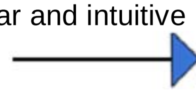
Student Handout 1: Introduction to Qualitative Modeling

Modeling has become an important tool in the study and management of ecological systems. An ecological system or process often cannot be directly manipulated in a field test. Costs and time constraints can limit large-scale experiments for testing community responses to an environmental disturbance. Models can help us:

- Generate and explore hypotheses quickly and rigorously
- Define research questions
- Identify data needs
- Understand ecosystem functioning by allowing us to visualize how species are influenced by each other and by abiotic conditions
- Make predictions of how ecosystems might change in response to human activities or other disturbances

In building your models and working together, you will be generating new knowledge about interactions which occur within an ecosystem and creating a tool that provides a better understanding of the ecosystem as a whole. Keep in mind, no model is a ‘perfect’ representation of the system but rather is a proposed hypothesis of how a system is structured; a simplification of a real system.

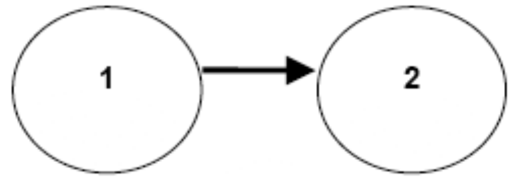
The process of constructing a model will help you combine previously isolated bits of knowledge into a larger construct. It can also contribute towards developing higher order thinking skills such as analysis, relational reasoning, and synthesis. The human brain cannot keep track of an array of complex interactions all at one time, but it can easily understand individual interactions one at a time. By adding components to a model one by one, we develop an ability to consider the whole system together, not just one interaction at a time.

Qualitative models are typically drawn as familiar and intuitive ‘signed digraphs’ consisting of ecological ‘components’ (in boxes) and positive  or negative  ‘links’ (arrows). A component is any variable part of an ecosystem. For example, an ecosystem component could be a population of a given species, or the amount of nitrogen held in the soil, or the temperature of the water in a stream. Links are symbols that represent interactions occurring between components. These can be used to show a flow of materials or energy between components or to indicate a causal effect of one component on another. The term ‘system’ refers to any combination of two or more components that have some form of interaction between them. Interactions between populations of different species in a community can be classified with combinations of the three symbols {–,0,+}. This modeling also uses a simple line for no effect or unchanged.

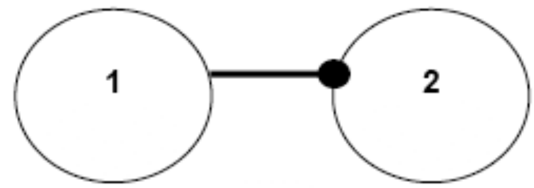
Blackwood, J. Scott, Marion Dresner, Hang-Kwang Luh. April 2006, posting date. Using Student Generated Qualitative Ecological Models. Teaching Issues and Experiments in Ecology, Vol. 4: Experiment #4 [online]. http://tiee.ecoed.net/vol/v4/experiments/ecological_models/abstract.html

<u>There are five basic types of ecological interactions that can be modeled this way:</u>

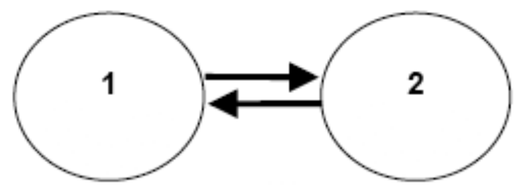
1) Component 2 has a positive effect on component 1 without any effect on itself. For example, if the sun is component 1 and plants are component 2, plant growth and reproduction are enhanced with increased exposure to solar radiation, but this has no effect on the sun. This relationship is not a feedback loop because there is no return signal (input) to component 1.



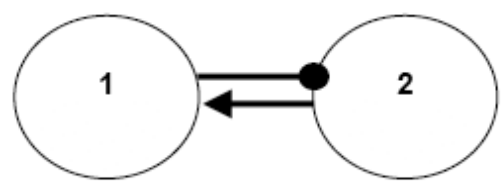
2) Component 1 has a negative effect on component 2 without any effect on itself. For example, non-breeding adult Nazca boobies (component 1) nest near the sites where blue-footed boobies (component 2) nest. Adult Nazca boobies will attack blue-footed boobies' nests and injure nestlings, which prevents them from fledging. This interaction does not result in any benefits (such as effects on fecundity and survival) for the adult Nazca boobies. This relationship does not constitute a feedback loop because there is no return signal (input) to component 1.



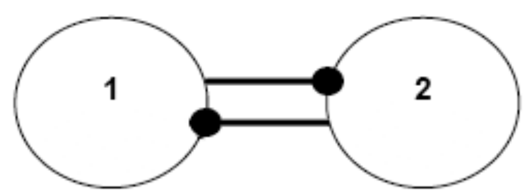
3) Two components positively affect each other. If each component is biological, this relationship is referred to as a 'mutualism.' If component 1 represents flowering plants and component 2 bees, flowers provide food while the bees help the plants to reproduce. This relationship is a positive feedback loop since the signs of the input and output are the same (here they are both positive).



4) Component 2 has a positive effect on component 1, but component 1 has a negative effect on component 2. This relationship between a predator and its prey could be represented by this digraph. As the predators (component 1) increase in numbers, they deplete the prey (component 2), which in turn has a decreasing effect back to the predators. Likewise, as the predators decrease in numbers, the prey benefit from reduced predation and this has an increasing effect on the predators as a result of increased food resources. This is a negative feedback loop because, for either component, the input is opposite in sign to the output.



5) Two components negatively affect each other. Two species in competition for the same resource can lead to this type of interference. Note that, in effect, this relationship constitutes a net positive feedback loop because the signs of the input and output are the same (they are both negative). The net effect is positive feedback since, as explored by May 1973, this interaction will result in instability – unless it is mediated by regulatory processes stemming from self-regulation or from interactions with other components.



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