Modeling
Statistics, *Modeling, Visualization*
CPaT
Spring 2013

http://canopy.evergreen.edu ; http://blogs.evergreen.edu/judyc, … vistas
judyc@evergreen.edu

Why Study ***Scientific Modeling****?*

What are Models

Some examples….

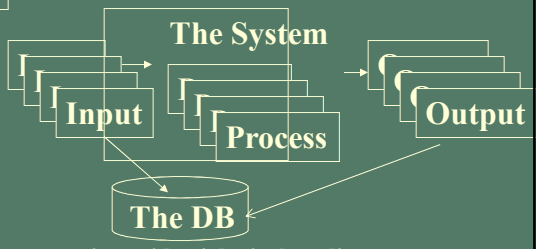
Our Stella models…& Lab Debrief

Models and Me?

As a programmer:

Input → **Process** → **Output**

But, a system designer…



medical systems - preserved data for retrospective epidemiological studies….

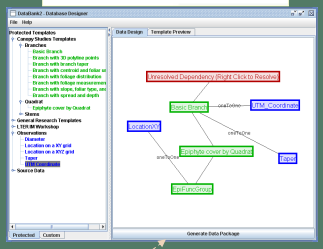
computational chemists & oceanographers - makee models available…, link them ….

ecologists – manage & archive data for use at every stage of their research,

and now? TOO MUCH DATA!

All this led me to Visualization – and Visual Analytics….

Canopy DataBank (with N. Nadkarni et al)



Documentation (*.HTML)

Access Database

_workspace.xml
(Specific to the particular study you are working on)
Includes Templates

(Includes Data entry forms)

Forms

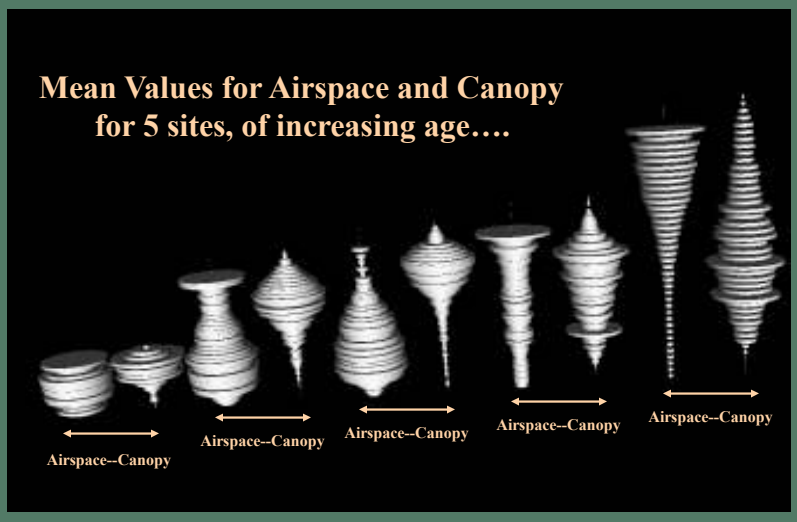
Ecological Metadata Language *_eml.xml

Palm Top + Laser Finder Field Data Entry

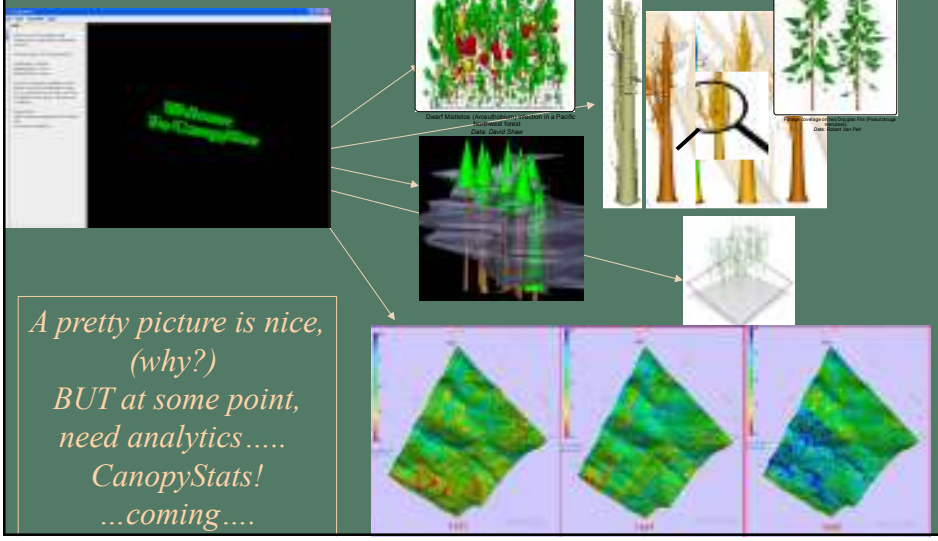
Visualization

Analysis?

Data Integration *(& Visualization!)*



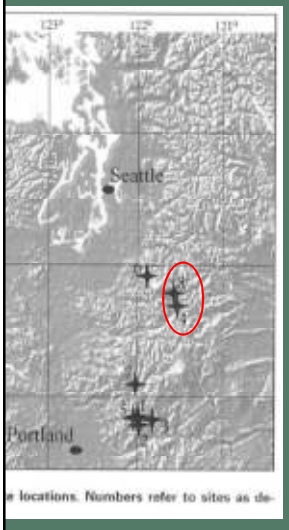
CanopyView



A pretty picture is nice, (why?)
BUT at some point, need analytics…..
CanopyStats!
…coming….

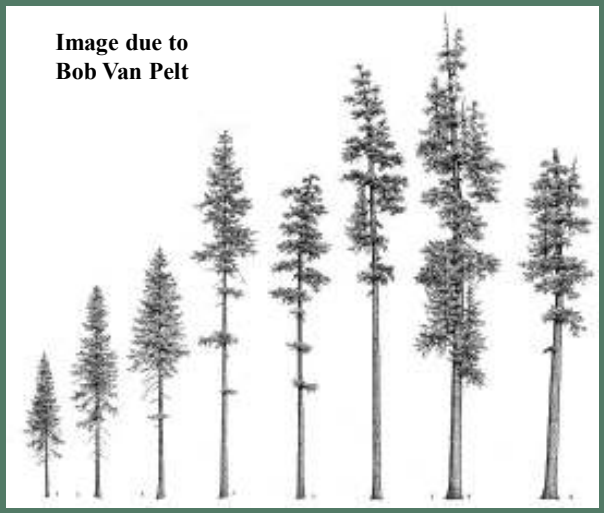
5

Thousand Year Chronosequence (1kcs)



locations. Numbers refer to sites as de-

Image due to Bob Van Pelt



overlap with the LIDAR coverage
- **Site 8 Chinook transects 1 (detailed branch data) and 2 –**
- **Site 4 Ohanapecosh complete coverage (Transect 3 detailed branch data**

Why *Models and Interventions?* (personal story cont.)

Visualization helped, but

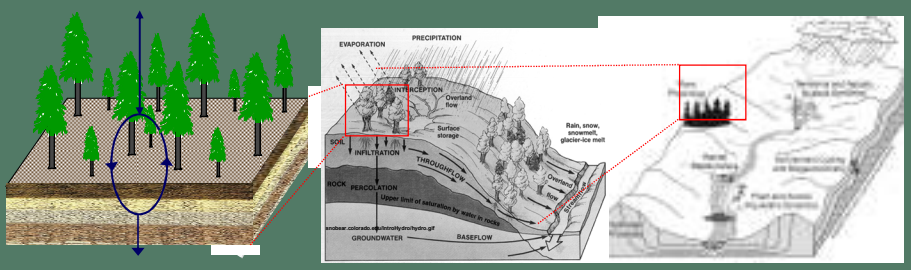
Why don't the models work everywhere, every time?

We know there are connections across space and time, and across subdisciplines, and across major disciplines,

but how do we form testable hypotheses ???

VISTAS

VISualization of Terrestrial-Aquatic Systems

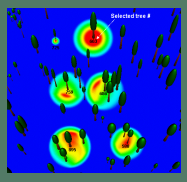


Plots, Stands *Hillslopes, Catchments* *Basin, Region*

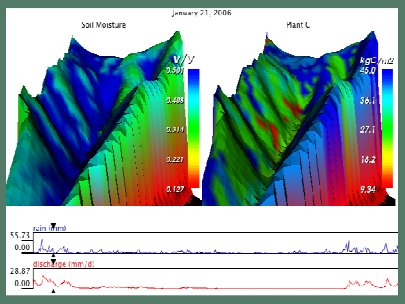
Eco-hydrologic modeling:
Integrate & Scale Up Data from Plots to Region, from Days to Centuries

VISTAS

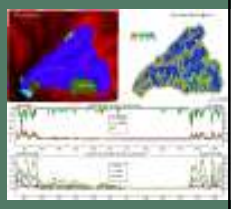
a) 0.1 km² forest stand, to b) 1 km² catchment, to c) 64 km² basin.



a) Effect of tree size & competitors on nitrogen uptake in a 400-yr forest. Visualized patterns not evident in raw data provide new insight into forest habitat structure.



b) Effect of tree size & competitors on nitrogen uptake in a 400-yr forest. Visualized patterns not evident in raw data provide new insight into forest habitat structure.



c) Visualizations at basin scale help users understand & communicate climate change & forest harvest: stream network, soil moisture, stream water quality & quantity.

What's a system?

A collection of elements or parts that is coherently organized and interconnected in a pattern or structure that produces characteristic behaviors, often classified as its "function" or "purpose".

You can't automate [or model] *a non-system….*

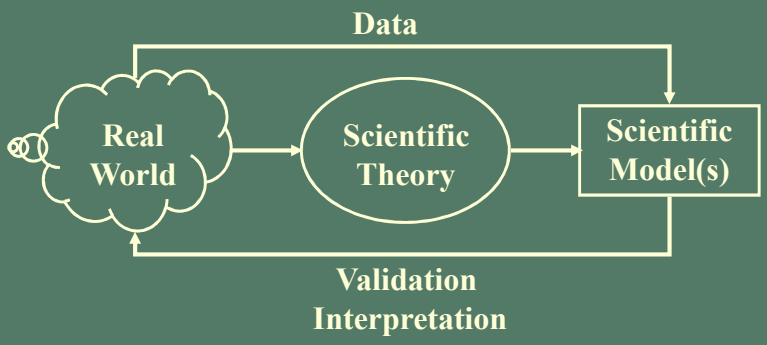
Judy's TI systems analyst mentor

What's a model?

- 'Play' Model (model train, model airplane, etc.)
- Prototype….
- Conceptual Model
- Mathematical Model
- Statistical Model
- Computer Model

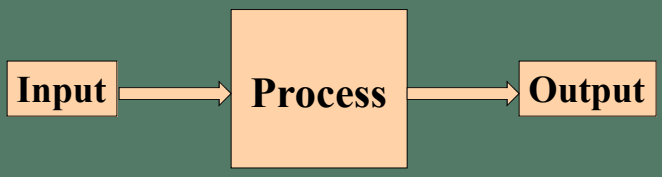
Scientific Models

how they relate to scientific theory and the world

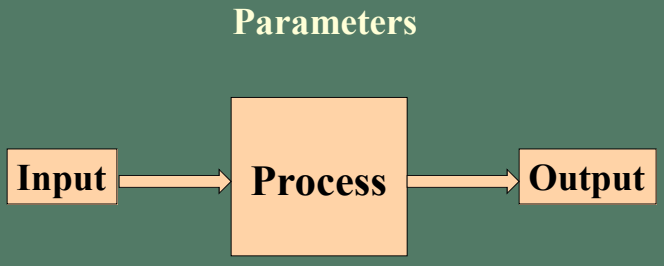


Science is inductive. Are models inductive, too?

Models and Systems

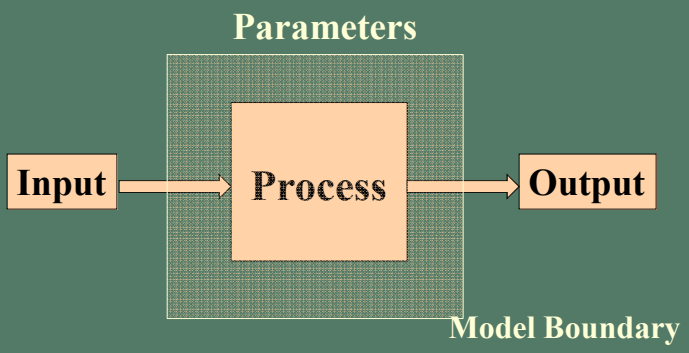


Models and Systems

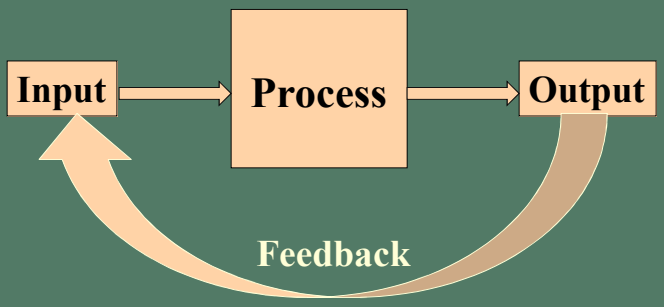


Models and Systems

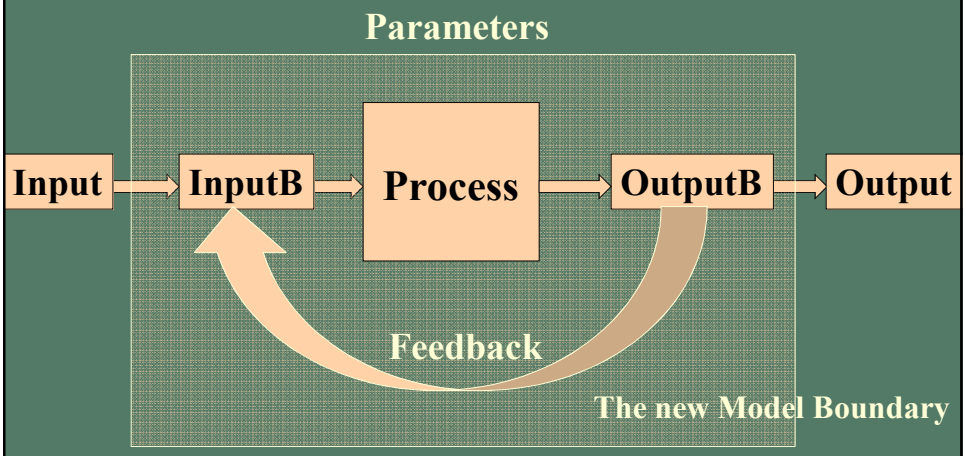
Ralph's *simple?* model of models



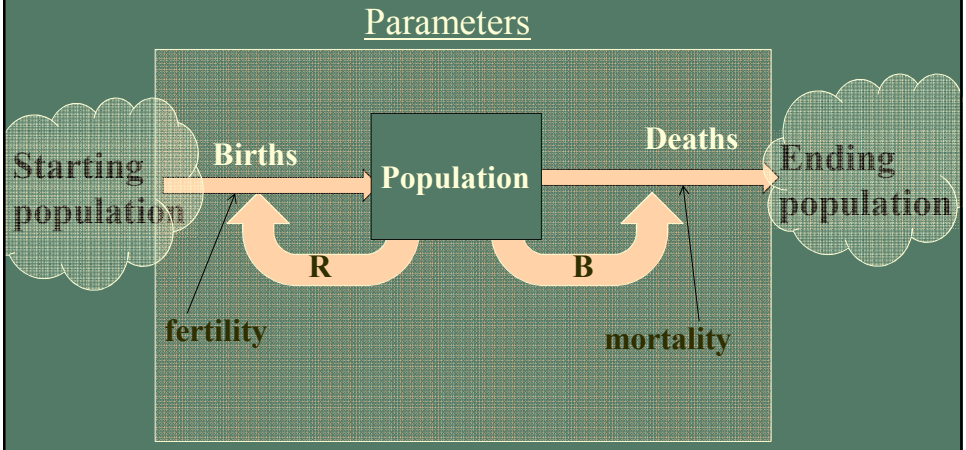
Models and Systems



Models and Systems

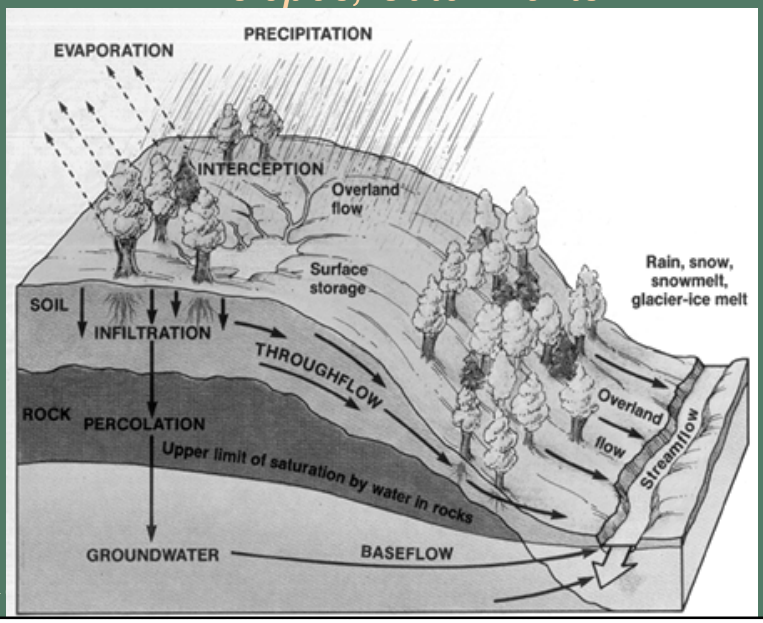


Models and Systems



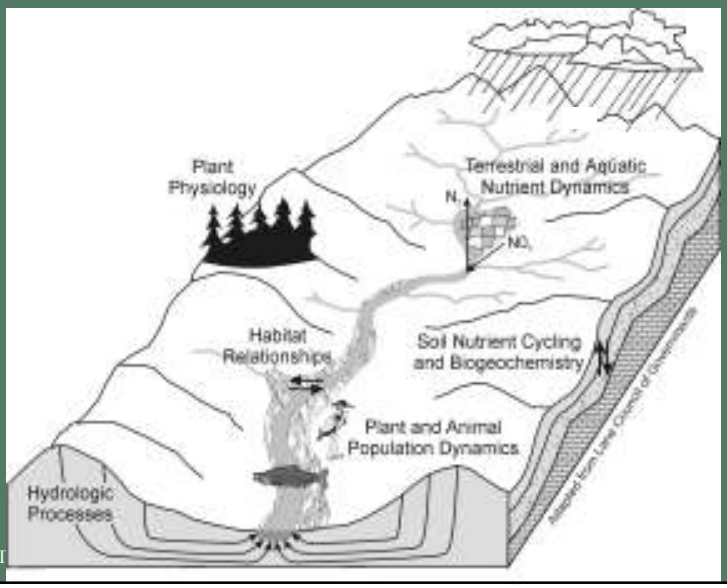
Eco-hydrologic model

Hillslopes, Catchments



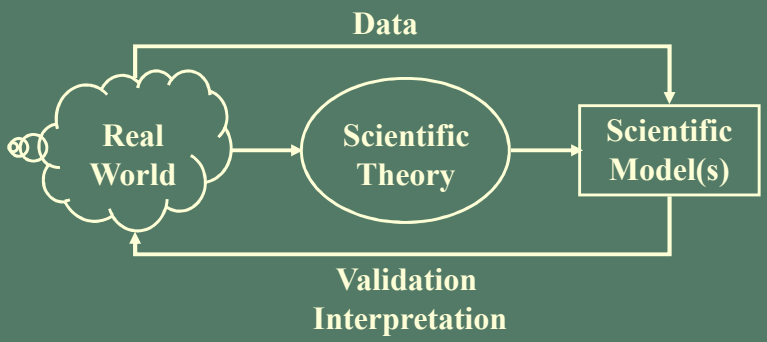
Eco-hydrologic model

Basin, Region



Deduction and Induction, so wut?

Our objective is to understand what science is
How it relates to the world,
And how scientific models relate to scientific theory
And in turn to the world….



Science is inductive. Are models inductive, too?

What do you need to know to use, describe, or build a model?

A collection of elements or parts that is coherently organized and interconnected in a pattern or structure that produces characteristic behaviors, often classified as its "function" or "purpose".

What do you need to know to use a model?

A collection of elements or parts that is coherently organized and interconnected in a pattern or structure that produces characteristic behaviors, often classified as its "function" or "purpose".

1. **Understand its purpose**
2. **Identify the inputs, outputs, and parameters**
3. **Study its behavior**
4. **Understand its boundaries and the context in which it was built – its power & limitations**

What's do you need to know to describe a system (for a model)?

A collection of elements or parts that is coherently organized and interconnected in a pattern or structure that produces characteristic behaviors, often classified as its "function" or "purpose".

What's do you need to know to describe a system (for a model)?

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1. **Understand its purpose**
2. **Identify inputs, outputs, and parameters**
3. **Study its behavior**
4. **Understand its boundaries**
5. **Understand the paradigm in which you are working**

1. **Identify the stocks, flows**
2. **Identify the parameters**
3. **Articulate how those parts are organized**
4. **Ask if this system like others you "know"?**
5. **What about the audience and actors?**

What's do you need to know to build a model?

A collection of elements or parts that is coherently organized and interconnected in a pattern or structure that produces characteristic behaviors, often classified as its "function" or "purpose".

What's do you need to know to build a model?

A collection of elements or parts that is coherently organized and interconnected in a pattern or structure that produces characteristic behaviors, often classified as its "function" or "purpose".

Know why you are building the model -

1. **conceptual understanding of the system,**
2. **test assumptions about the system (with empirical data),**
3. **understand what conditions will lead to certain outcomes – *what if models* …**

What's do you need to know to build a model (that can be "run"?

A collection of elements or parts that is coherently organized and interconnected in a pattern or structure that produces characteristic behaviors, often classified as its "function" or "purpose".

1. **Write down why you are building the model**
2. **Study the existing description of the system/model**
3. **Identify a representation for model elements**
4. **Identify the mechanism to build it, and who will do what**
5. **Build it….**
6. **Document, test, validate, use it….**
7. **Refine it….**
8. **Make it available to others?**
9. **Combine it with other models?**
10. **….**

How does using a dynamic model differ from using a statistical model?

using a statistical model….

Consider **The "Universal Soil Loss" equation, from the geological/earth sciences, a regression analysis-based theory.**

Erosion (A, the *dependent* variable) is explained as a function of factors" RKLSCP (the *independent* variables): A=RKLSCP

A - soil loss /unit of area
R - rainfall
K - soil erodability
L - slope length
S - slope gradient
C - crop management
P - erosion control practice

using a dynamic model…

Meadows (and others) might claim such cause-and-effect relationships are *static* linear, and unfold instantaneously.

A dynamic model offers an ongoing process, or *dynamic*, view of the underlying system, a view of reality as made up of a web of *closed loops* (called *feedback loops*), and a structure of relationships between elements in mental models.

Soil Erosion
A=RKLSCP vs. a Dynamic Model *…

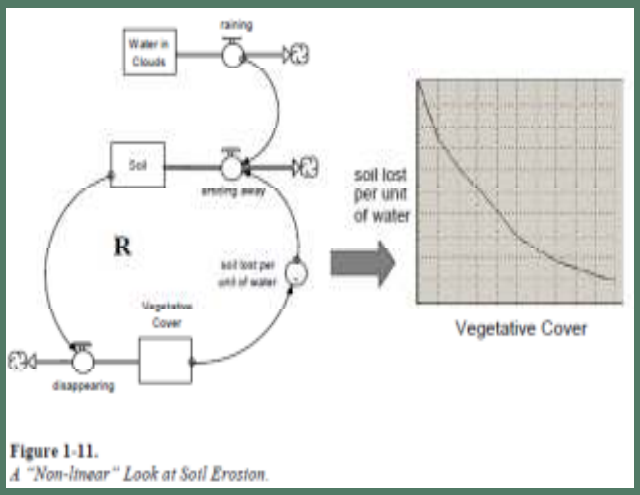


Figure 1-11.
A "Non-linear" Look at Soil Erosion.

From *The Language of Systems Thinking*: Ch.1

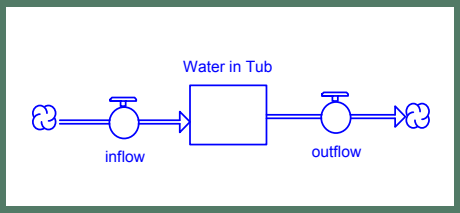
A simple modeling exercise….

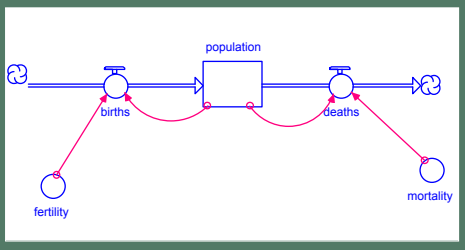
Build a simple model to study
how limited resources affect
the growth of a population.

As population grows,
resources become more scarce, and
the rate of growth slows.

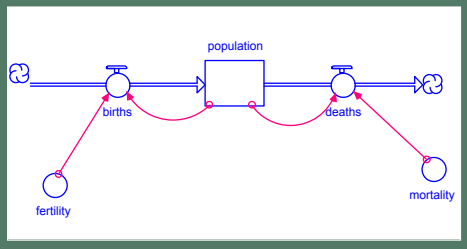
Systems Thinking….
Let's do a model

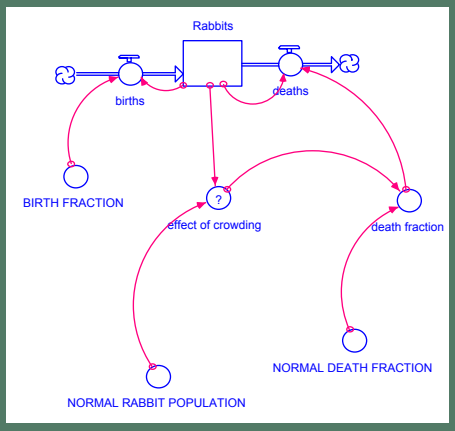
Thinking in Systems: STELLA demo discussion….





Thinking in Systems: STELLA demo discussion….





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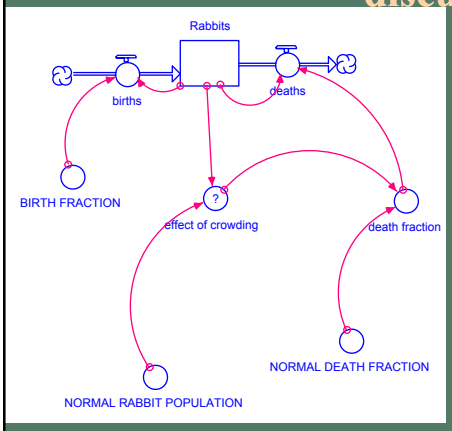

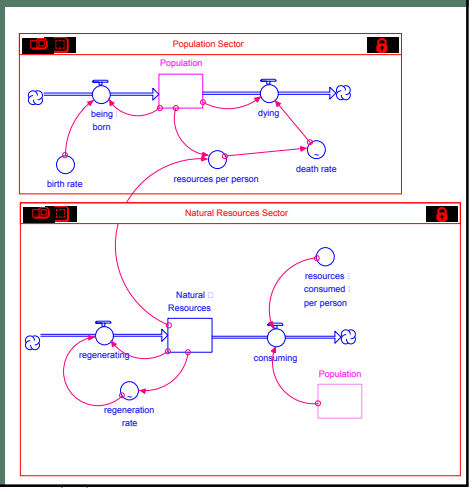

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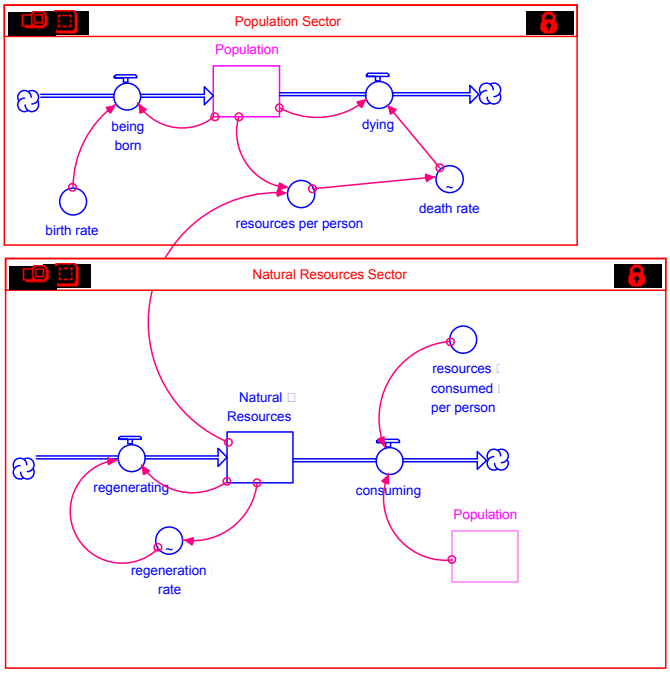
Thinking in Systems: STELLA demo discussion….

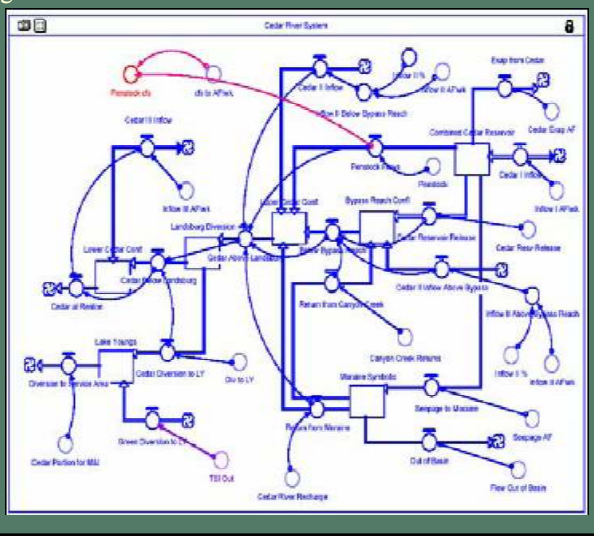


Cushing – CPaT Spring 2013, W

serious stuff with STELLA?

Modeling Climate Change Impacts in the Connecticut River Basin: Integrating Simulation, Optimization, and Decision Support Richard Palmer, et al, UMass Amherst, Civil & Environmental Engineering

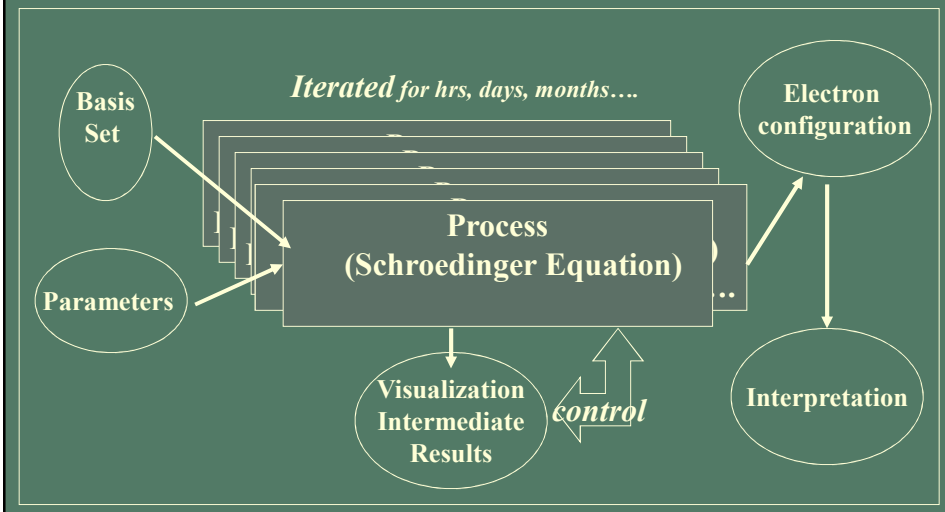
Create a basin-wide decision support tool that will allow water managers and other key stakeholders to evaluate environmental and economic outcomes based on various management scenarios.



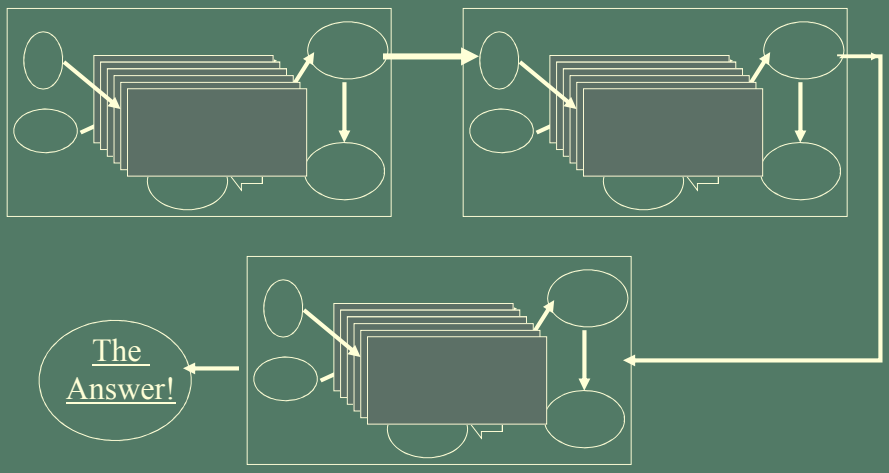
Some Kinds of Scientific Models

- Conceptual Model (*Resilience Thinking, Thinking in Systems*)
- Mathematical Model
  - what is the length of the shadow (or the flagpole)
  - natural system *X ~ some mathematical fcn*, use it to predict x
- Statistical Model
  - Given my sex, height, weight, age… what is my cholesterol?
  - Given size of tumor, trt, age…what is recurrence likelihood?
- Theoretical Model
  - Ab initio Computational Chemistry. Given the Schroedinger equation, what does is the outer ring of electrons ….
- Semi-empirical theoretical models
  - my molecule is too big to compute from 1st principles, ….
- Models that simulate Real World phenomena (Meadows)
- Models of Models…. VELMA + Envision….

Computational Chemistry….



Model of Models….



Some Advice about Modeling….

Validate the Model
Why?

Are we trying to show that the model is right?

Simplify and Compress Model Results

Why?

Simplify and Compress Model Results

Why?

Confirm initial conclusions and gain explanatory power….

Modeling Rules

1. 1st step: analyze decision making environment
2. The model should be as comprehensive as possible
3. The goal of description is description
4. Validation should show if the model is right
5. A complex system requires a complex model

Modeling Rules Myths

1. 1st step: analyze decision making environment
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Modeling Myths to Modeling Rules?

1. 1st step: analyze decision making environment

First, study underlying processes…..

Modeling Myths to Modeling Rules?

2.The model should be as comprehensive as possible

A model is an abstraction of reality.

The problem is not whether, but what, to leave out.

Modeling Myths to Modeling Rules?

3.The goal of description is description

A multivariate statistical model (from existing data) does not always suffice –
need to know frequency behavior on large time scale.

Also, new policy might create situations
not in historical record.

For some problems, want a causal model.

Modeling Myths to Modeling Rules?

4. Validation should show if the model is right

Validation explores limits of credibility,
and requires invalidation (not validation).

Modeling Myths to Modeling Rules?

5.A complex system requires a complex model

Compression & simplification are essential,
to encapsulate understanding and help
intuition play its central role in analysis –
and communication.

Modeling Rules

1. 1st step: analyze decision making environment First, study underlying processes…..
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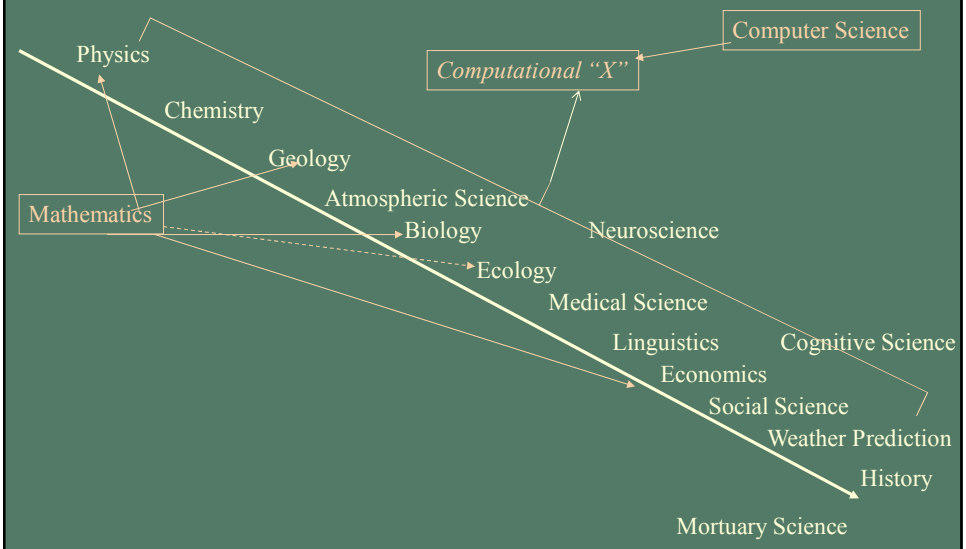
4. Validation should show if the model is right Validation explores limits of credibility, and requires invalidation (not validation).
5. A complex system requires a complex model Compression & simplification are essential, to encapsulate understanding and help intuition play its central role in analysis – and communication.

Three Scenarios – Forest Management Strategies

SCENARIO	NARRATIVE
Status Quo	Continue existing growth management, forest management policies, and patterns of use.
Smart Growth / Carbon Offset Forestry	Emphasize protection of resource lands and compact growth in urban areas. Forest management focus on carbon sequestration on public lands, longer (80 yr) rotations on private lands; afforestation of low-value ag lands in response to incentives for carbon sequestration.
Unmanaged Growth/ Extractive Forestry	Relax restrictions on development on resource lands and rural lands, near urban growth boundaries; some extractive uses allowed on public forest lands; private forest lands emphasize extractive uses, short (40-year) rotations.

The Emerging "new" Sciences….



The Emerging "new" Sciences….