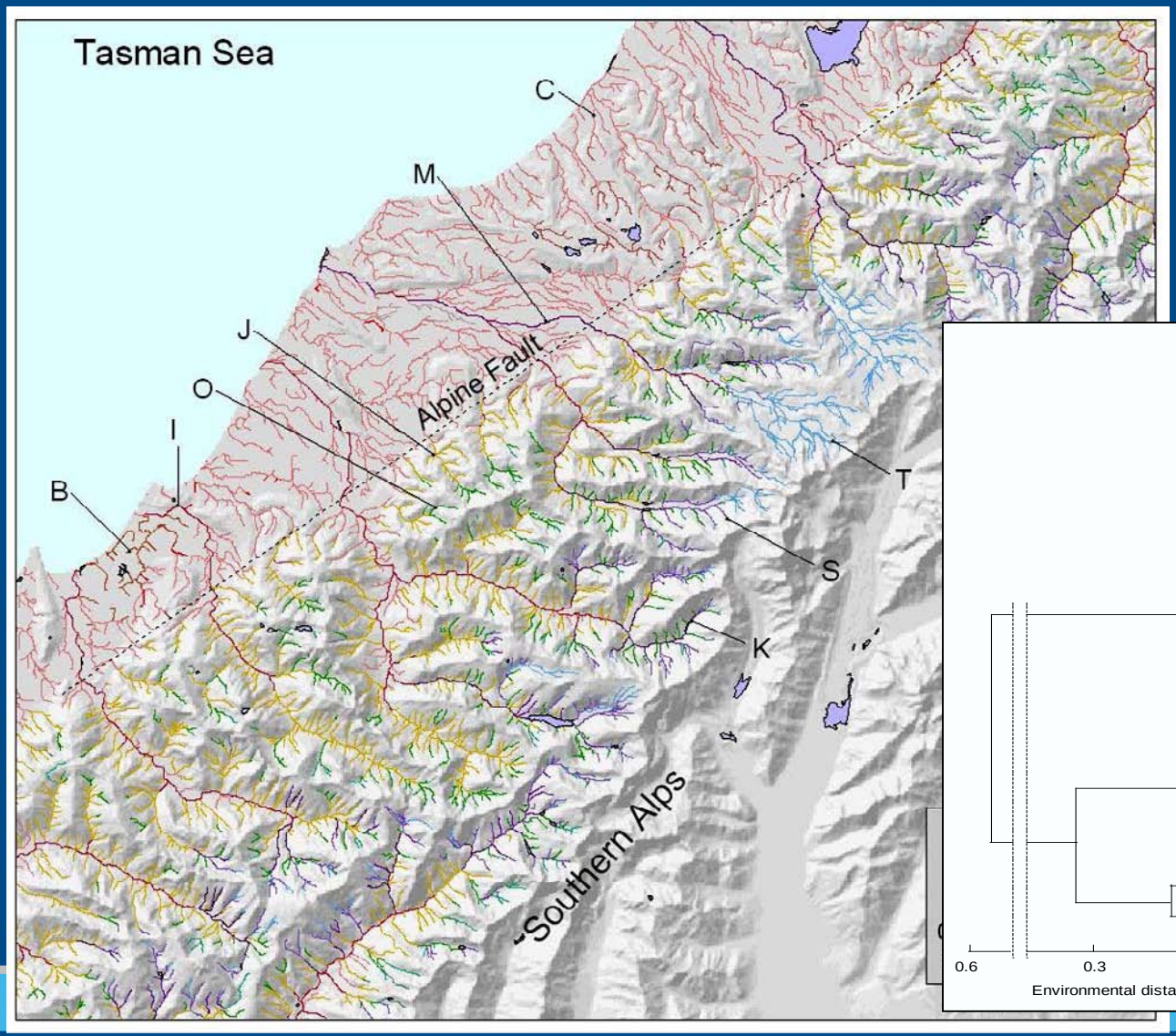
Ferrier, S et al (2007)
Diversity & Distributions

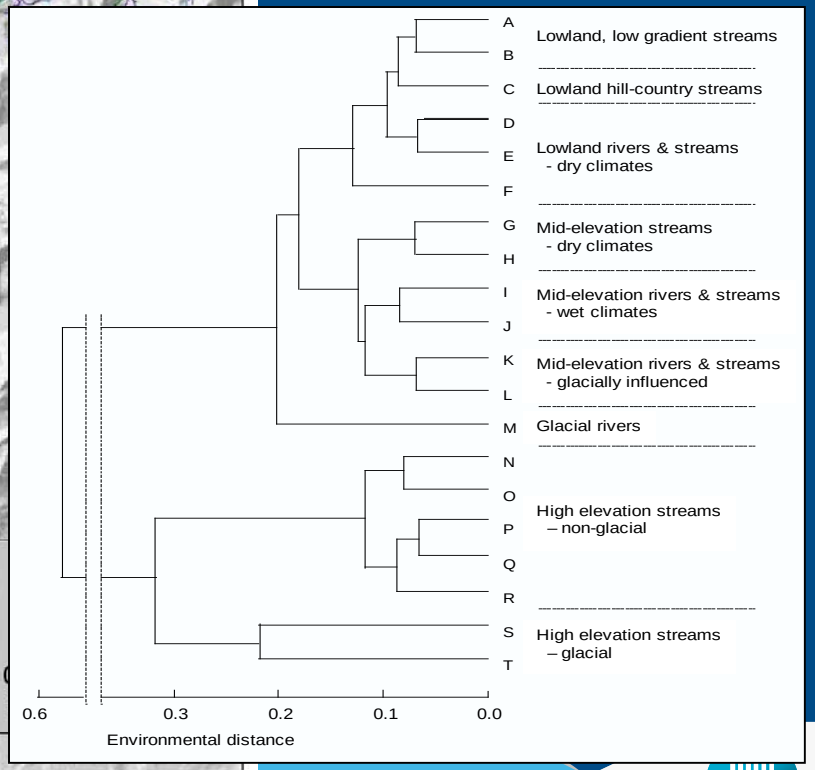






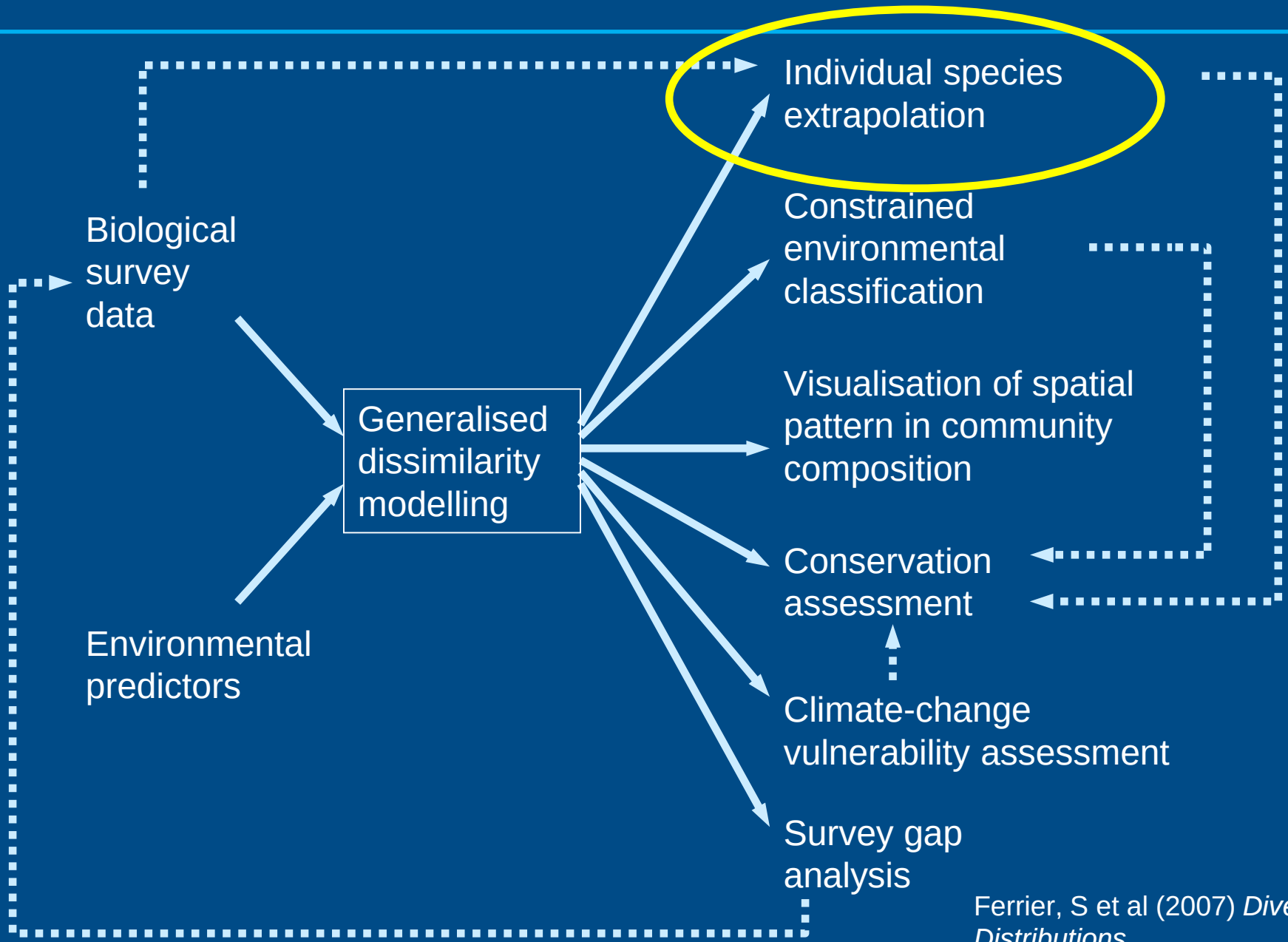
Visualisation and classification of spatial pattern in compositional turnover





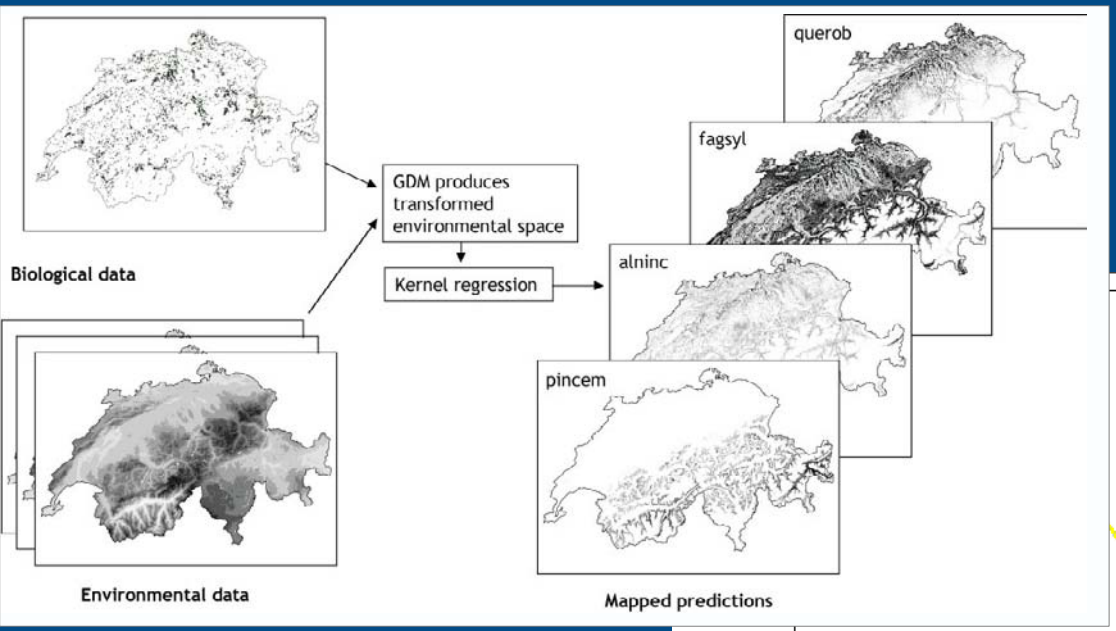
Leathwick, JR et al (2011) *Freshwater Biology* 56: 21-38

Perspective on potential roles of GDM, *circa* 2007

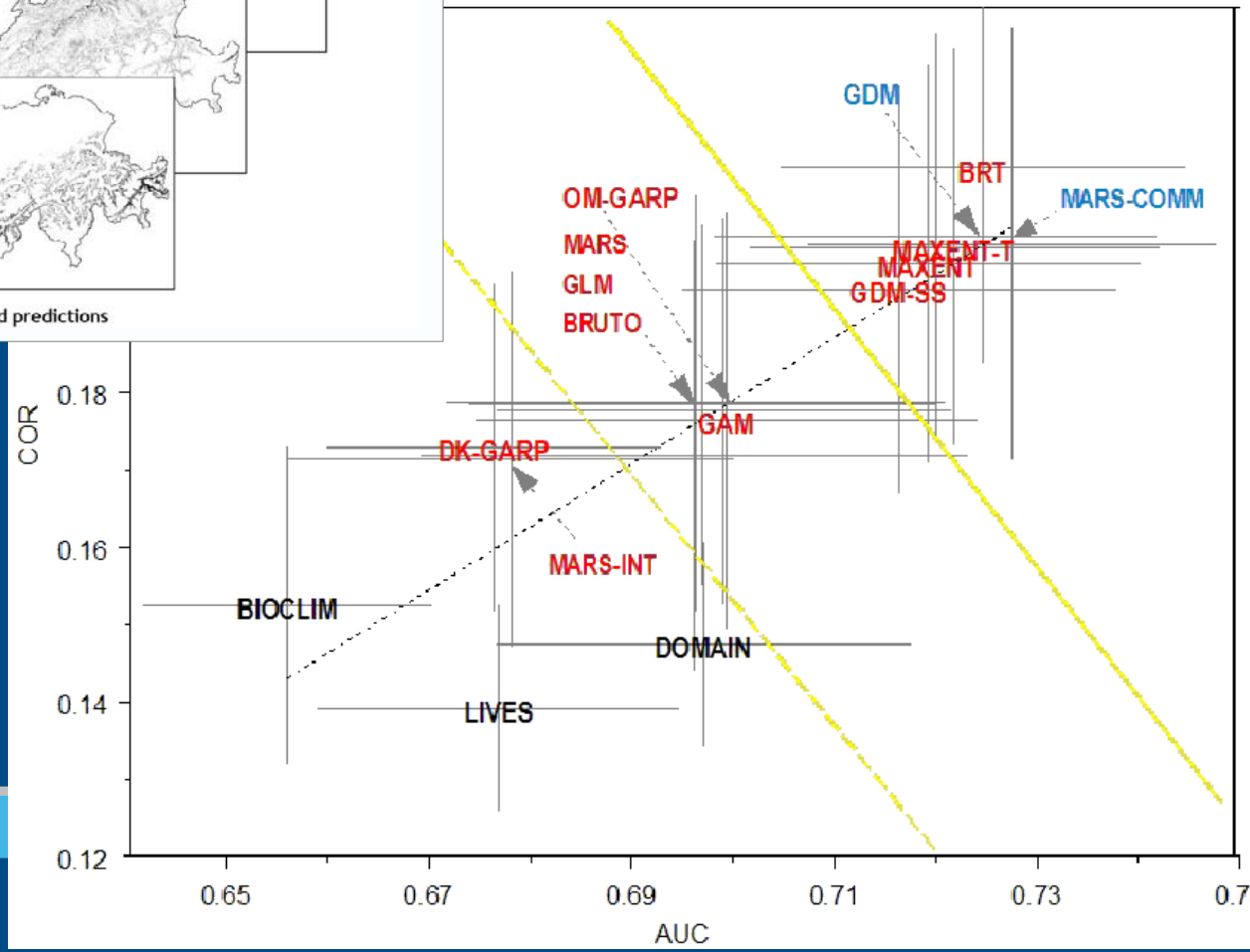


Ferrier, S et al (2007) *Diversity & Distributions*

Predictively mapping distributions of individual species?



Ferrier, S *et al* (2007) *Diversity & Distributions*



Elith, J *et al (2006) Ecography*

Predictively mapping distributions of individual species – potential to simulate unknown species?

ECOLOGY LETTERS

Ecology Letters, (2011) **14**: 1043–1051 doi: 10.1111/j.1461-0248.2011.01675.

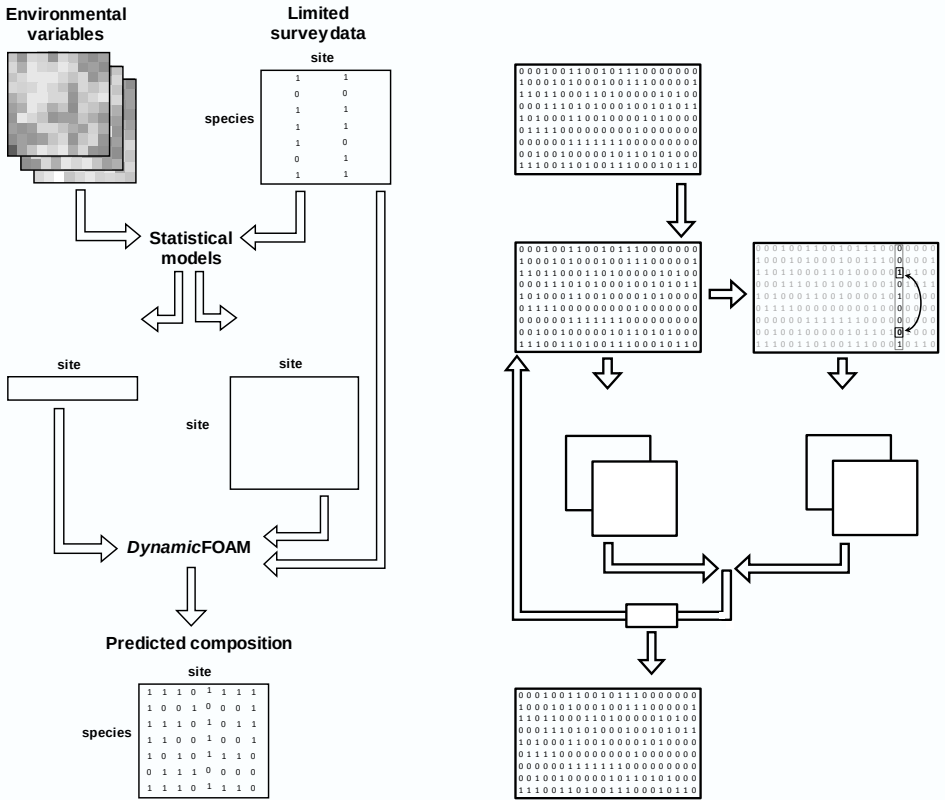
LETTER

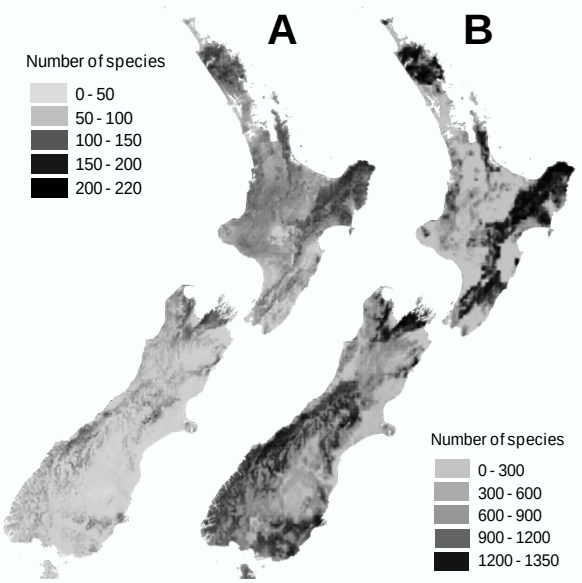
Combining α- and β-diversity models to fill gaps in our knowledge of biodiversity

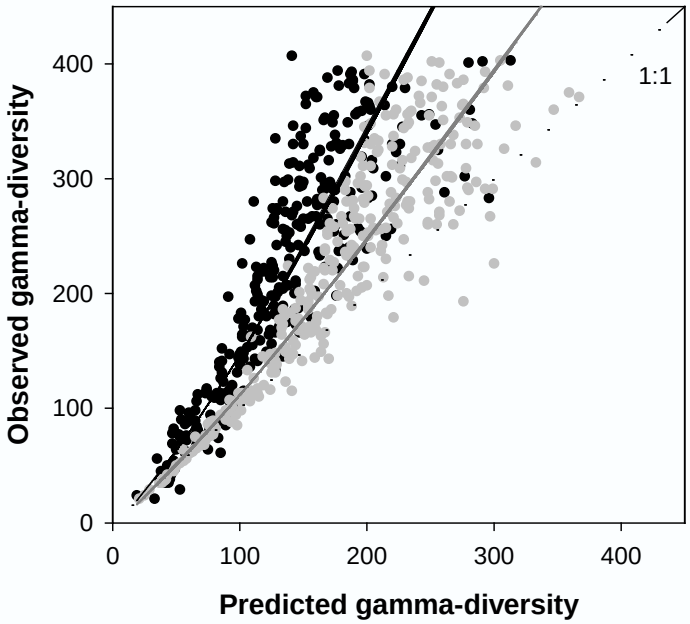
Karel Mokany,[1]* Thomas D. Harwood,[1] Jacob McC. Overton,[2] Gary M. Barker[2] and Simon Ferrier[1]

Abstract

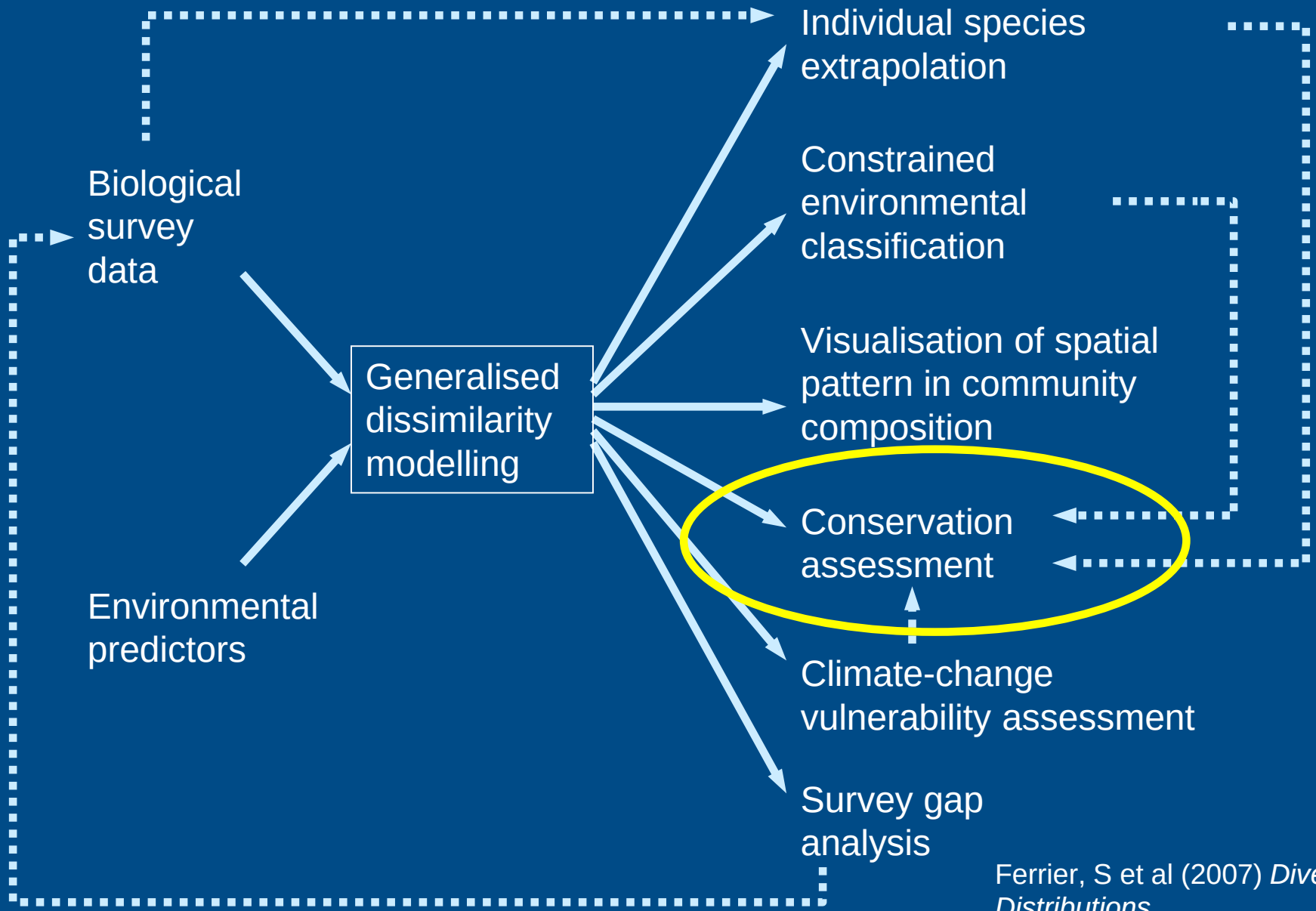
For many taxonomic groups, sparse information on the spatial distribution of biodiversity limits our capacity to answer a variety of theoretical and applied ecological questions. Modelling community-level attributes (α- and β diversity) over space can help overcome this shortfall in our knowledge, yet individually, predictions of α





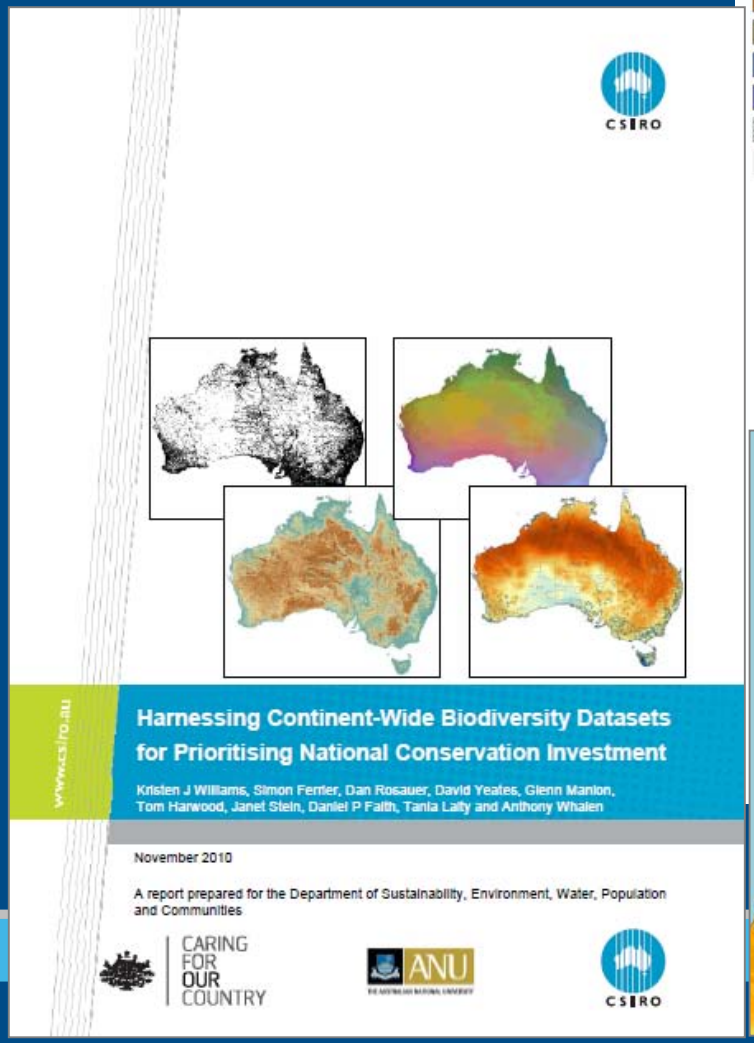


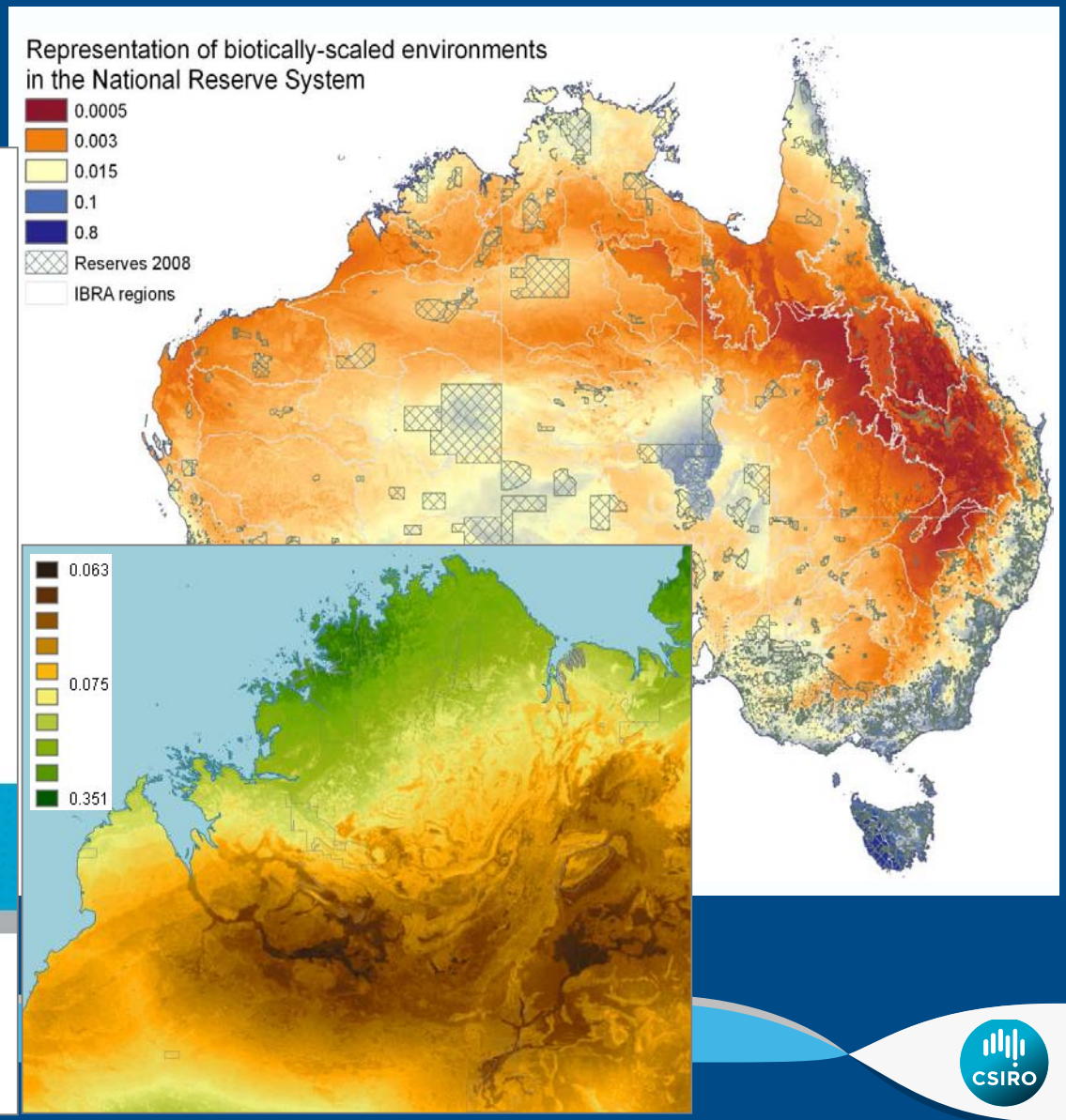
Perspective on potential roles of GDM, *circa* 2007



Ferrier, S et al (2007) *Diversity & Distributions*

Conservation assessment – national/continental scale



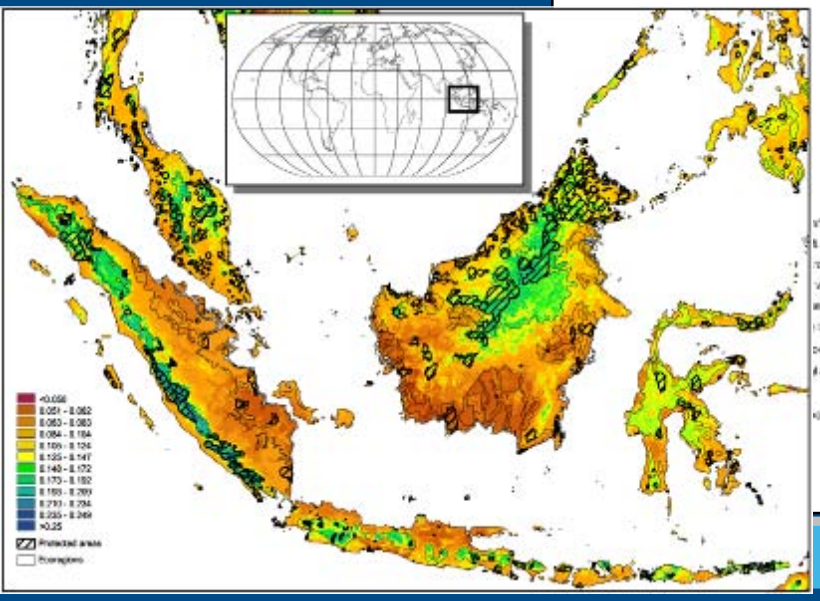


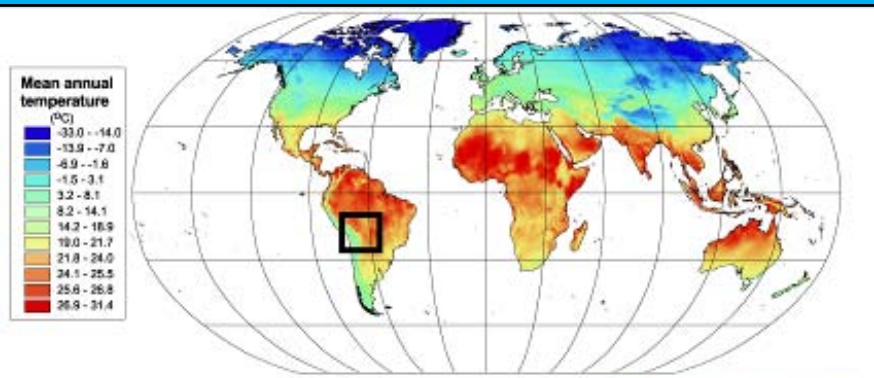
Conservation assessment – global scale

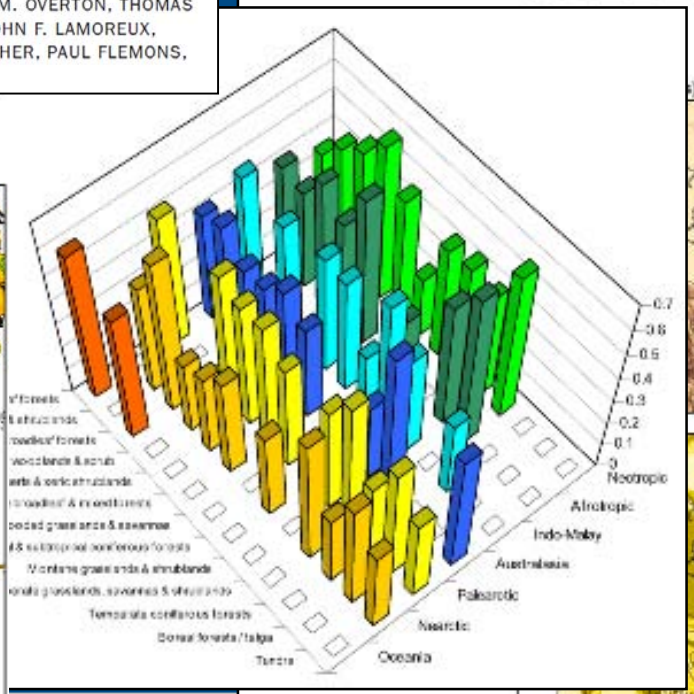
Articles

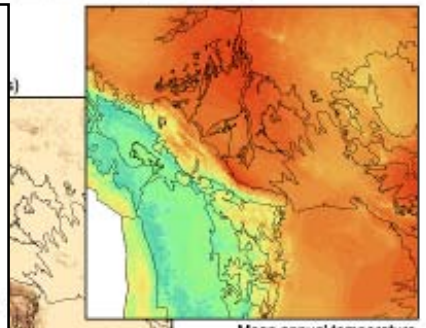
Mapping More of Terrestrial Biodiversity for Global Conservation Assessment

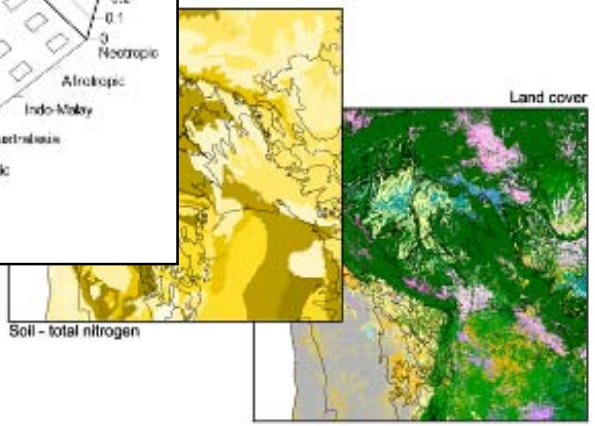
SIMON FERRIER, GEORGE V. N. POWELL, KAREN S. RICHARDSON, GLENN MANION, JAKE M. OVERTON, THOMAS F. ALLNUTT, SUSAN E. CAMERON, KELLIE MANTLE, NEIL D. BURGESS, DANIEL P. FAITH, JOHN F. LAMOREUX, GEROLD KIER, ROBERT J. HIJMANS, VICKI A. FUNK, GERASIMOS A. CASSIS, BRIAN L. FISHER, PAUL FLEMONS, DAVID LEES, JON C. LOVETT, AND RENAAT S. A. R. VAN ROMPAEY





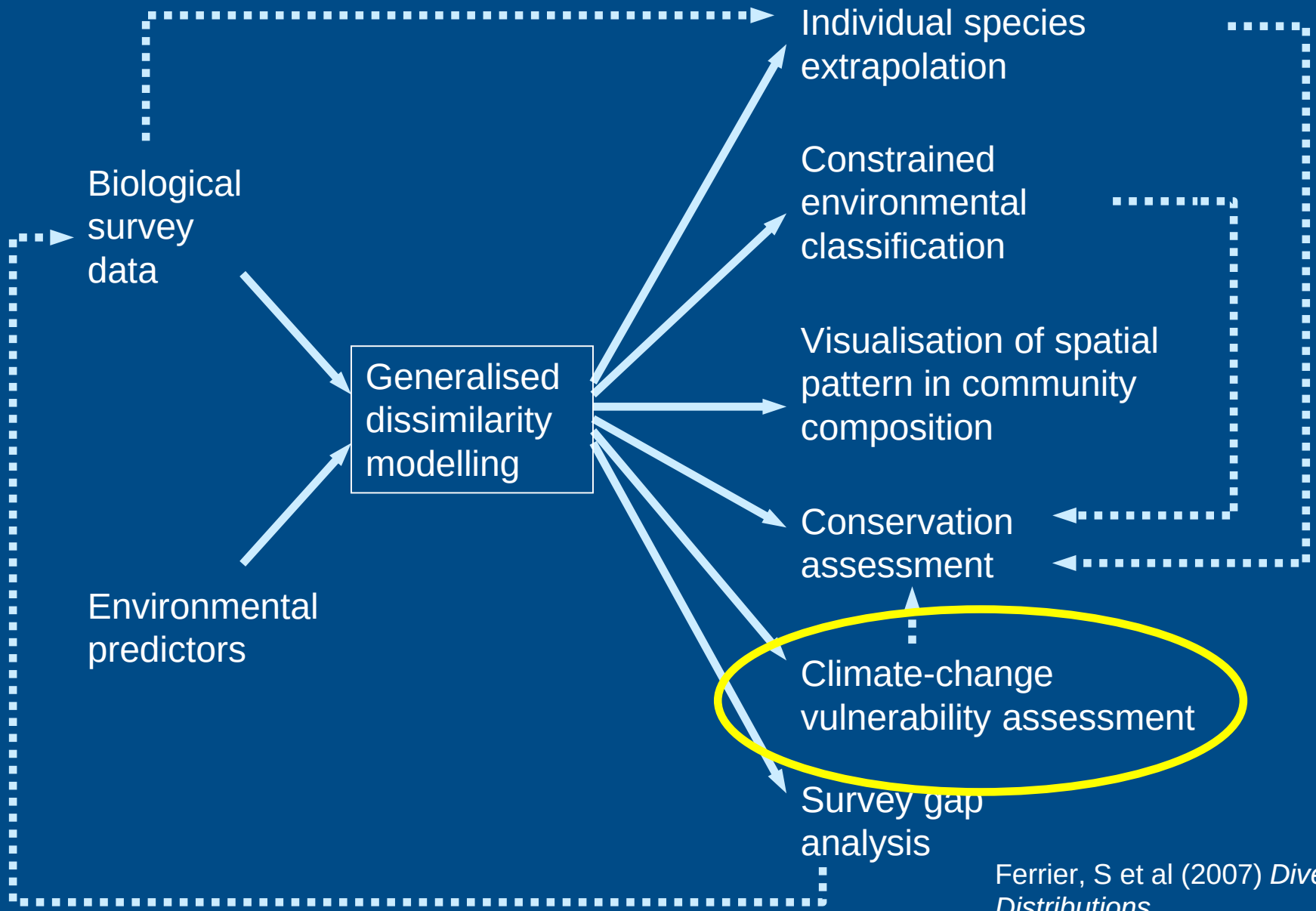






Ferrier et al (2004) *BioScience*

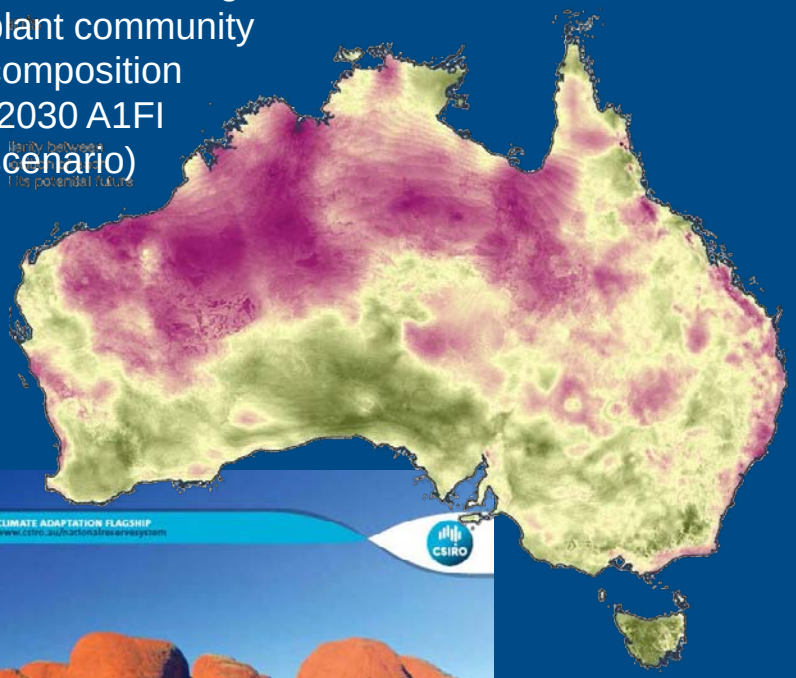
Perspective on potential roles of GDM, *circa* 2007

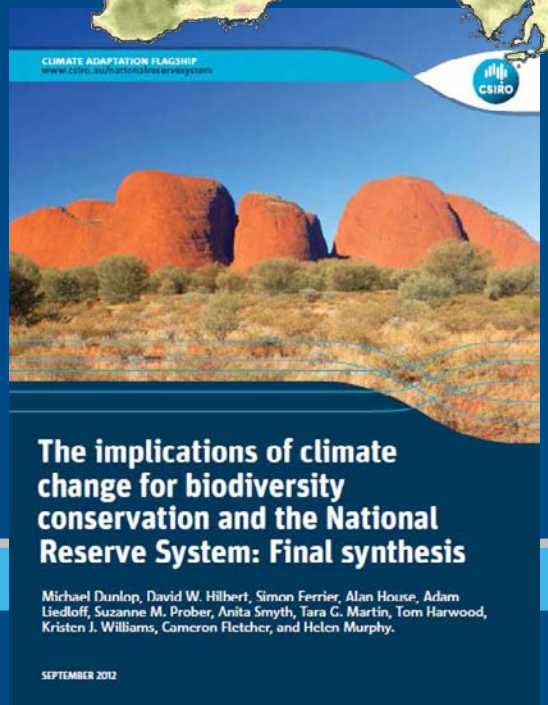


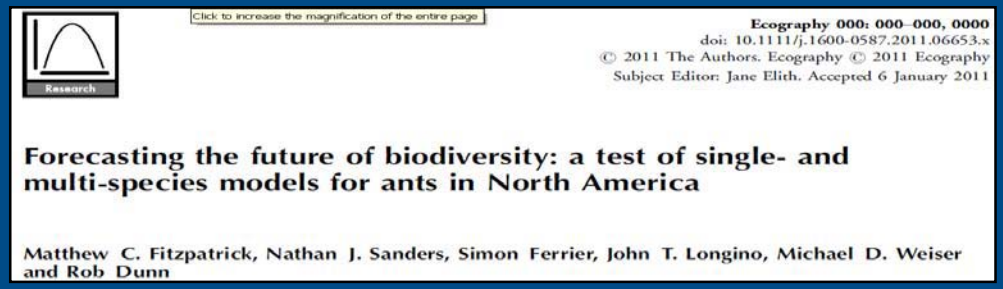
Ferrier, S et al (2007) *Diversity & Distributions*

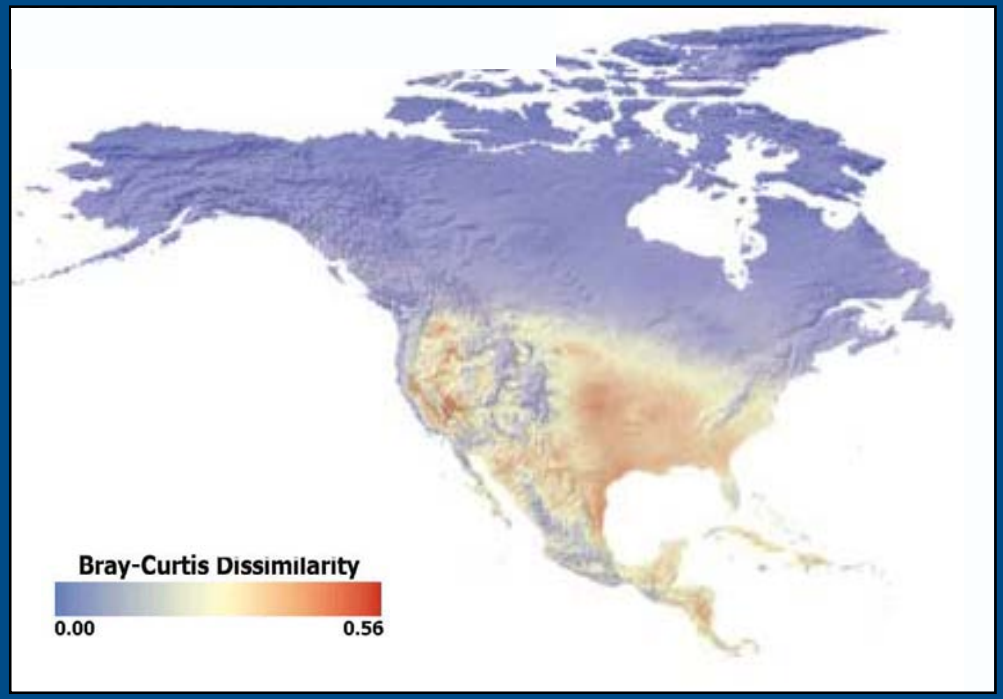
Projecting potential impacts of climate change – correlative space-for-time substitution

Potential change in plant community composition (2030 A1FI scenario)

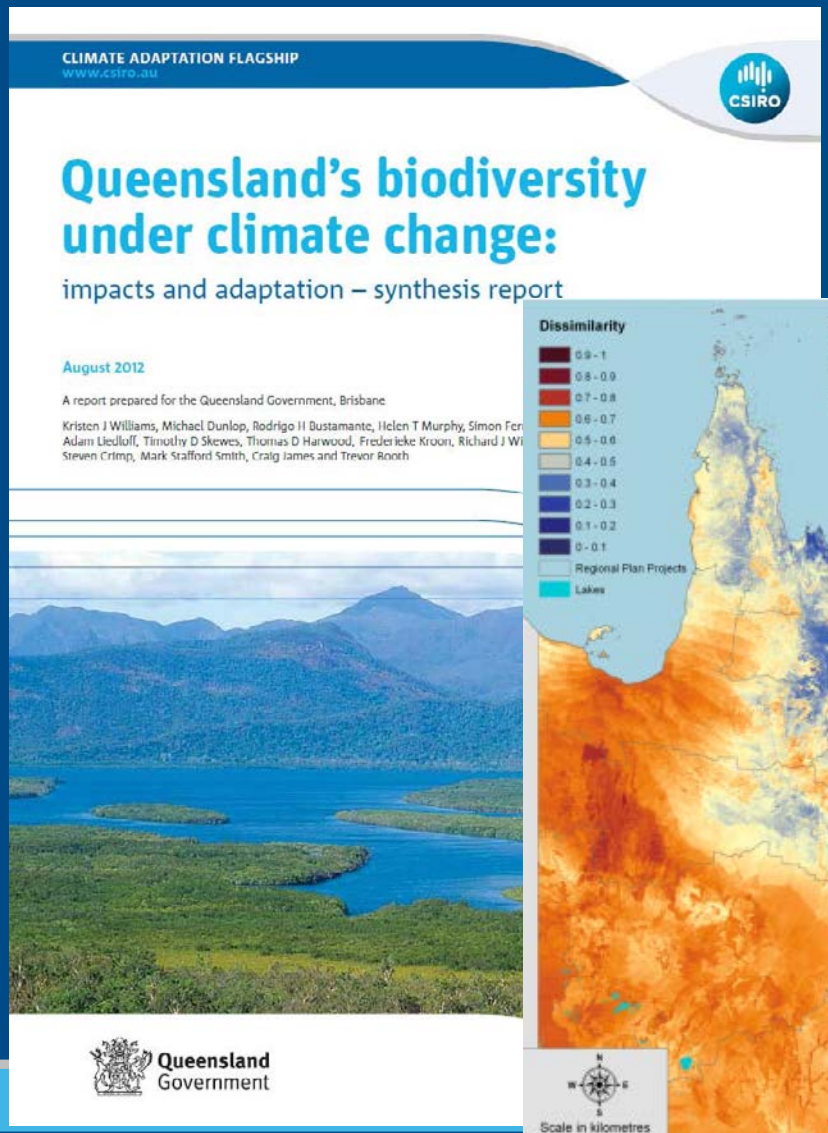


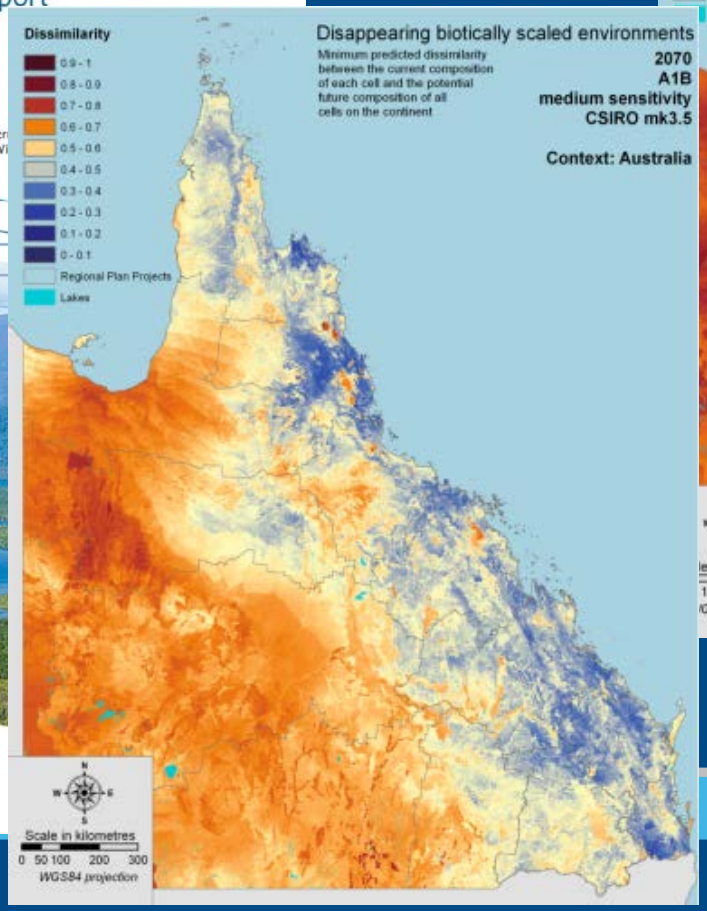


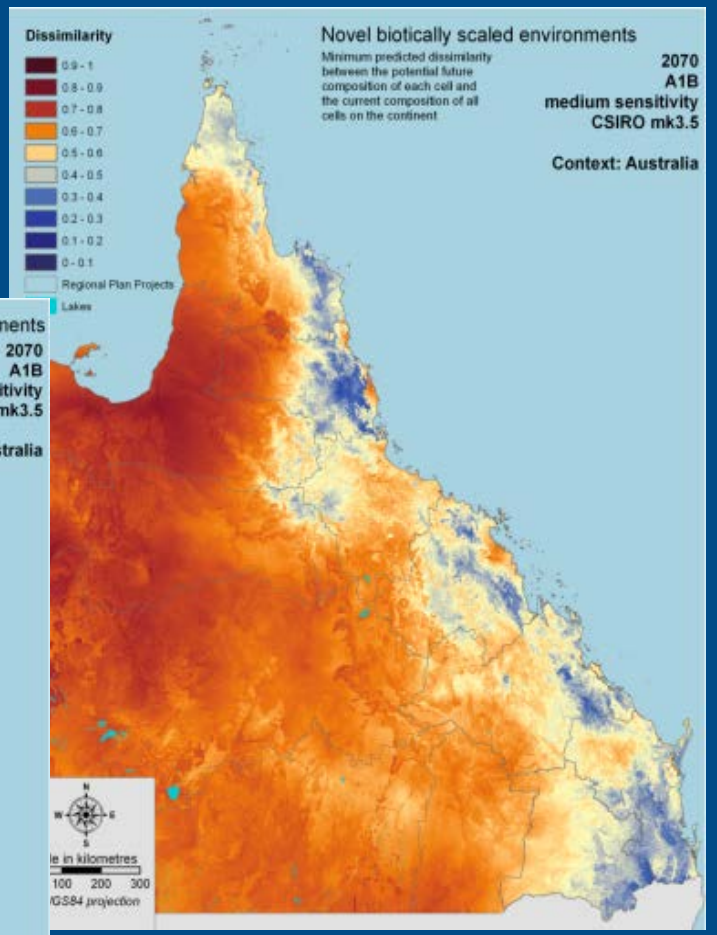




Projecting potential impacts of climate change – correlative space-for-time substitution







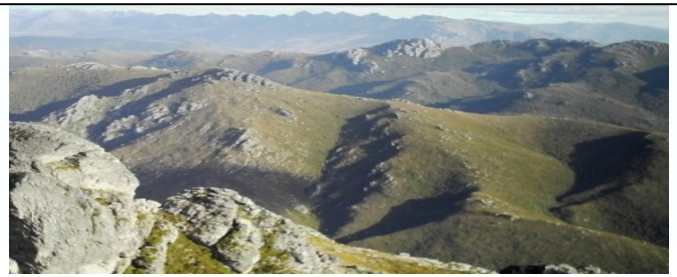
Projecting potential impacts of climate change – semi-mechanistic modelling

Global Change Biology

Global Change Biology (2012) 18, 3149–3159, doi: 10.1111/j.1365-2486.2012.02760.x

Dynamic macroecology and the future for biodiversity

KAREL MOKANY, THOMAS D. HARWOOD, KRISTEN J. WILLIAMS and SIMON FERRIER



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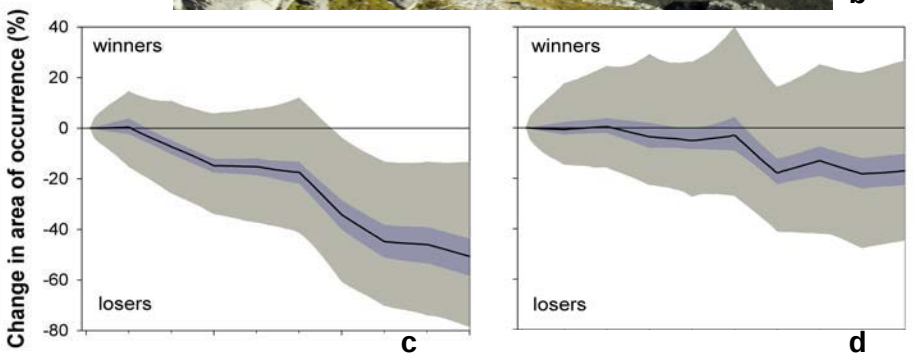
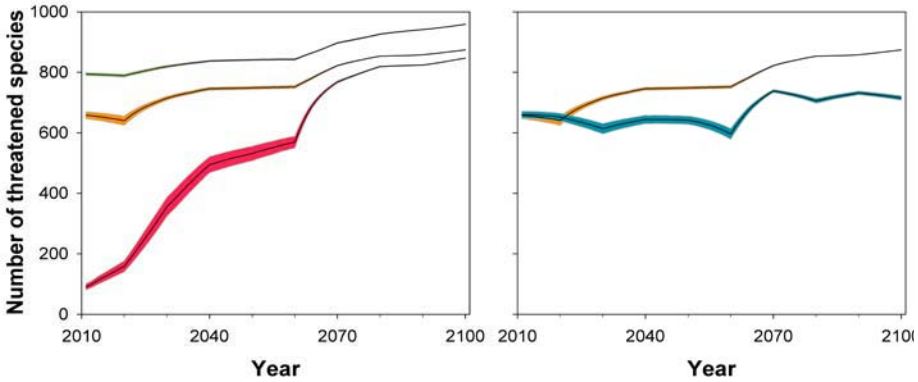
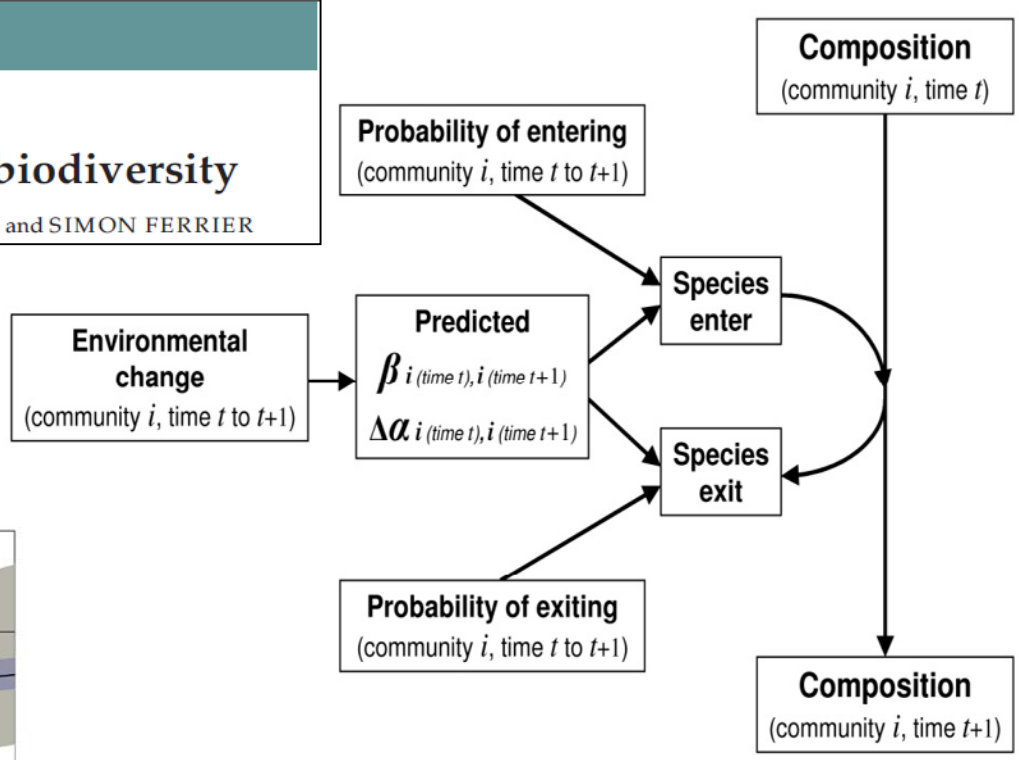
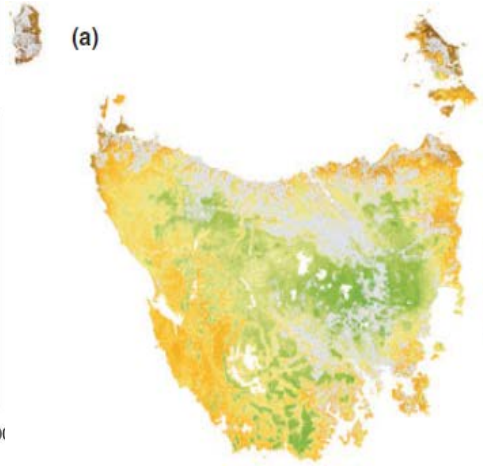
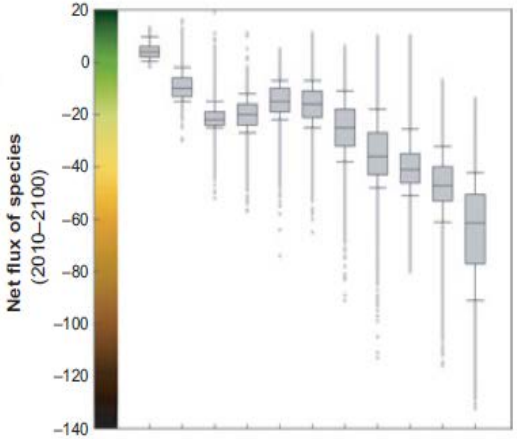








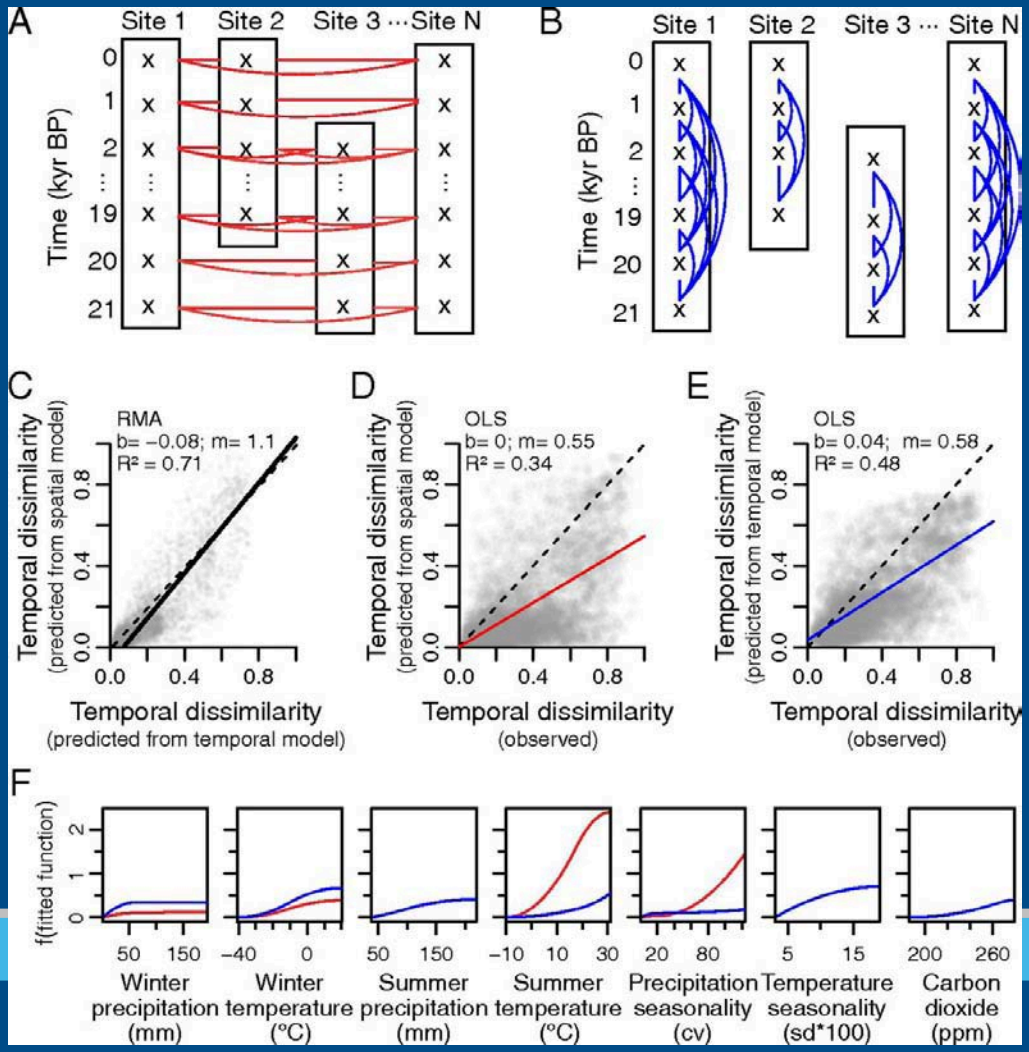


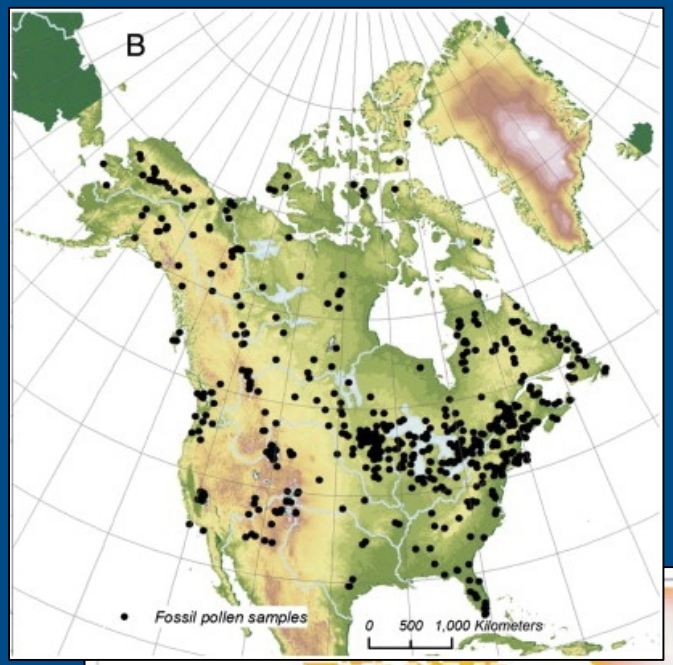
Using paleo-ecological data to test the predictive performance of projections

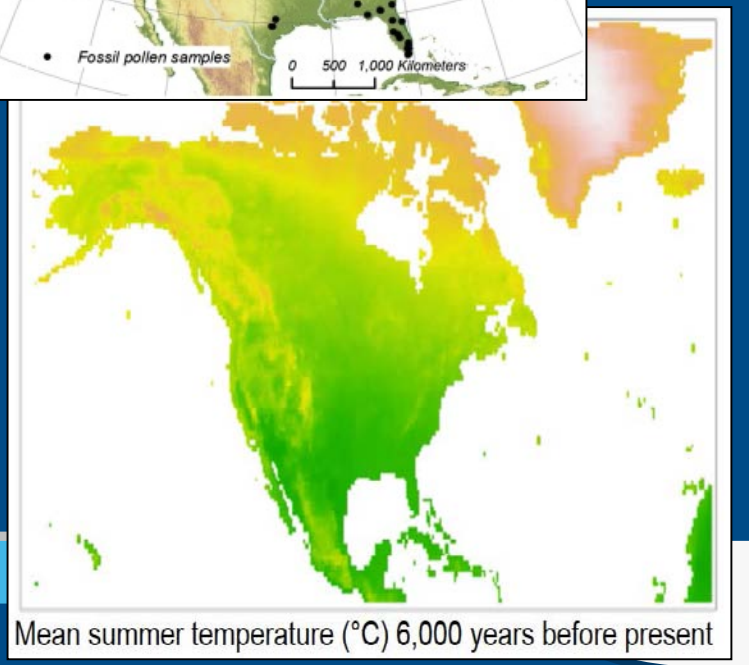
PNAS

Space can substitute for time in predicting climate-change effects on biodiversity

Jessica L. Blois[a,1], John W. Williams[a], Matthew C. Fitzpatrick[b], Stephen T. Jackson[c], and Simon Ferrier[d]







Mean summer temperature (°C) 6,000 years before present

A largely unforeseen use – testing fundamental hypotheses around drivers of beta-diversity patterns

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Environmental and historical imprints on beta diversity: insights from variation in rates of species turnover along gradients

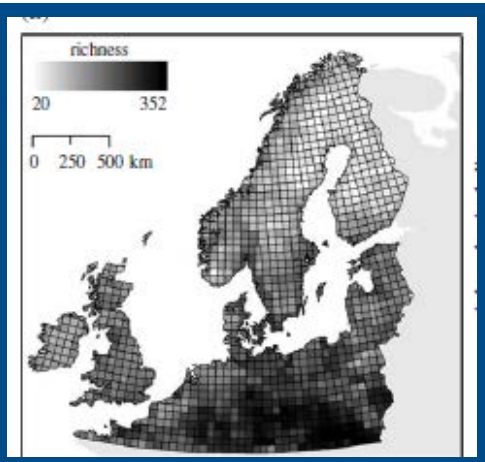
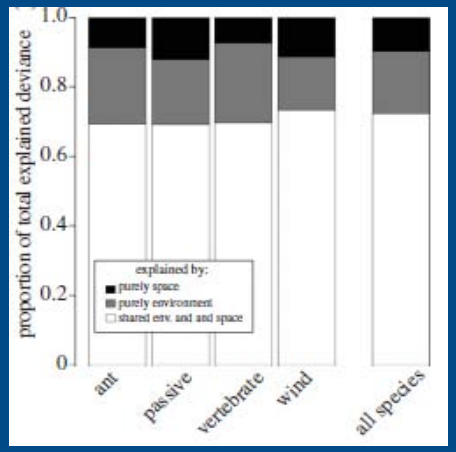
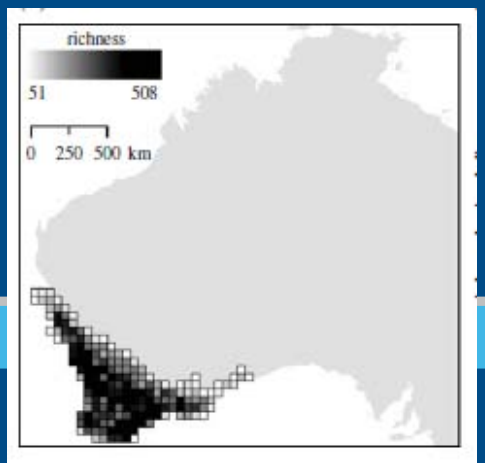
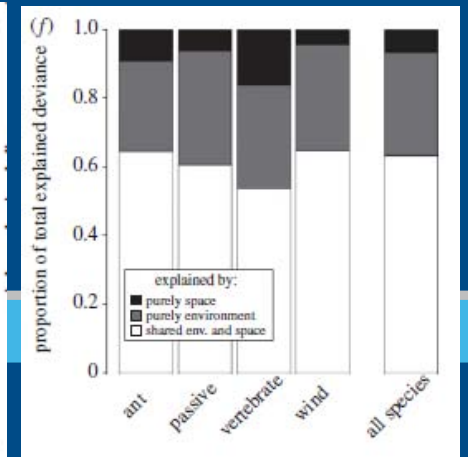
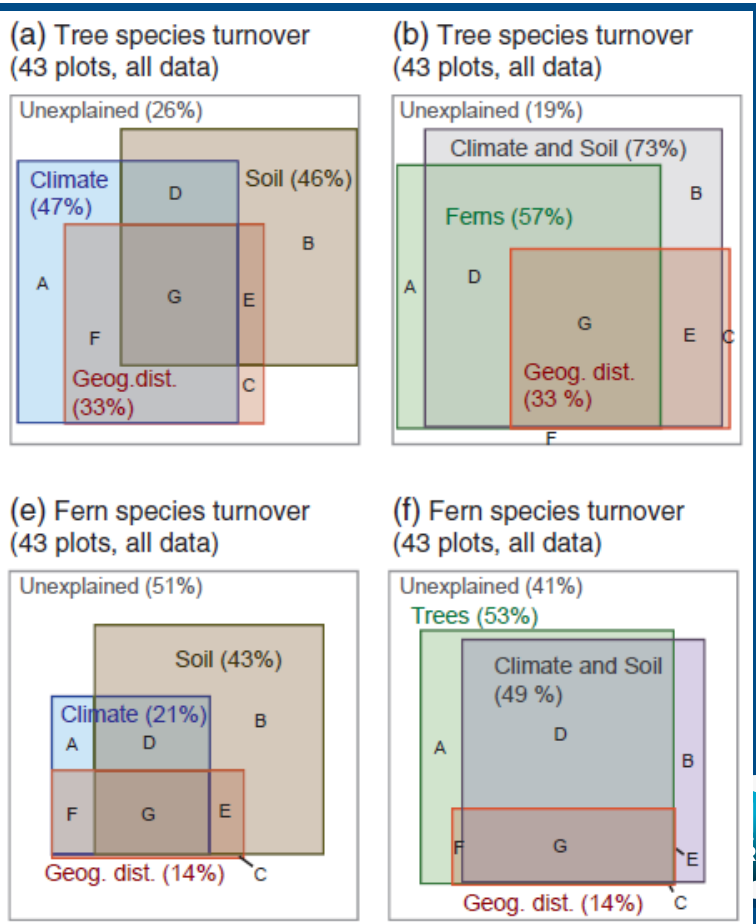
Matthew C. Fitzpatrick[1], Nathan J. Sanders[2], Signe Normand[3], Jens-Christian Svenning[4], Simon Ferrier[5], Aaron D. Gove[6] and Robert R. Dunn[7,8]

100 YEARS Journal of Ecology

British Ecological Society

Journal of Ecology 2013, **101**, 506–516

doi: 10.1111/1365-2745.12053

Strong congruence in tree and fern community turnover in response to soils and climate in central Panama

Mirkka M. Jones[1]*, Simon Ferrier[2], Richard Condit[3], Glenn Manion[4], Salomon Aguilar[3] and Rolando Pérez[3]