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?
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

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

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

Trait-based models

Dose-response models

SAVS: A System for Assessing Vulnerability of Species

NatureServe Climate Change Vulnerability Index

A Global Species Assessment

Dose-response models

Summer precipitation 0.55
Stream high flow events 0.60
Avg max summer temp 0.80
Stream temperature 0.70
Trout population growth rate

Figure 2.8. BLM conceptual framework for ecological components and linkages.
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

Null et al. 2010
Integrated mechanistic models

Dynamic vegetation models

Socio-economic scenarios

Drivers
- Climate change
- Land use change
- N-deposition
- Infrastructure
- Fragmentation

Biodiversity range component

Species loss component

Biodiversity measure

IPCC SRES scenarios, MA scenarios, GBO 2 scenarios

Diverse drivers

Socio-economic relationships

Drivers to extinction
- Extinction risk
- Abundance changes
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

Habitat and occupancy models (aka distribution models)

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

Secondary factors: hydrology

Stream temp
Hydrology

Species traits

Geomorphic variation

Reproduction potential
Habitat potential

Future population status
Colonization potential

Current population status
Occupancy-based models with habitat correlates

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 MiRDC over 100 years.

Types of ecological response models

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