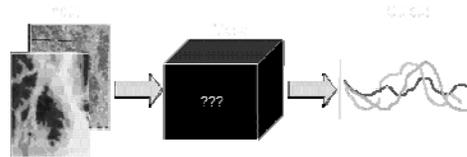# Introduction to Models

March 2007

Why Do Landscape Ecologists Use Models?
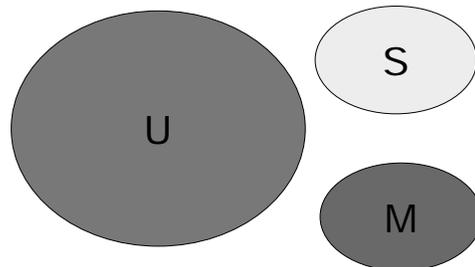

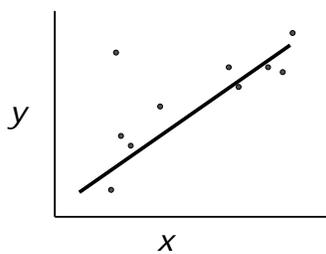
Why use models?

1. Make Predictions

USM (Universe, Sample, Model)

Statistical Model

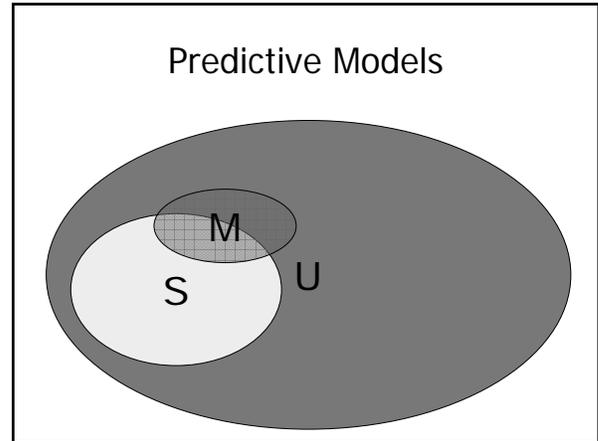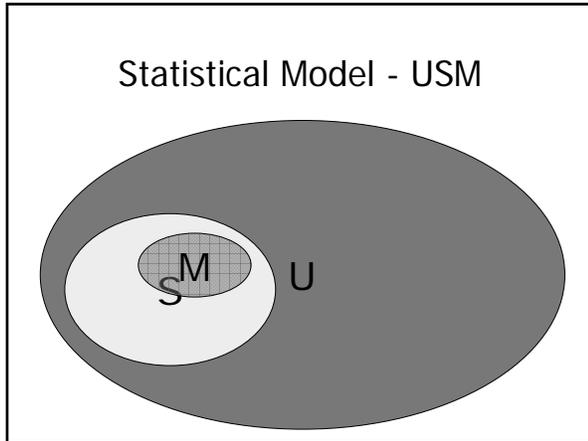# Statistical Model

Statistical Model - USM
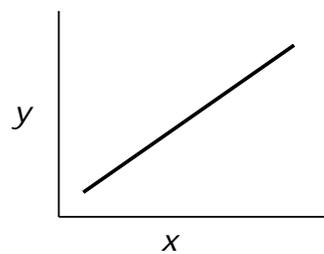
Predictive Models

What information do predictive models provide?

1. Past
   - what were pre-settlement conditions?
   - what was the 'natural' range of variability?
   - what should our restoration goals be?
   - how far have we deviated from 'natural' conditions?

2. Present
   - filling in the gaps
   - e.g., MODIS data products

What information do predictive models provide?

3. Future
   - what are the consequences of our current actions?
   - driven by management concerns
   - 'ecological forecasting' is an emerging imperative

What information do predictive models provide?

3. Future

   - Landscape Ecology: interpolate or extrapolate current understanding across broad scales.

Why use models?

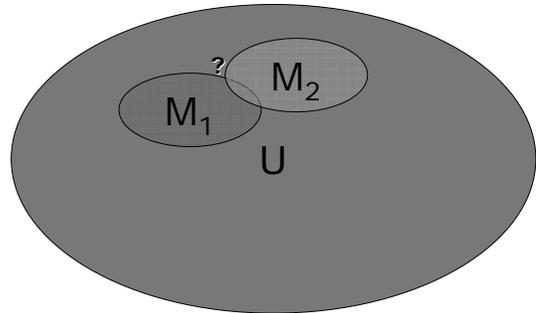2. Heuristic Value – How well do we understand the system?

Why use models?

2. Heuristic Value – How well do we understand the system?

- Models help us formally organize ideas or data

- Identify areas of understanding

- Identify sensitive parameters

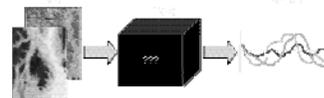---

Heuristic Value of Models

Why use models?

2. Heuristic Value – Landscape Ecology:

- Do we know how to extrapolate to larger scales?

- Can we combine relationships collected at different scales?

- Does pattern matter?
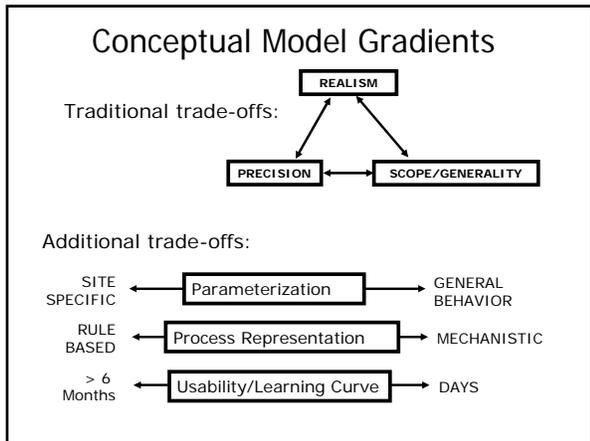

Why use models?

3. Experimentation!

- Spatial and temporal constraints on landscape studies and experiments

- Even more difficult to replicate experiments or even "sample" and analyze replicates

- Many large-scale processes operate slowly, so landscapes also change slowly

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Model Limitations and Assumptions

Model Limitations and Assumptions

- Knowledge-based limitations
  - Ecological, management questions have gotten more complex

- Data-based limitations
  - Often, adequate data to parameterize large landscapes do not exist.

- Scale assumption:
  - To understand the outcome of a process at a given scale, *complete* representation of broader scale (context) and finer scale (underlying mechanisms) is not necessary nor achievable.

- Problem:
  - Determining how much knowledge is needed

Conceptual Model Gradients

Traditional trade-offs:

REALISM

PRECISION ←→ SCOPE/GENERALITY

Additional trade-offs:

SITE SPECIFIC ←→ Parameterization ←→ GENERAL BEHAVIOR

RULE BASED ←→ Process Representation ←→ MECHANISTIC

> 6 Months ←→ Usability/Learning Curve ←→ DAYS

Three Model Types Common to Landscape Ecology

Operationally, useful to think of three general types of models

- Neutral Models
- Individual-based models
- *Landscape change models* – Lecture April 23

Neutral Landscape Models

Neutral landscape models generate raster maps in which complex habitat structures are generated with analytical algorithms. Thus, they are neutral to the biological and physical processes that shape real landscape patterns.

Neutral Landscape Models

What is the value of neutral models? **Heuristic**

- How do structural properties of landscapes deviate from theoretical spatial distributions?

- How are ecological processes affected by landscape pattern? (Pattern is the **sensitive parameter**.)

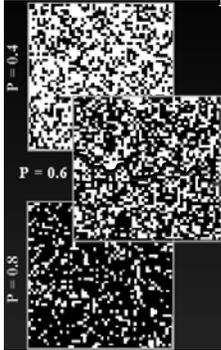**Neutral models DO NOT represent actual landscapes**

Neutral Landscape Models

Neutral landscape models may be generated by random, hierarchical, or fractal algorithms.

Random maps   Hierarchical maps   Fractal maps

Neutral Landscape Models

Simple random maps

	$p = 0.4$	$p = 0.6$	$p = 0.8$
Two classes			
Multiple classes			

4

## Neutral Model Example: Percolation Theory

- As an increasingly large proportion of the landscape is occupied, the occupied cells coalesce into larger patches.

- Once $p = 0.59$, the largest cluster will span the map edge-to-edge.

- Important because most landscape metrics covary with p.
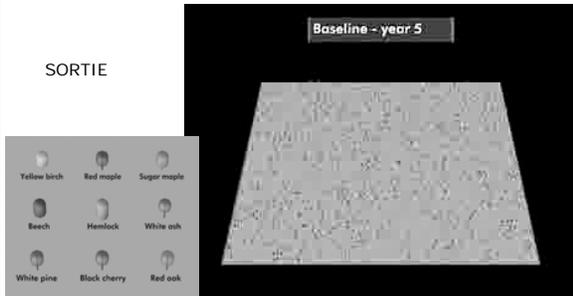

Individual Based Model: Forests

SORTIE is a mechanistic, spatially explicit, stochastic model of **individual trees**.

Parameters:
Tree Allometry
Crown Allometry
Growth Function
Mortality Function
Dispersal
Shading
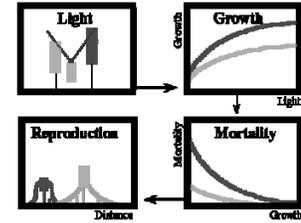
Individual Based Model: Forests

SORTIE

Individual Based Model: Forests

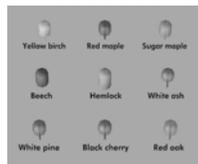SORTIE

Individual Based Model: Forests

Year 100 - Clear cut

Year 500

Year 1000

Individual Based Models: Metapopulation

http://www.cbc.yale.edu/courseware/metapop.html

http://www.bne.marine.csiro.au/~roc037/metapop/index.html