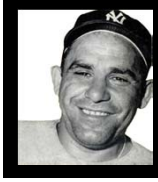
Ecological response models: part 1 - overview

Approaches to vulnerability assessment

"It's tough to make predictions, especially about the future."

"Judicious use of model projections at appropriate scales may help us prepare."



What approach do we take, and at what scale?

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

Considerations for Ecological Response Models

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

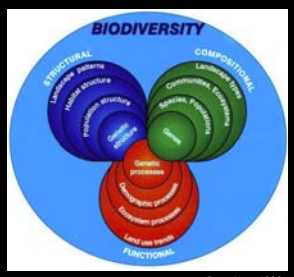
WHY are you modeling?

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

Attributes for each level of Biodiversity

- Composition
- Structure
- Function



From Noss 1990

"Distinguishing among these three attributes…can be important for distinguishing among the climate impacts to a particular species or habitat type"

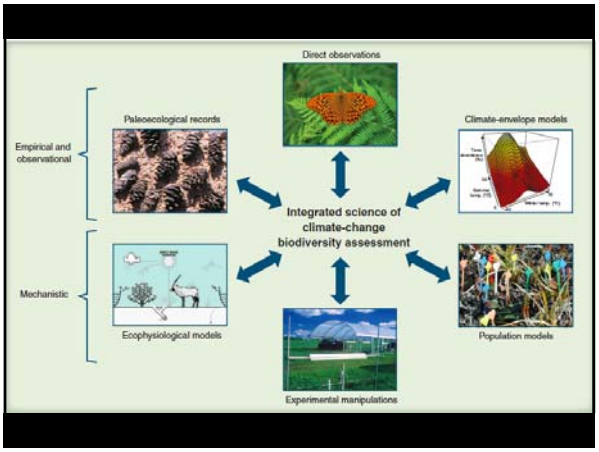
Glick at al.

Ecologically Defined Assessment Targets

- Vegetation/Habitat types
  - Specific ("blue-oak woodland")
  - General ("wetlands" "grasslands")
- Physical structures
  - Sea ice, glaciers
- Physical processes
  - Cold-water streams
  - Fire frequency
- Ecosystem Services
  - Storm protection
  - Water production
  - Carbon sequestration

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



A few model types in more depth…

- Conceptual models
- Trait-based models
- Dose-response relationships
- Niche models
- Integrated mechanistic models
- Dynamic vegetation models

Conceptual models

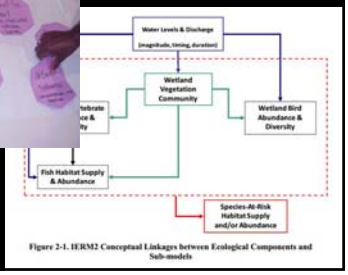


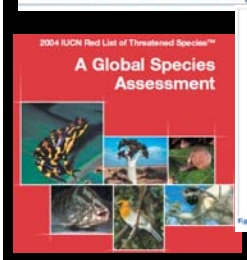
Figure 2-1. IERM2 Conceptual Linkages between Ecological Components and Sub-models

Trait-based models

SAVS: A System for Assessing Vulnerability of Species

USDA Forest Service

NatureServe Climate Change Vulnerability Index



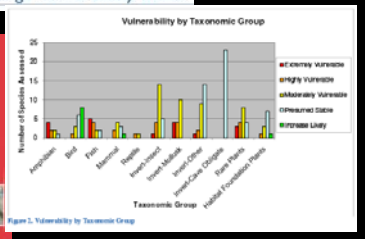
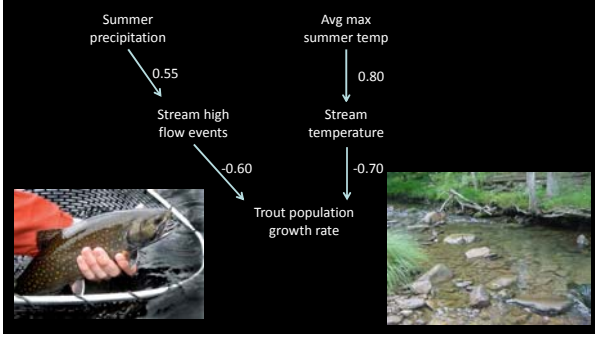


Figure 1. Vulnerability by Taxonomic Group

Dose-response models

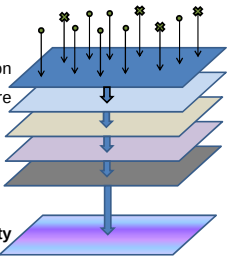


Correlative niche modeling

GIS layers

Current precipitation
Current temperature
Current vegetation
Elevation
Soils

Habitat suitability

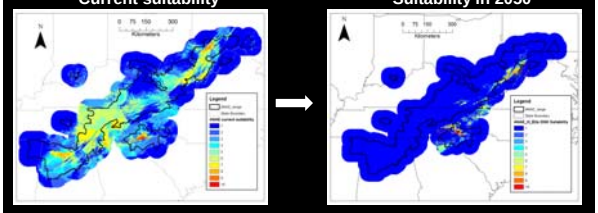


Presence or presence/absence data

Niche modeling

Current suitability

Suitability in 2050

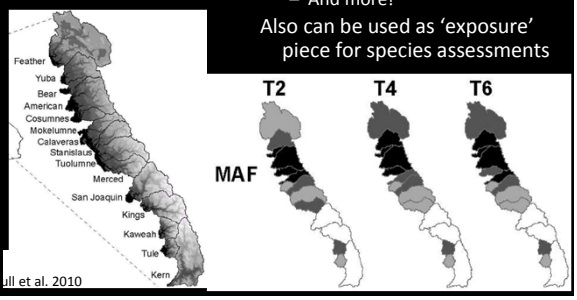


Hydrologic Models

Can provide information on:

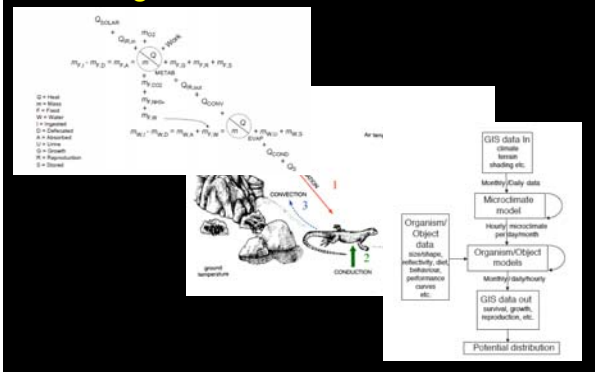
- Flows (high, low, flood)
- Center of timing of flows
- Stream temperature
- Snowpack
- And more!

Also can be used as 'exposure' piece for species assessments

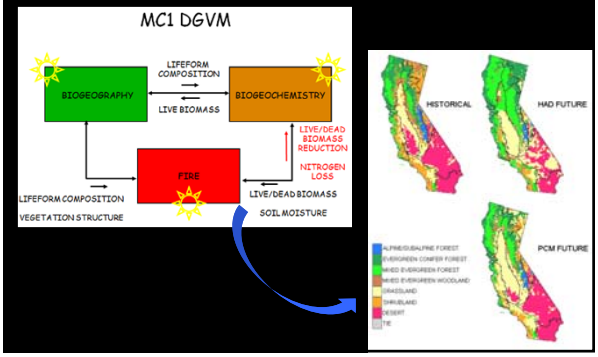


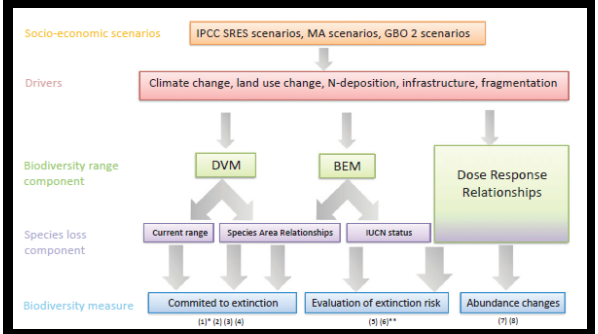
ll et al. 2010

Integrated mechanistic models



Dynamic vegetation models

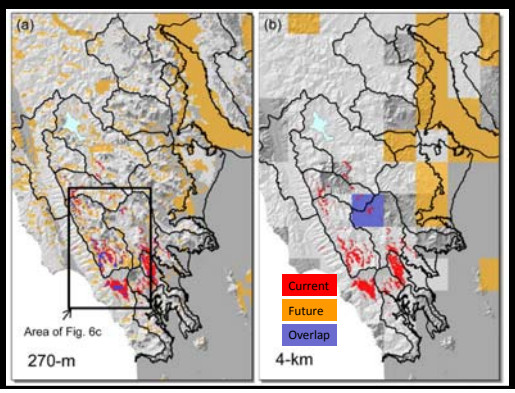




Which model is best for my needs?

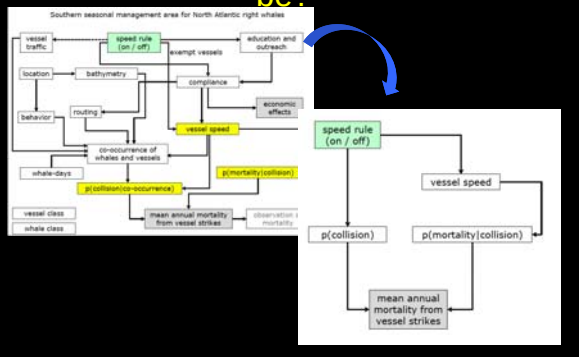
- What data are available?
- What's your timeline, expertise, and budget?
- What output do you need to meet your objectives (e.g. making a decision, understanding system function, etc.)

What would *you* do?



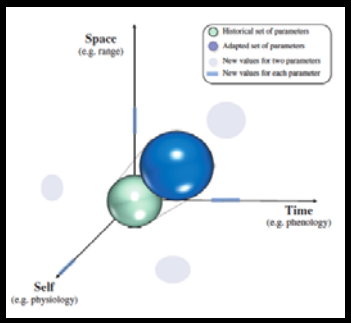
EXTRAS

How complex should the model be?

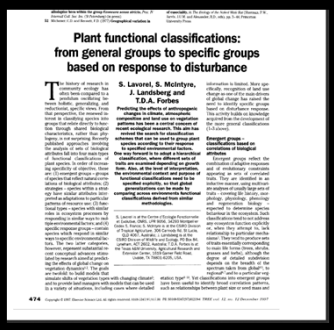


Where Do I Start?

- Useful to have a conceptual model to think through all stressors to be assessed and how they can affect resources
  - Precursor to "response models" covered in the assessment section
- Can also be greatly informed by scenario-based planning approaches to identify potential future stressors



General characterization models



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

Lavorel et al. 1997 – Trends in Ecology & Evolution

Habitat and occupancy models (aka distribution models)

75% of 239 scientific papers filtered using the keywords "climate change", "conservation", and "species distribution model" or "niche model" have been published since 2009

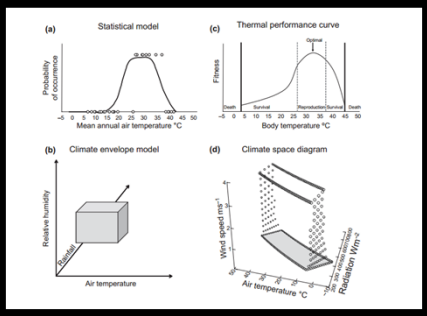
Biological Conservation

Using niche models with climate projections to inform conservation management decisions

Mark W. Schwartz

Vegetation/habitat response models

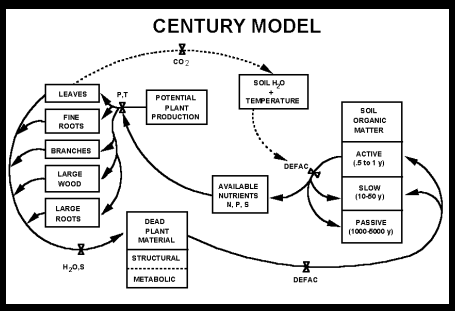
- Species distribution models
- GAP models
- Landscape models
- Biogeochemical models
- Dynamic global vegetation models



Physiologically based models can also be a variant of distribution models

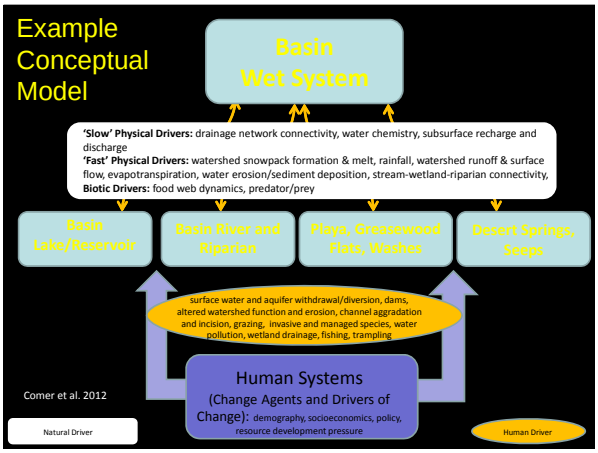
Figure taken from Kearney and Porter 2009 – Ecology Letters

Ecological models



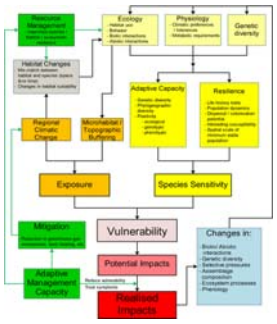
Overall flow diagram for the CENTURY model.

Example Conceptual Model



Comer et al. 2012

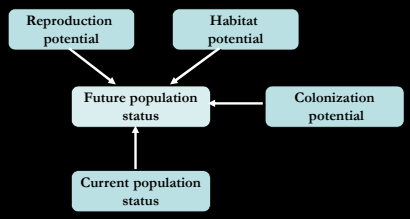
Figure 1. A General Framework To Assess the Vulnerability of Species to Global Climate Change



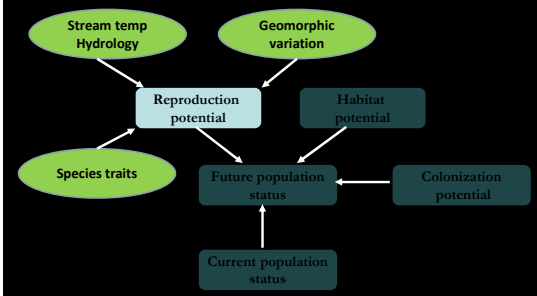
Williams SE, Shoo LP, Isaac JL, Hoffmann AA, et al. (2008) Towards an Integrated Framework for Assessing the Vulnerability of Species to Climate Change. PLoS Biol 6(12): e325. doi:10.1371/journal.pbio.0060325
http://www.plosbiology.org/article/info:doi/10.1371/journal.pbio.0060325

PLOS BIOLOGY
TENTH ANNIVERSARY

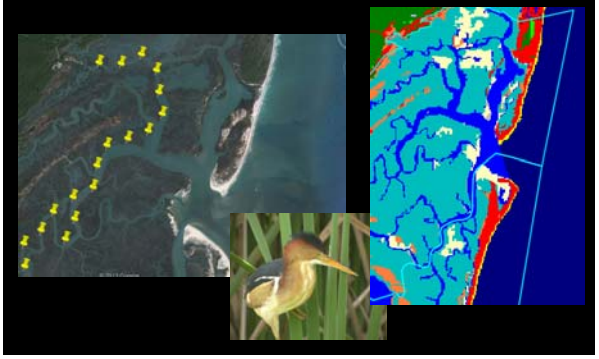
Secondary factors: hydrology



Secondary factors: hydrology



Occupancy-based models with habitat correlates



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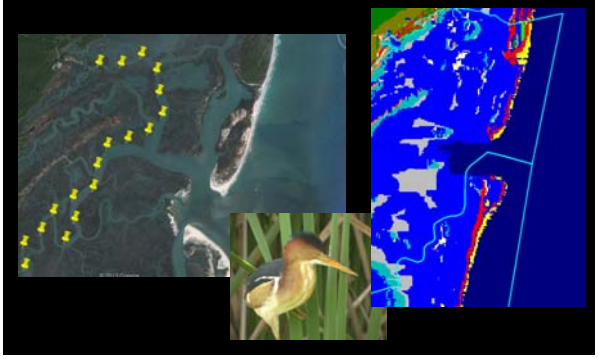
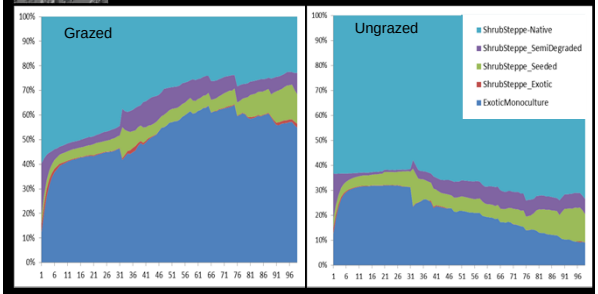


Secondary: dynamic veg models

- Niche-based modeling to understand vegetation response to changing climate
  - Uses empirical physiological characteristics to model
  - Can link to GCMs (but with caution)
  - Excludes some ecosystem types (e.g., wetlands)
- Exposure or sensitivity?

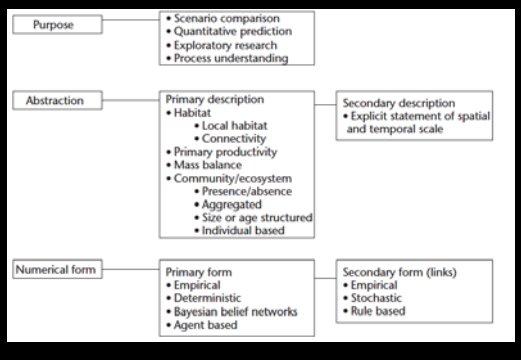
Climate Analysis Results

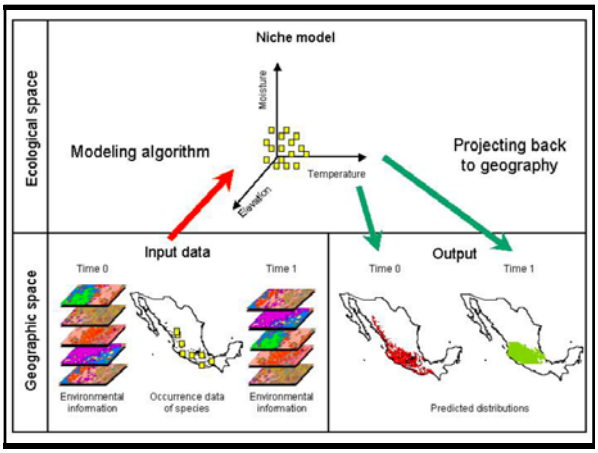
Results for Wyoming Big Sage in Sage Hen Creek watershed with grazing (left) and without grazing (right) under MIROC over 100 years

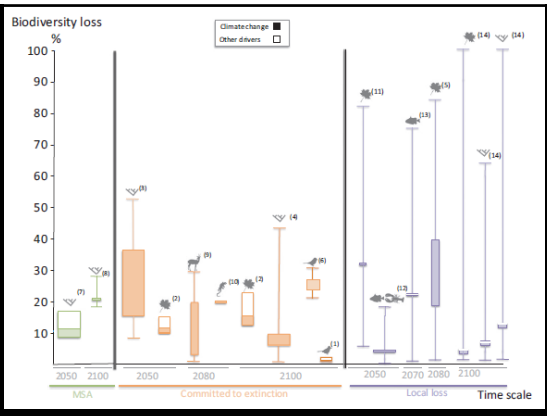


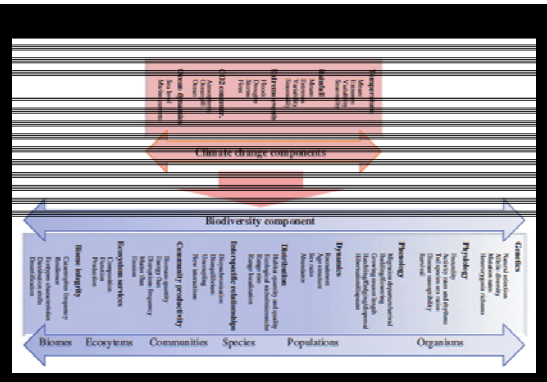
Oregon Biodiversity Information Center 2011

Types of ecological response models

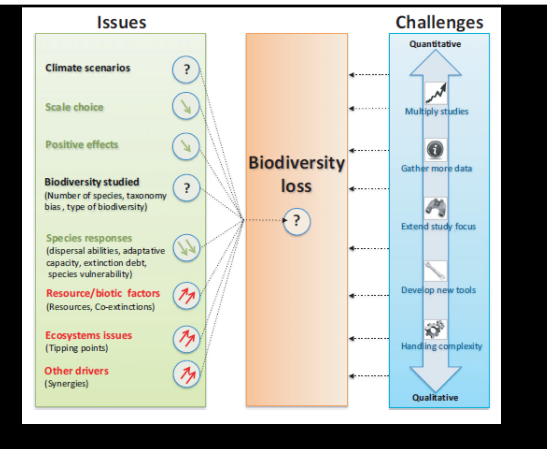








From Bellard et al. 2012. Ecology Letters.



Habitat Response Model – SLAMM