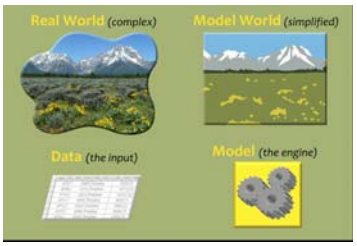
Modeling landscape change



Starfield 1997

Review Real World – Model World

What is a model?

How is the “model world” different from the “real world”?

Review Real World – Model World

How can models be helpful in addressing natural resource problems?

Why model landscape change?

1. Develop estimates of Historical Range of Variation (HRV)
2. Predict future changes in landscape composition, configuration, etc.
3. Strategic planning
   - Where would fuel treatments be most effective in reduce wildfire risk?
   - Where are the most effective locations to place biological reserves?
4. Scenario assessment
   - What are the landscape effects on the landscape of different fire suppression strategies?
   - Scenarios for the NEPA process (National Environmental Policy Act)

Terminology

1. **Deterministic model**- always end up at same point which is predetermined by model assumptions. Time-step successional models are deterministic with respect to succession.

2. **Stochastic model**- at least a portion of the model has a random probability included within which allows model to come to varying endpoints, must "run" model several times to determine characteristics of outcome (mean, variance, range etc.).

T, G & O 2001

More Terminology

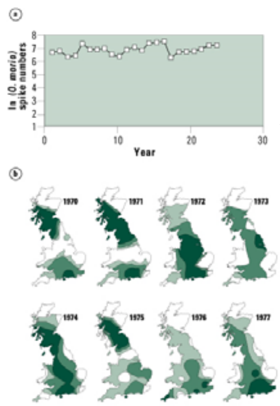
1. **Mechanistic model**- a mechanistic models attempts to represent dynamics in a manner that is consistent with real world phenomena, the term implies that the parts are arranged to explain the whole system

2. **Process-based model**- implies that the model components are specifically developed to represent specific ecological processes

   For example, equations for photosynthesis, birth, death, growth and respiration may be used to estimate biomass yields. A mechanistic model may use the driving variables of temperature, precipitation and light directly.

3. **Empirical model**- a model that is designed to explain an existing data set, may not involve an explanation as to why things are happening. Most models have empirical components included within them which are used to parameterize the model.

T, G & O 2001



Distribution Model

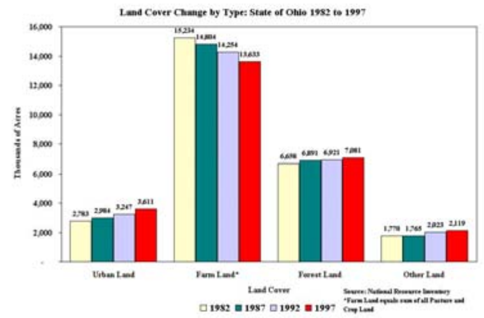
A. Changes over time in the population of green-winged orchids (*Orchis morio*) at one locality.

Spatial Models

B. Change in the spatial distribution of elder aphid (*Aphis sambucci*) between 1970 and 1977. Darker shading represents greater density.

T, G & O 2001, Figure 3.3

Is this an output from a Distribution Model or a Spatial Model?

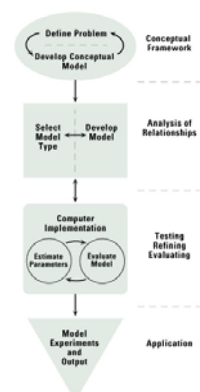


Model components (Baker 1989)

1. initial configuration
2. birth, death and change functions (succession, disturbance)
3. output configuration

Driving factors of landscape change

1. time-step functions
2. bio-geo-chemical processes
3. stochastic events (probability functions)



Steps in Building a Model

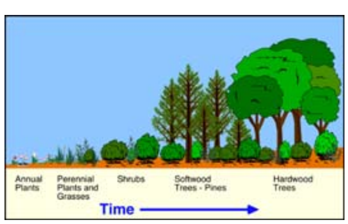
1. Define the problem
2. Select the model type
3. Develop model
4. Computer implementation
5. Parameter estimation
6. Model evaluation (sensitivity analysis)
7. Experimentation, application, refinement

T, G & O 2001, Figure 3.4

Examples of modeling approaches

We use the results of models all the time, in all aspects of our life. Below are some common ones that are related to landscape change and/or management.

1. **Conceptual models** (usually not quantitative)



Examples of modeling approaches

We use the results of models all the time, in all aspects of our life. Below are some common ones that are related to landscape change and/or management.

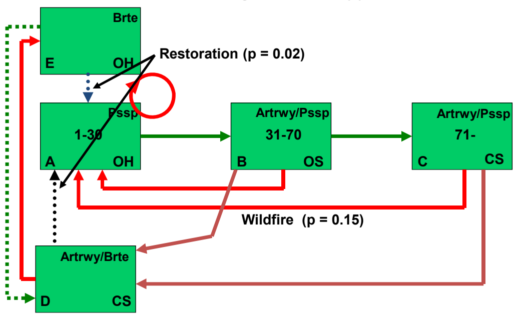
1. **Conceptual models**

2. **Distribution models**

VDDT (Vegetation Dynamics Development Tool)- developed as part of the Columbia Basin Assessment

succession- driven on time-step function with expert knowledge base
disturbance- probability function
scale- defined by user
objective- land management scenario assessment

Develop disturbance pathways for each Potential Vegetation Type (PVT)

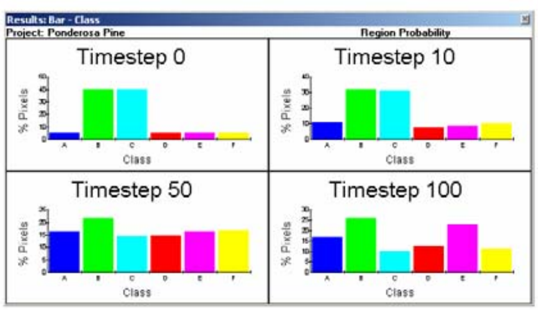


Wyoming big sagebrush / bluebunch wheatgrass

How does VDDT work?

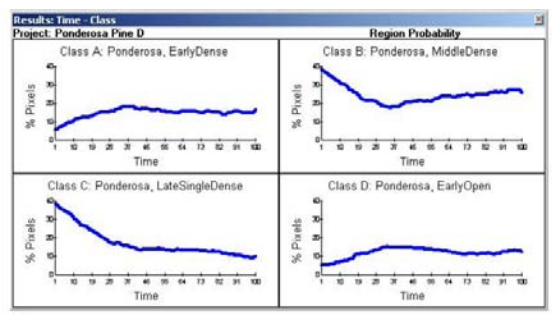
- For each PVT the model tracks the proportion of all pixels in each successional class (cover type and structural stage) over time, A, B, C, D, E in on the slide.
- Using the pathways and probabilities defined for that PVT, the model simulates the probability of each pixel being affected by one of the disturbance types, and if a disturbance does occur within a specified time period, the model moves the pixel to the appropriate class.
- To initialize, each polygon is randomly assigned an age within the range of ages possible for that successional class, e.g. 5% in A, 20% in B, 25% in C. etc.…

VDDT: Example output



Source: www.essa.com/documents/vddt/VDDT-60-User-Guide.pdf

VDDT: Example output



Source: www.essa.com/documents/vddt/VDDT-60-User-Guide.pdf

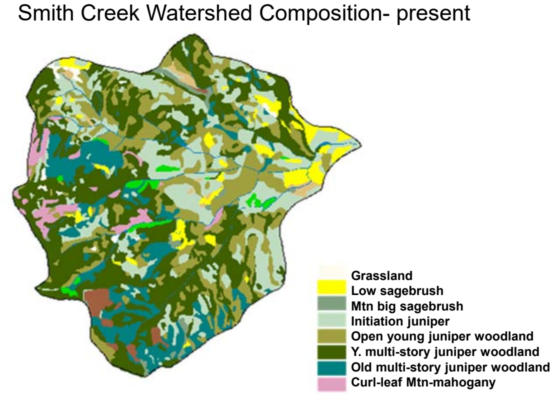
Examples of modeling approaches

3. **Spatial explicit models**:

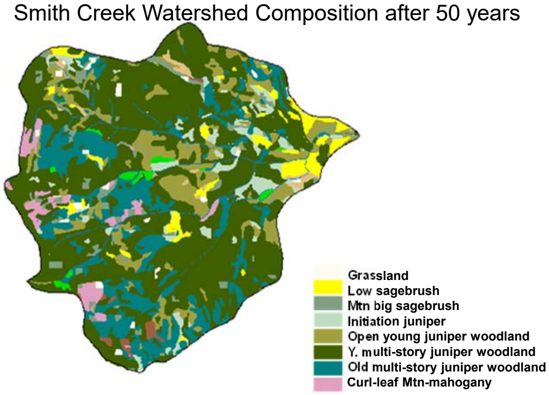
TELSA (Tool for Exploratory Landscape Scenario Analysis): Spatial explicit model that uses a VDDT approach in predicting disturbance and succession.

SIMPPLLE (Simulating Patterns and Processes at landscape Scales) spatially explicit expert system model, includes spatial context.

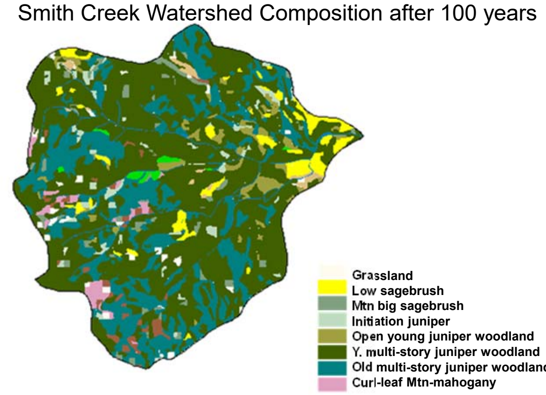
Smith Creek Watershed Composition- present



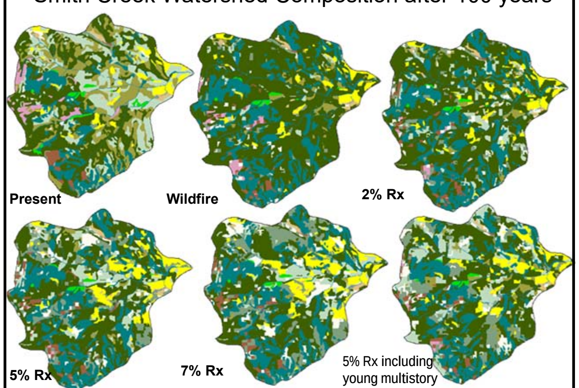
Smith Creek Watershed Composition after 50 years



Smith Creek Watershed Composition after 100 years



Smith Creek Watershed Composition after 100 years



4. Fire-BGCv2 (Keane et al. 2011)

Gap succession model family

Vegetation change **driven by C & N** with a system of differential equations, ecological process model

Models individual tree response aggregated to stands which are aggregated to landscapes

Disturbance- stochastic through probability functions by site type

Data and time intensive: 1200 parameters, can take several days to run

Can be spatially explicit

Objective: test climatic change and fire occurrence dependence, test research hypotheses.

Similar models: **CENTURY** (CSU), **ZELIG** (Miller & Urban 1999)

ZELIG runs more on soil moisture and temperature.

5. Growth and yield models

FVS (Forest Vegetation Simulator), formerly known **Prognosis** as a stand simulator.

- Statistical model- measured the effects of various treatments directly.
- It aggregates the effects at stand level and then aggregates to landscape level.
- Most limited of models discussed in ability to extrapolate to other areas.

FFE (Fire Fuels Extension) recently added to FVS to simulate the effects of fire.

SPUR (Simulation of Production and Utilization of Rangelands) Similar type model related to herbaceous growth and effects of herbivory on growth.

How do we choose a model?

- What do we want the model to predict?
- What is the required resolution (temporal & spatial) and confidence of the outputs?
- Does the model need to have a spatial component or is a distributional model adequate?
- What are the data input requirements?

T, G & O 2001, Figure 3.4

Summary:

Quantifying landscape change

1. Landscapes are naturally dynamic, and our management activities contribute to the dynamic nature. Consequently it is extremely important to be able to quantify those changes.
2. Historical data can help us analyze the nature and perhaps the causes of landscape change. They are often limited by low resolution, however.
3. The importance of landscape configuration (influence of the neighborhood) is one of the basics of landscape ecology, however, few landscape models sufficiently account for this.

Summary:

Quantifying landscape change

4. There are many reasons to compare landscapes. When predicting future changes a model is normally involved.
   - develop estimates of Historical Range of Variation
   - predict future changes in landscape composition, configuration etc.
   - strategic planning
   - scenario assessment
   - cumulative effects assessment

Summary:

Quantifying landscape change

5. There also many approaches to modeling landscape change. It is important that we match the objective with the data requirements, the model's outputs and scale of consideration.
6. Modeling change is our primary means to predict future changes due to management decisions or natural processes.

Seven misconceptions about models

1. A model cannot be built with incomplete data
2. The model is not useful if there are gaps in the data
3. A model cannot be used until it has been validated
4. A model must account for all detail
5. Models are difficult to understand
6. The primary purpose of a model is to make predictions
7. Modeling is time-consuming and expensive

Rather….a model is a purposeful representation

Recommended reading – Starfield 1997

Friday's lab:
Vegetation Dynamics Development Tool