# Individual-Based Models

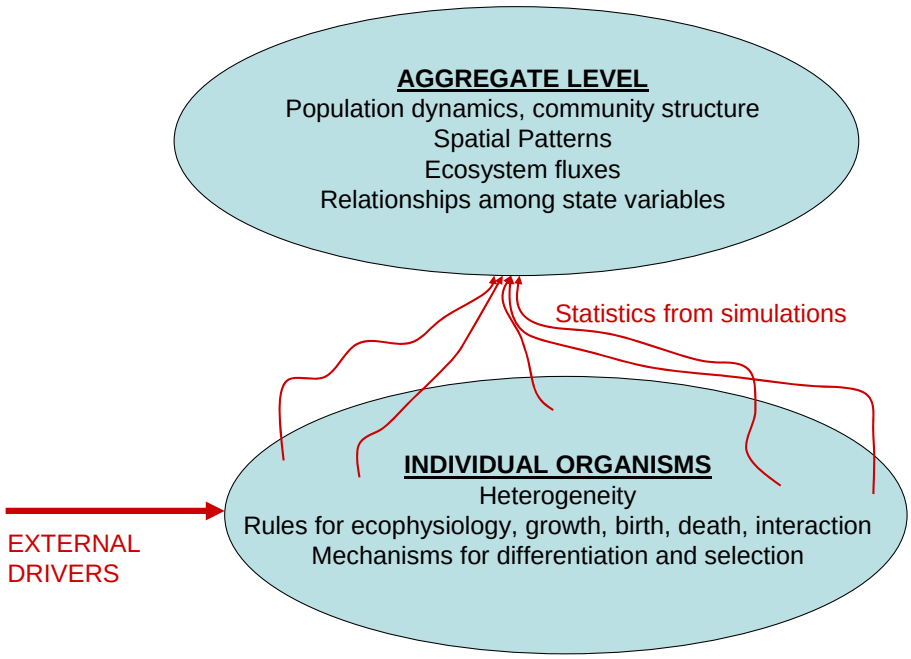
Zoology 535, Spring 2008

1. Particle models: See the handout on stochastic simulation, and the lab exercise for Week 10.

2. Use of models for the "average particle" to connect the individual level to the aggregate level: See the handout on functional response kinetics for an example. By modeling the probabilistic behavior of individual predators, and averaging over a large number of them, one can derive functional responses for entire trophic levels. In this case, the individuals are assumed to be rather homogeneous.

3. Individual-based models (IBMs) deliberately include heterogeneity among individuals (Figure 1). Typically heterogeneity is built in for particular attributes of interest, such as body size, spatial location, bioenergetic or physiological parameters, behavioral characteristics, and so forth.

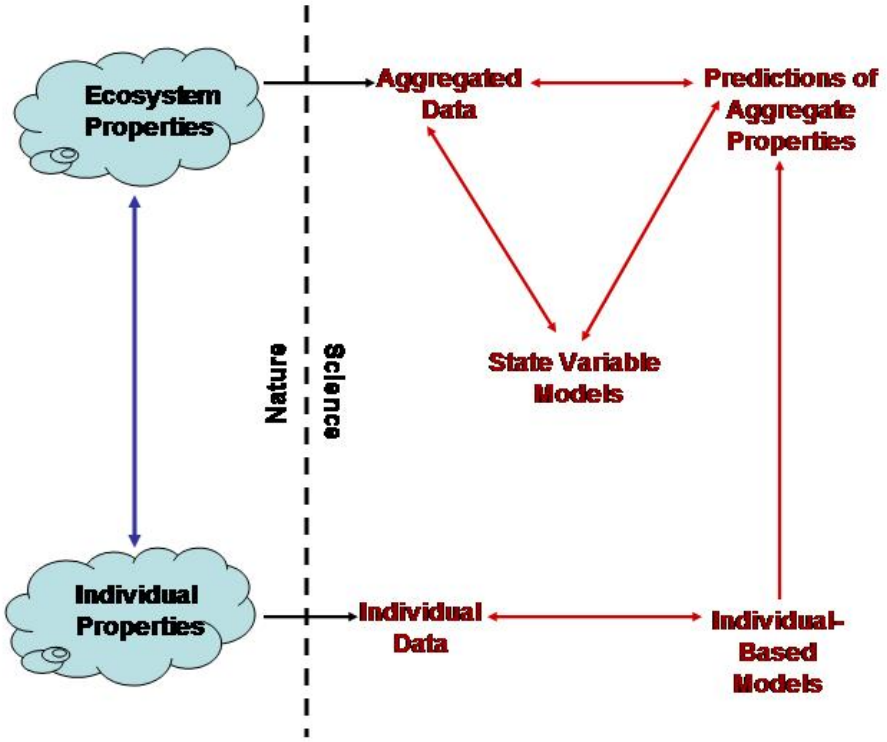
Figure 1. Linkage of individuals to aggregate state variables in IBMs. In animal ecology, the individuals are usually organisms. In plant ecology, the individuals may be organisms or small habitat patches. Some models represent habitat patches and movement of individual organisms.




IBMs are used (1) When there is a lot of information about the ecology of individuals, (2) when models for aggregated state variables are deficient, or ignore important aspects of differentiation among individuals, or (3) when the scientific question involves the connection between individual and aggregated levels.

IBMs can potentially bring an additional level of information into ecosystem analysis (Figure 2). In many cases, we know a lot about ecophysiology, behavior and interactions of individuals. Using IBMs, this information can be aggregated to build understanding about ecosystem variables, and evaluate state variable models. However, Grimm (1999) argues that this conceptual role of IBMs has rarely been exploited. He believes that this is because (1) IBMs have mostly been used to address fairly narrow questions of local ecosystem behavior, instead of broader conceptual questions about ecosystems, (2) modelers have not developed the tools for "computer experiments" needed to address broader ecosystem questions, and (3) the field is still fairly new.

Figure 2. Linkages among nature, data, state variable models and IBMs.




Grimm (1999) suggests several "rules" for individual-based modelers. His rules are paraphrased below.

a) Individual based modeling is just another form of modeling. It is a purposeful representation of an abstraction, designed to explore potential answers to a question.

b) Keep IBMs as simple as possible (just as with other kinds of models).

c) The goal of IBMs is understanding (just as with other kinds of models).

d) Experiments are a good way to understand IBMs. Usually they are too complicated to be understood with pencil-and-paper. Computer experiments are important.

e) IBMs are most useful when the question starts with a pattern that is observed in nature.

f) IBMs should bridge to state-variable approaches and classical theoretical ecology.

g) Modelers should seek opportunities to analyze IBMs and state-variable models in a common framework (e.g. by comparing predictions of the same aggregate variables to data).

h) The definition of "individual" is flexible, and should be adapted to the question.

i) Experiment with IBMs by developing them at different levels of aggregation. The power of IBMs is to understand phenomena that cross levels of aggregation.

For the particular case of spatial stochastic ecological models, Levin and Pacala (1997) offer some "rules of thumb" for condensing complex patterns to simple scaling rules.

References

DeAngelis, D.L. and L.J. Gross (eds). 1991. *Individual-based Models and Approaches in Ecology*. Chapman and Hall, NY.

Grimm, V. 1999. Ten years of individual-based modeling in ecology: what have we learned and what could we learn in the future? Ecological Modelling 115: 129-148.

Levin, S.A. and S.W. Pacala. 1997. Theories of simplification and scaling of spatially distributed processes. Pp 271-295 in D. Tilman and P. Kareiva (eds.), *Spatial Ecology*. Princeton University Press, Princeton, NJ.