Ecological response models: part 1 - overview

Approaches to vulnerability assessment


APRIL 3, 2006
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TIME
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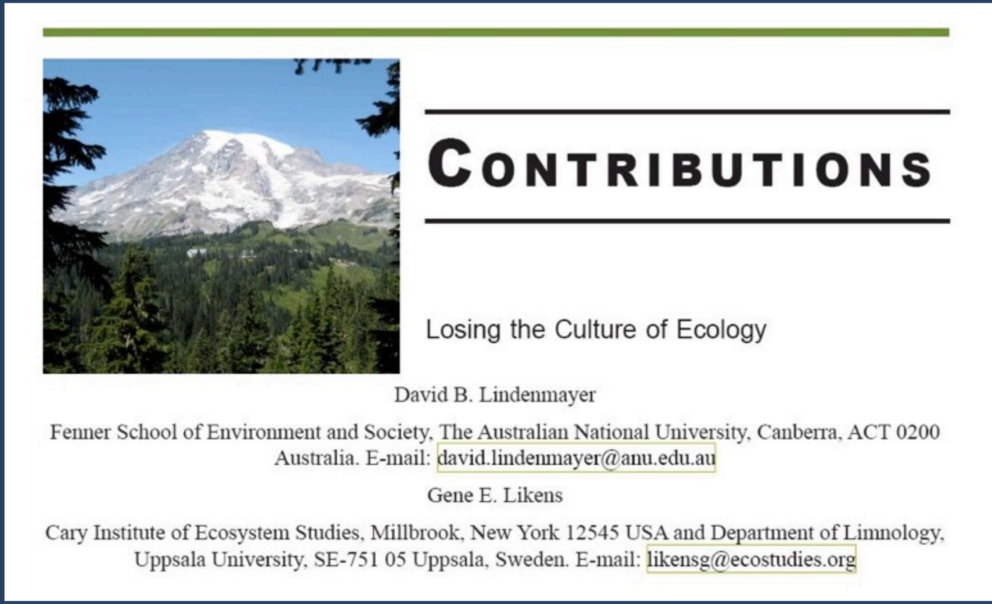
THE CLIMATE CRUSADERS

Scale

Scope

What approach do we take, and at what scale?

- Action plans should be use the best information
  - Qualitative assessment
  - Experimentation
  - Models



CONTRIBUTIONS

Losing the Culture of Ecology

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Considerations for Ecological Response Models

- WHY are you modeling?
- WHAT are you modeling?
- HOW are you modeling?

WHY are you modeling?

WHAT are you modeling?

- Target
  - Genes, species, ecosystems
  - Primary productivity
  - Mass balance
  - Nutrient flow
- Context
  - Spatial and temporal aspects of input and output
  - Factors and interactions included

HOW are you modeling it?

- Data sources
  - Experiments, experts, observations, paleo

- Model type
  - Conceptual
  - Correlative/phenomenological
  - Mechanistic
    - Deterministic vs. stochastic
    - Physiological, biogeochemical, etc.
    - Rule-based, agent-based, trait-based
    - Bayesian

Types of ecological response models

- Conceptual models
- Expert opinion models
- General characterization models
- Habitat or occupancy models
- Vegetation/habitat response models
- Physiologically based models
- Ecological models

Conceptual models

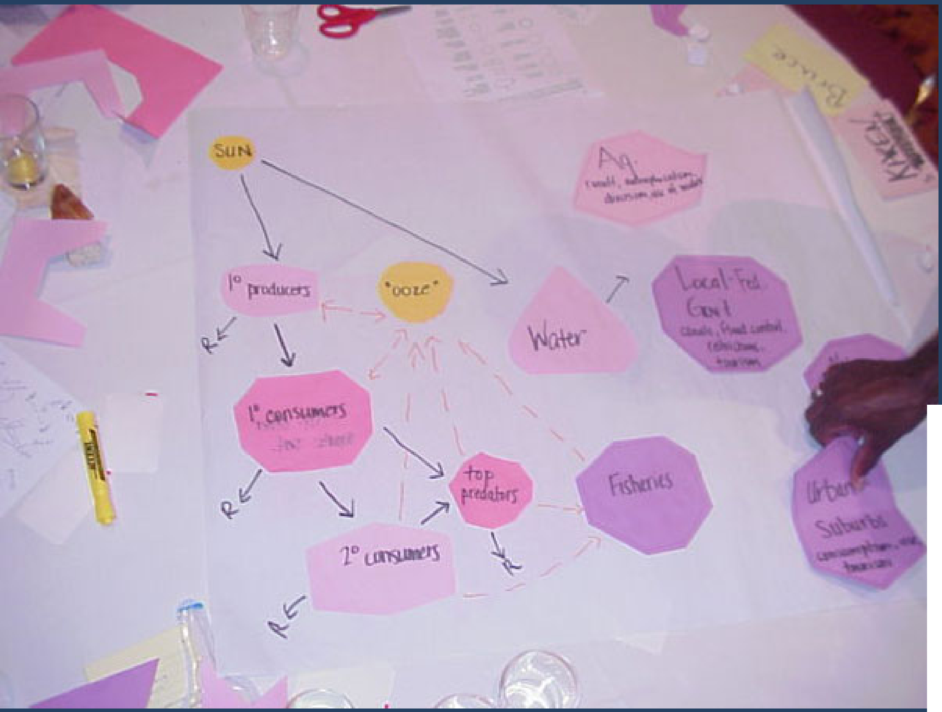


Figure taken from Heemskerk et al. 2003 – Ecology and Society

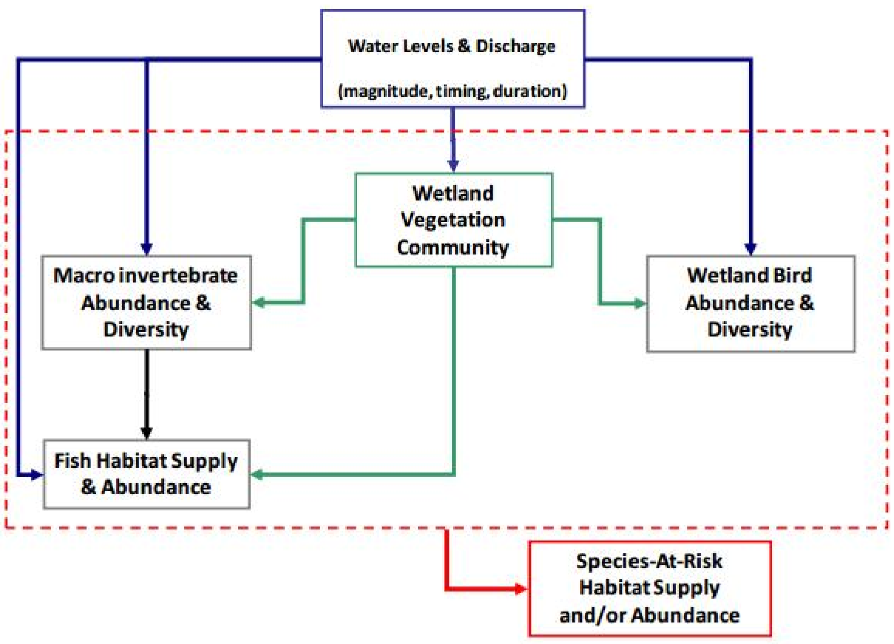
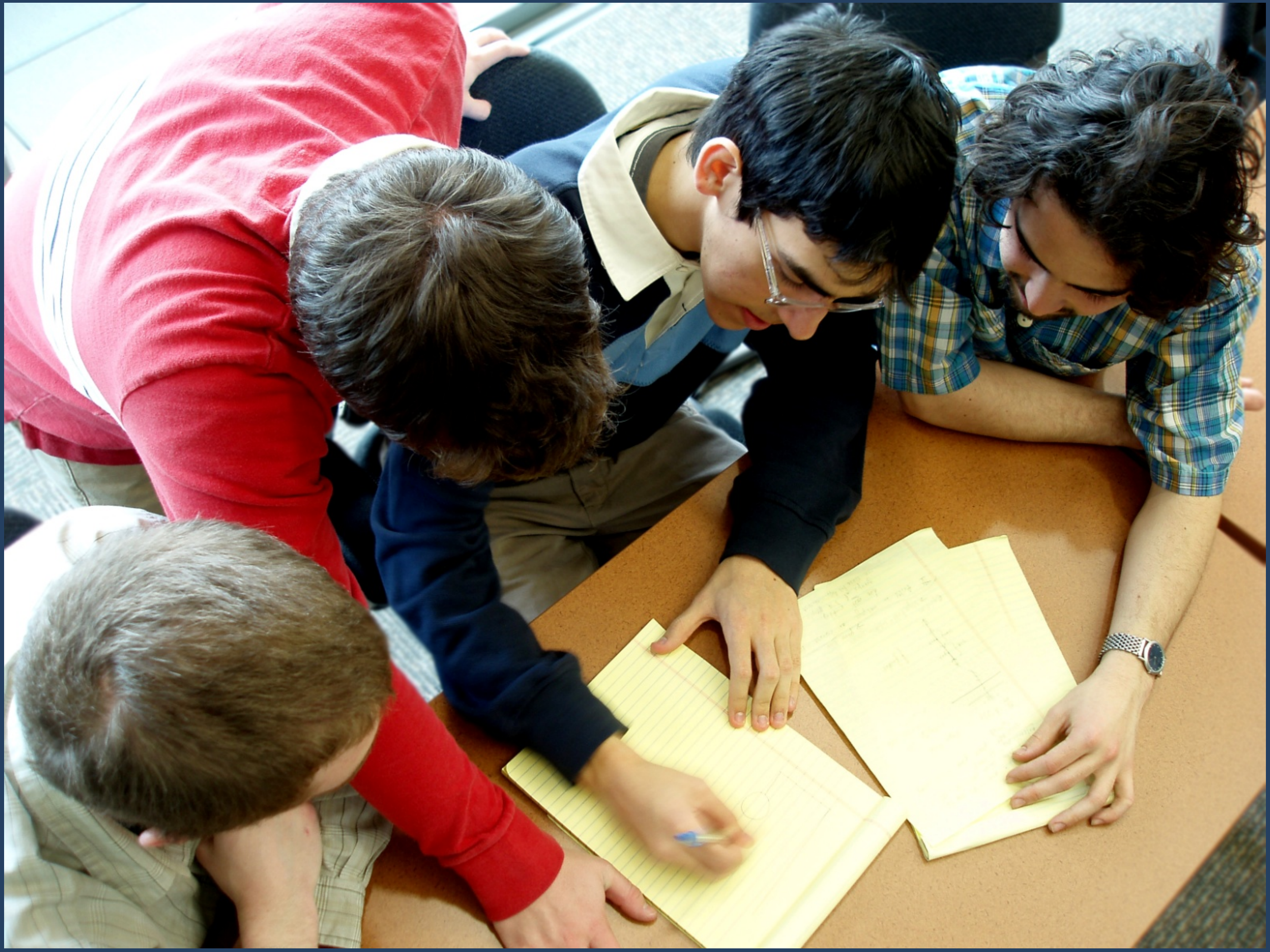
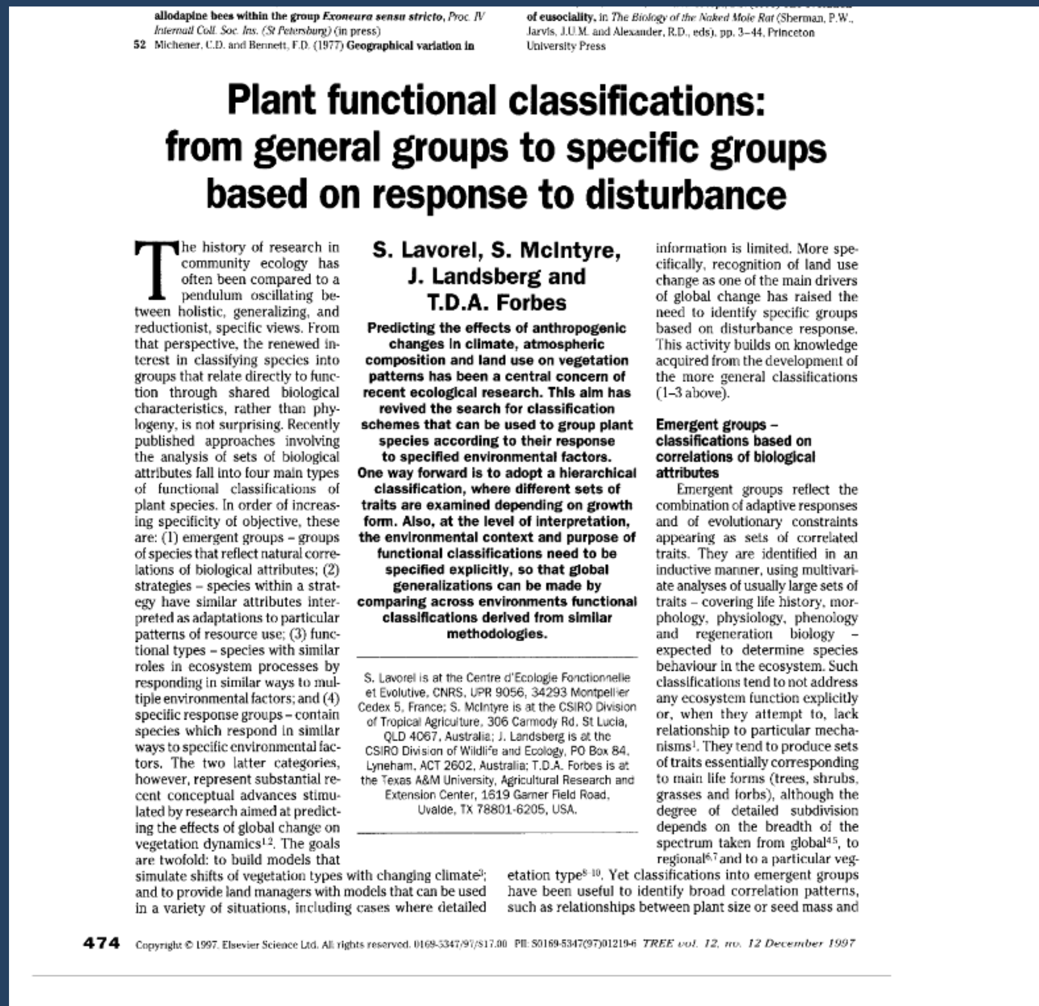


Figure 2-1. IERM2 Conceptual Linkages between Ecological Components and Sub-models

Expert opinion models



General characterization models



allodapine bees within the group *Exoneura sensu stricto*, *Proc. IV Internatl Coll. Soc. Ins. (St Petersburg)* (in press)

52 Michener, C.D. and Bennett, F.D. (1977) **Geographical variation in**

of eusociality, in *The Biology of the Naked Mole Rat* (Sherman, P.W., Jarvis, J.U.M. and Alexander, R.D., eds), pp. 3–44, Princeton University Press

Plant functional classifications: from general groups to specific groups based on response to disturbance

S. Lavorel, S. McIntyre, J. Landsberg and T.D.A. Forbes

Predicting the effects of anthropogenic changes in climate, atmospheric composition and land use on vegetation patterns has been a central concern of recent ecological research. This aim has revived the search for classification schemes that can be used to group plant species according to their response to specified environmental factors. One way forward is to adopt a hierarchical classification, where different sets of traits are examined depending on growth form. Also, at the level of interpretation, the environmental context and purpose of functional classifications need to be specified explicitly, so that global generalizations can be made by comparing across environments functional classifications derived from similar methodologies.

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The history of research in community ecology has often been compared to a pendulum oscillating between holistic, generalizing, and reductionist, specific views. From that perspective, the renewed interest in classifying species into groups that relate directly to function through shared biological characteristics, rather than phylogeny, is not surprising. Recently published approaches involving the analysis of sets of biological attributes fall into four main types of functional classifications of plant species. In order of increasing specificity of objective, these are: (1) emergent groups – groups of species that reflect natural correlations of biological attributes; (2) strategies – species within a strategy have similar attributes interpreted as adaptations to particular patterns of resource use; (3) functional types – species with similar roles in ecosystem processes by responding in similar ways to multiple environmental factors; and (4) specific response groups – contain species which respond in similar ways to specific environmental factors. The two latter categories, however, represent substantial recent conceptual advances stimulated by research aimed at predicting the effects of global change on vegetation dynamics[1,2]. The goals are twofold: to build models that simulate shifts of vegetation types with changing climate[3]; and to provide land managers with models that can be used in a variety of situations, including cases where detailed information is limited. More specifically, recognition of land use change as one of the main drivers of global change has raised the need to identify specific groups based on disturbance response. This activity builds on knowledge acquired from the development of the more general classifications (1–3 above).

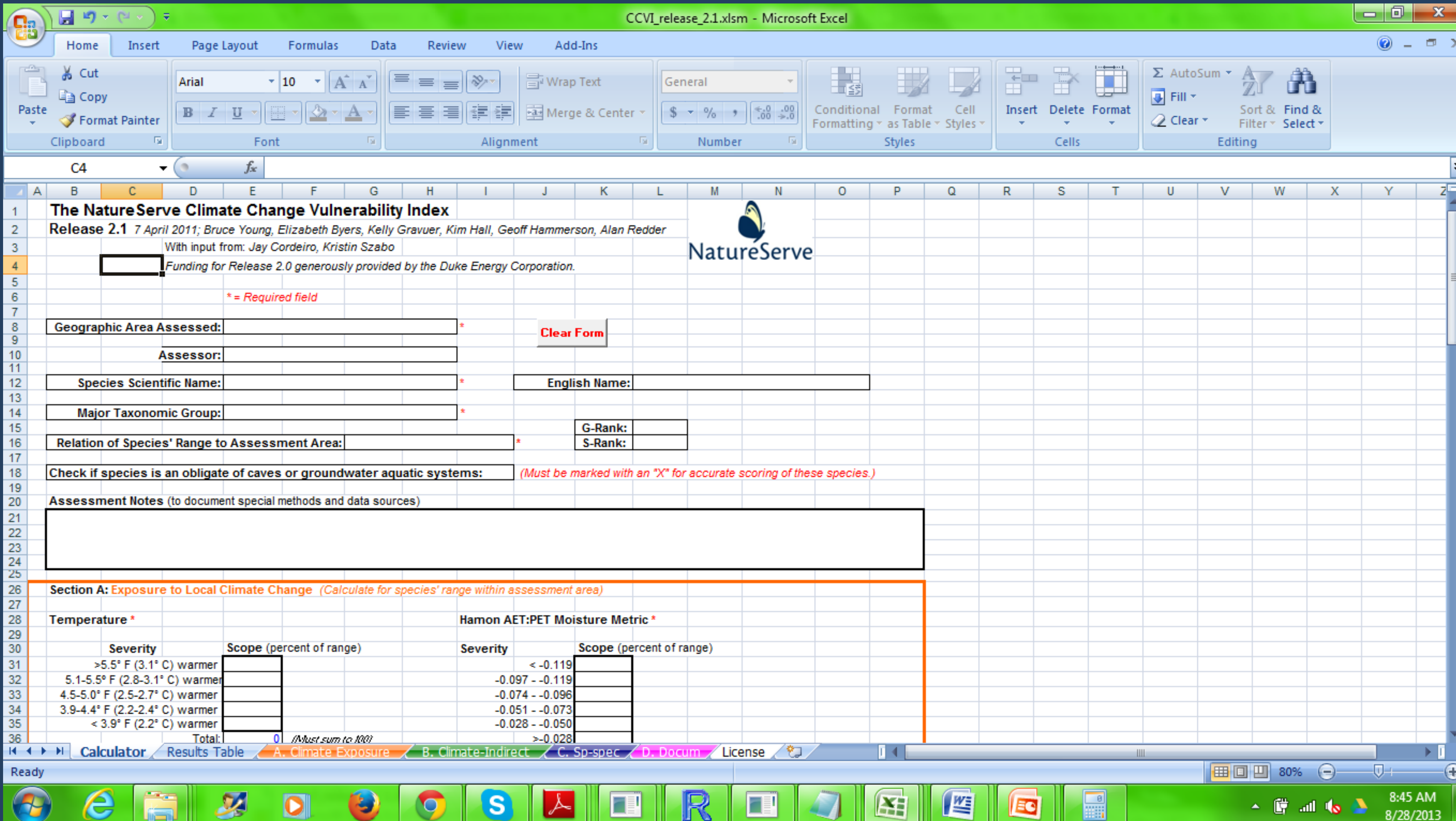
Emergent groups – classifications based on correlations of biological attributes

Emergent groups reflect the combination of adaptive responses and of evolutionary constraints appearing as sets of correlated traits. They are identified in an inductive manner, using multivariate analyses of usually large sets of traits – covering life history, morphology, physiology, phenology and regeneration biology – expected to determine species behaviour in the ecosystem. Such classifications tend to not address any ecosystem function explicitly or, when they attempt to, lack relationship to particular mechanisms[1]. They tend to produce sets of traits essentially corresponding to main life forms (trees, shrubs, grasses and forbs), although the degree of detailed subdivision depends on the breadth of the spectrum taken from global[4,5], to regional[6,7] and to a particular vegetation type[8–10]. Yet classifications into emergent groups have been useful to identify broad correlation patterns, such as relationships between plant size or seed mass and

PII: S0169-5347(97)01219-6 *TREE vol. 12, no. 12 December 1997*

Lavorel et al. 1997 – Trends in Ecology & Evolution

General characterization models



Habitat and occupancy models (aka distribution models)

- A rose by any other name…
  - Ecological niche modeling
  - Element distribution modeling
  - Predictive range mapping
  - Habitat suitability modeling
  - Climate envelope modeling

Habitat and occupancy models (aka distribution models)

<u>GIS layers</u>

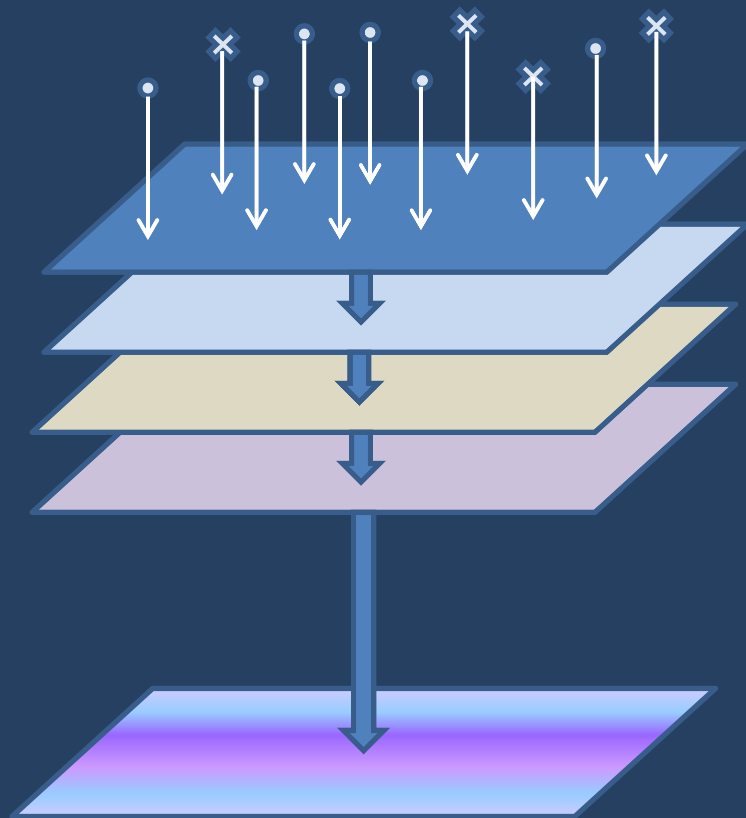
Precipitation

Temperature

Wind speed

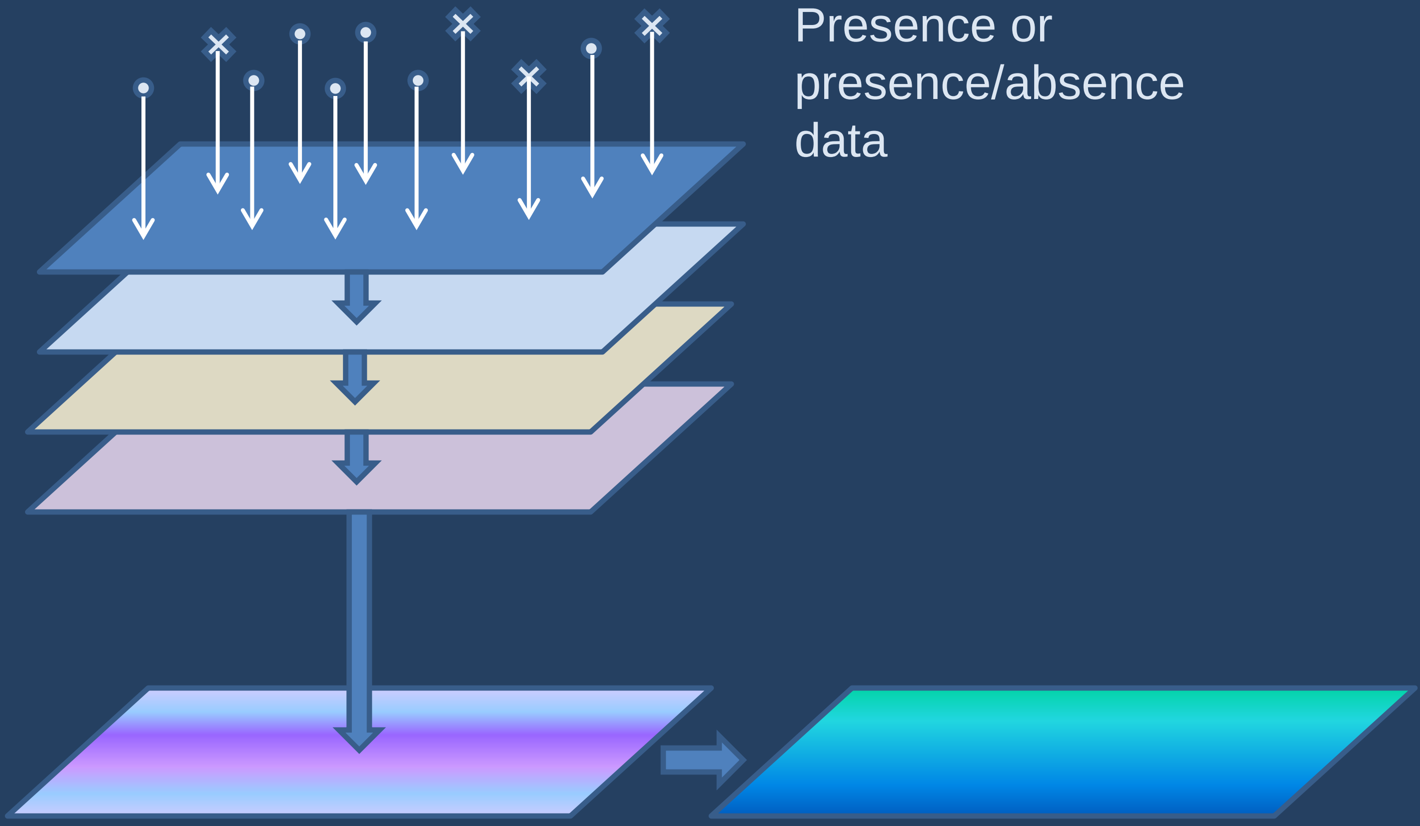
Humidity

Presence or presence/absence data



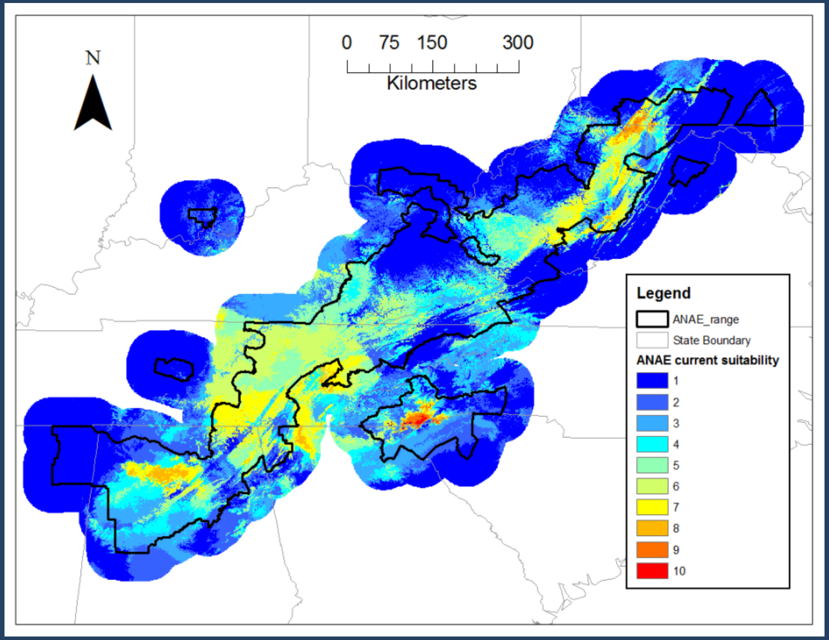
Current habitat suitability

Habitat and occupancy models (aka distribution models)

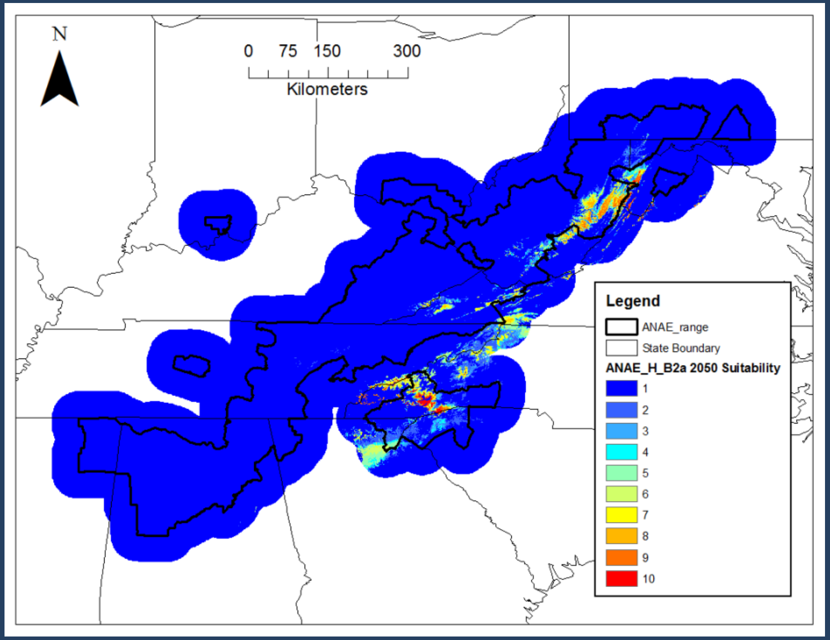


Habitat and occupancy models (aka distribution models)

Current suitability



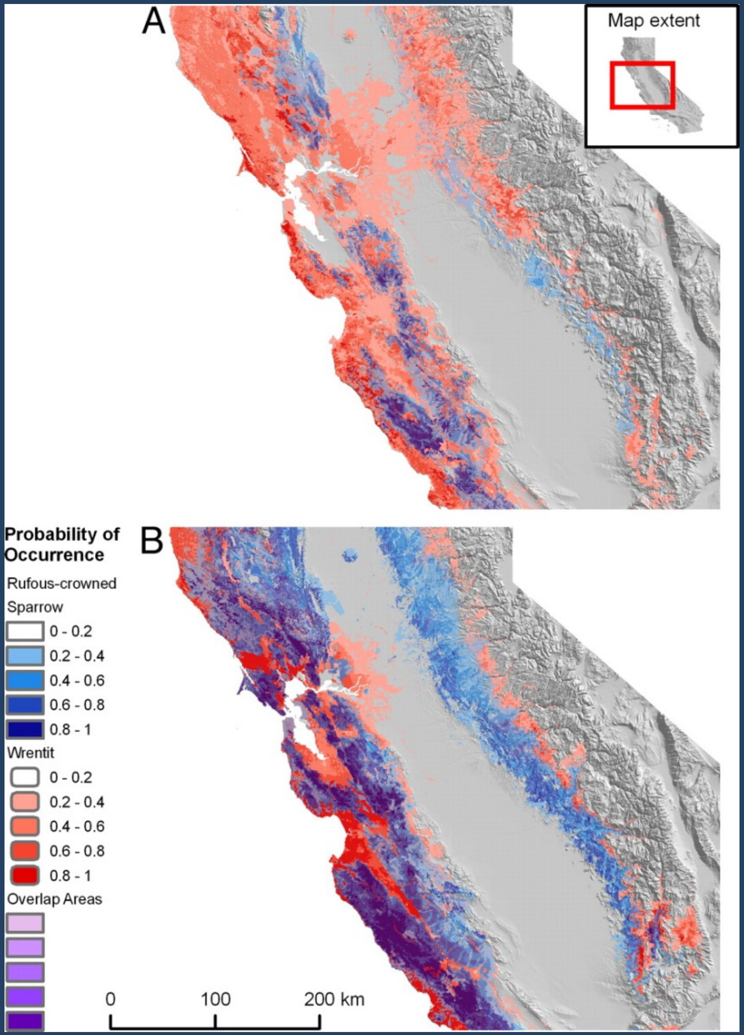
Suitability in 2050



Exposure can be assessed in a quantitative and spatially explicit manner

Understanding model assumptions

Modeled current and future distributions of wrentit and rufous-crowned sparrow in California



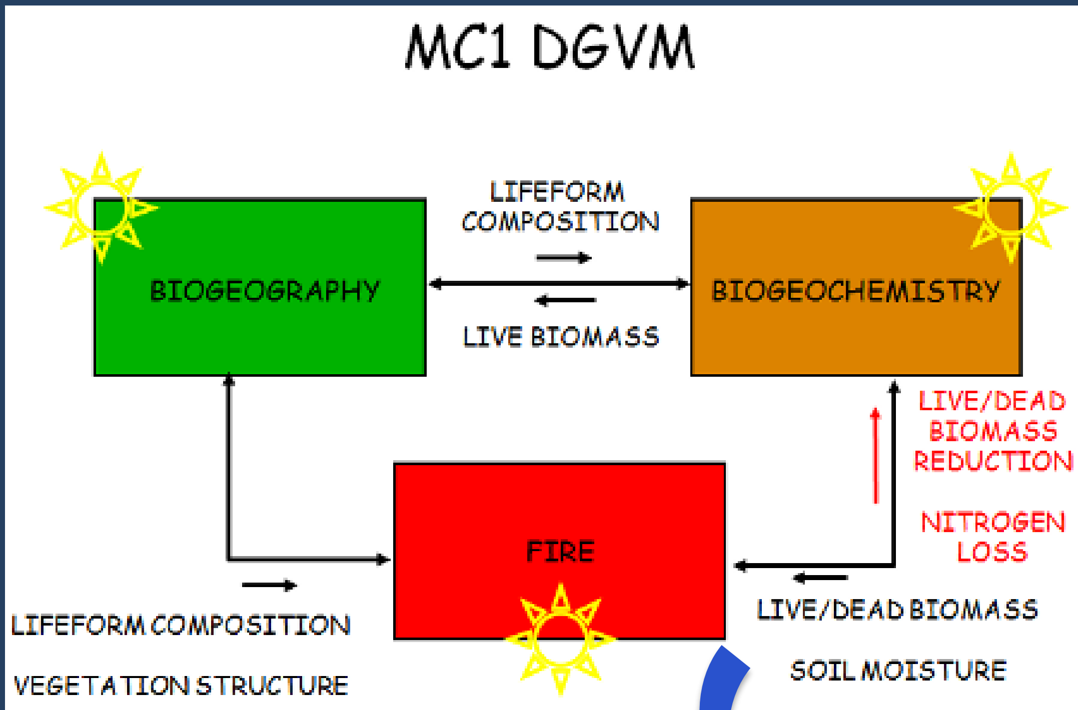
Wiens J A et al. PNAS 2009;106:19729-19736

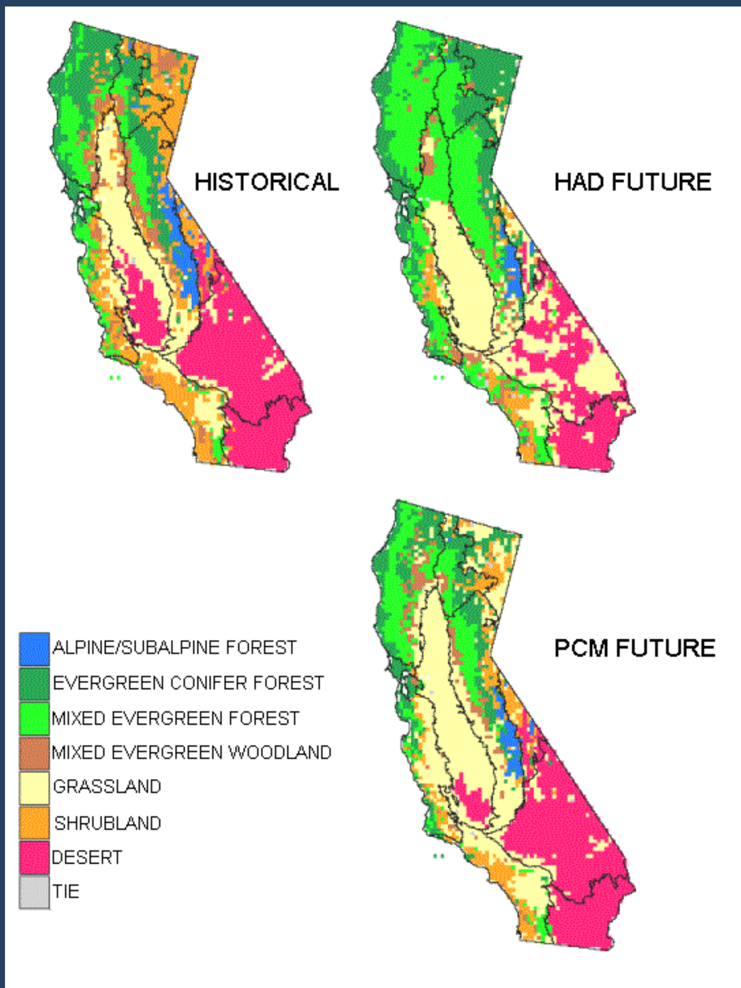
Vegetation/habitat response models

- Species distribution models
- GAP models
- Landscape models
- Biogeochemical models
- Dynamic global vegetation models

Robinson et al. 2008. Vegetation models and climate change: Workshop Results.

Dynamic vegetation models





Physiologically based models

Can be a variant of distribution models

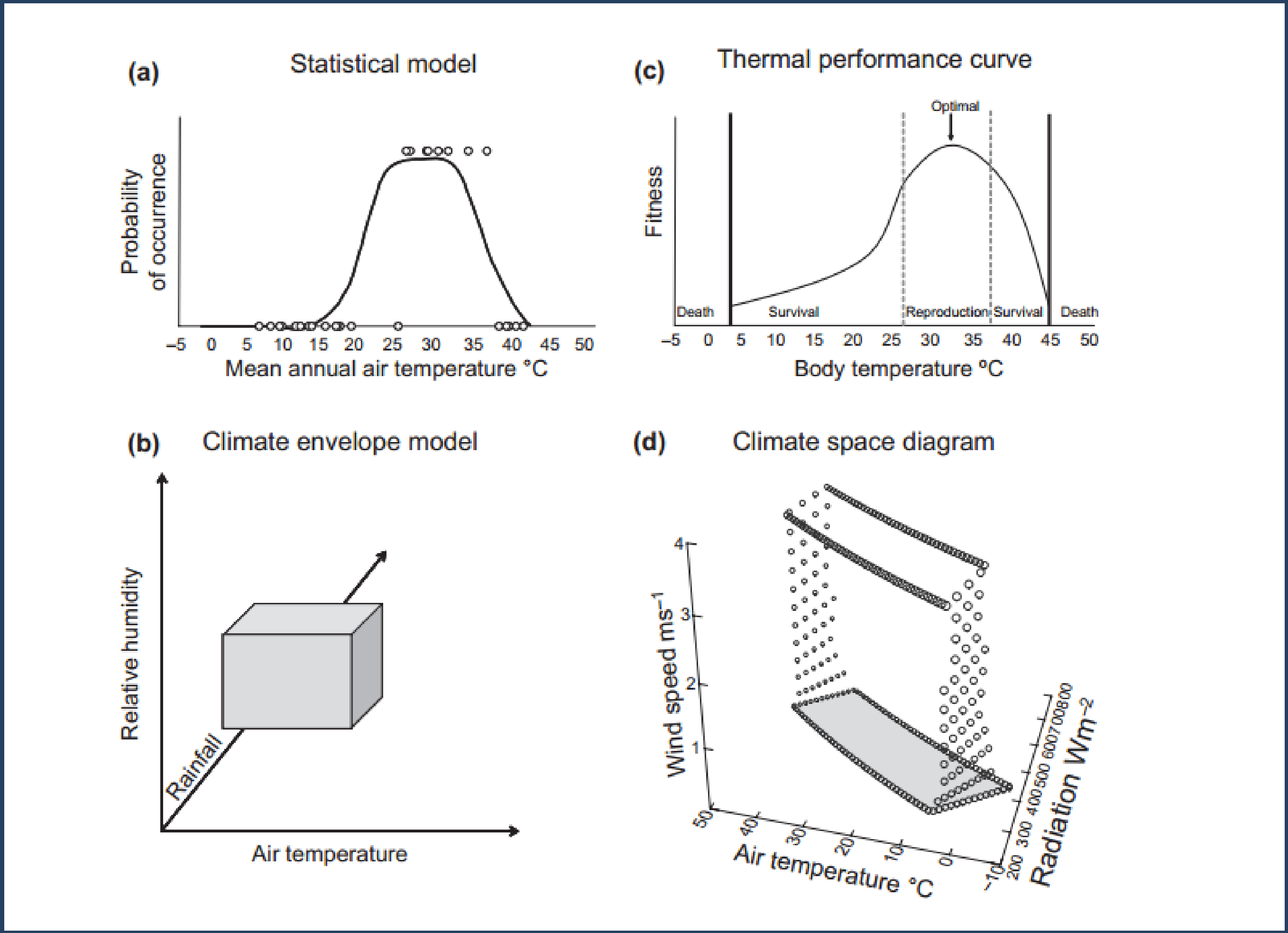
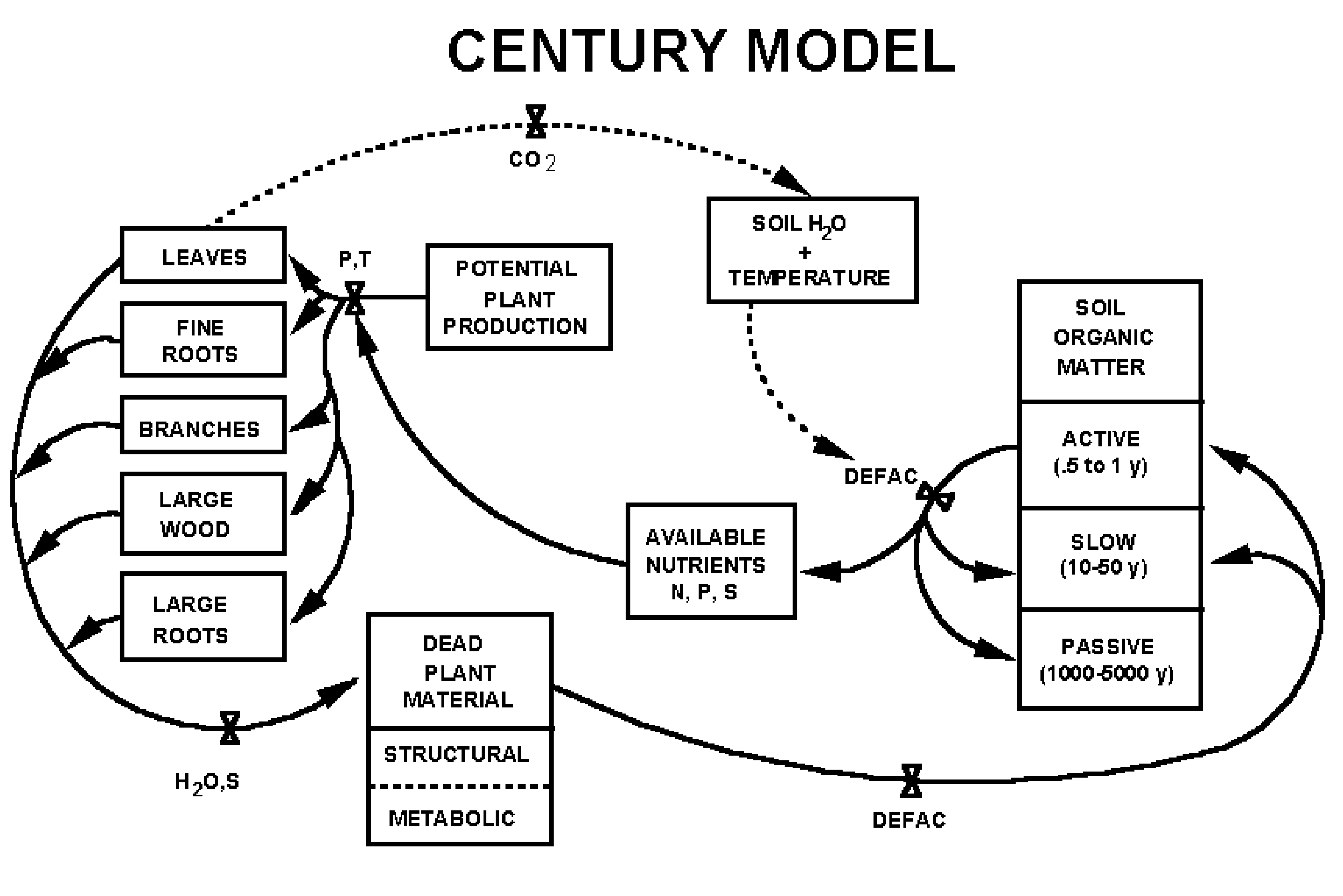
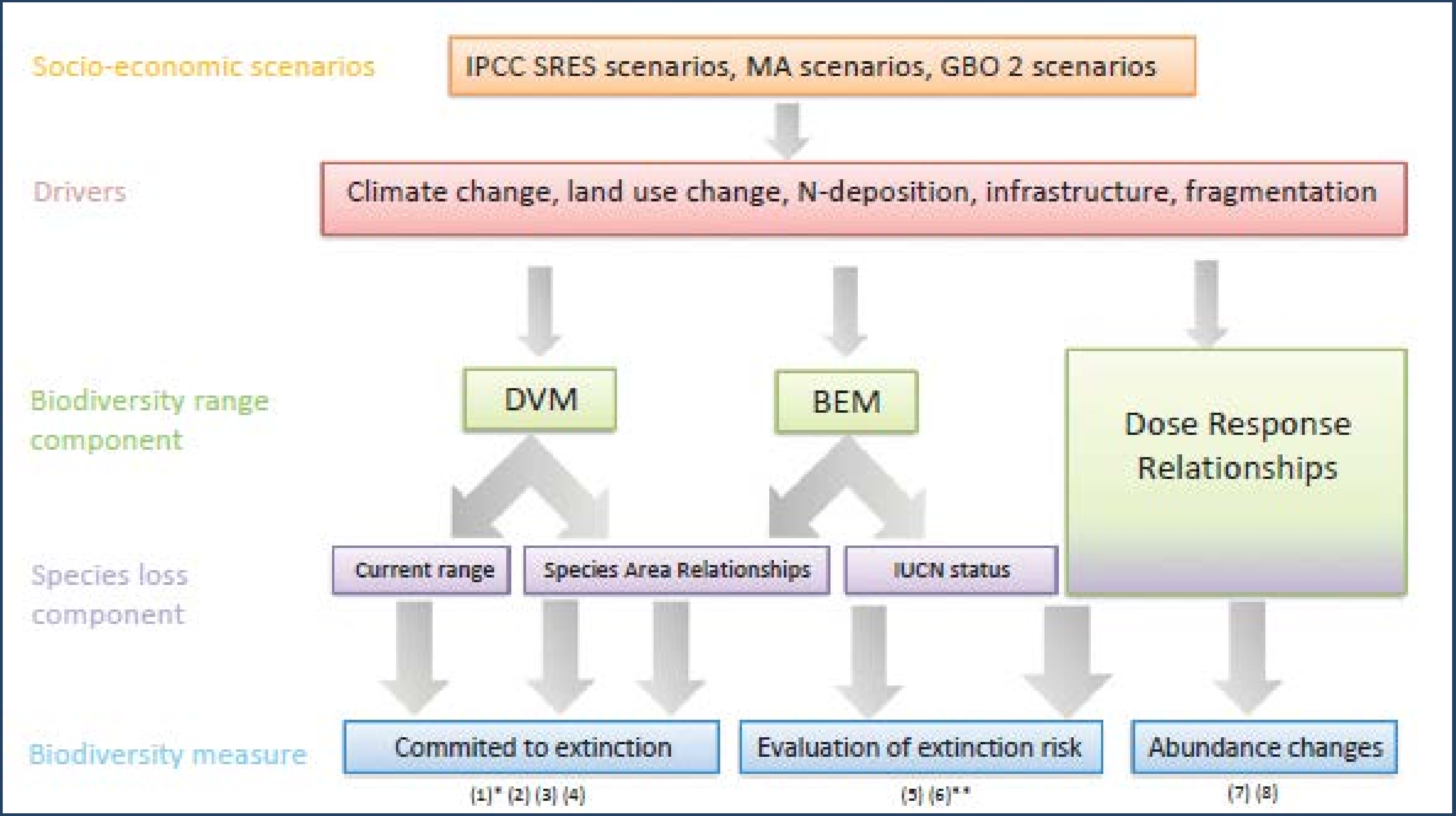


Figure taken from Kearney and Porter 2009 – Ecology Letters

Ecological models



Simulates C, N, P, and S dynamics through an annual cycle over time scales of centuries and millennia



From Bellard et al. 2012. Ecology Letters.

Which model is best for my needs?

- What data are available?
- What's your timeline, expertise, and budget?
- What output do you need to meet your objectives (e.g. making a decision, understanding system function, etc.)

What would *you* do?