

# Problem solving: a foundation for modeling

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Reading and discussing primary literature is central to communicating science. Students need practice in reading the literature for purposes beyond gaining information. Literature can be used to both increase knowledge and comprehension and to engage students in higher-level thinking (Bloom 1956; Levine 2001; Gillen *et al.* 2004; Finelli *et al.* 2005). Because science is also about making predictions and testing models, using information gained from reading to construct models allows students to develop problem-solving skills (Starfield *et al.* 1994). Ellison *et al.* (pp 479–486) provide information on how the removal of foundation species has affected the structure and function of a wide range of forest communities. In this article, we show how the Ellison *et al.* paper can be used to help students make connections between their prior knowledge and new information. Students explain the causes and effects of forest decline and the ecological processes involved by developing an explicit model that interconnects the data presented in the paper. They confer with their peers to explain and refine their models and then use the knowledge represented in their models to make predictions about novel situations. In this way, students actively develop their understanding of science and practice their ability to solve problems.

## ■ Student goals

- Demonstrate expertise in reading and interpreting scientific literature to solve problems.
- Analyze and apply information to design models that explain changes in ecosystem processes.
- Transfer understanding of ecosystem processes in forests to other ecosystems.

## ■ Instructor goals

- Use a jigsaw assignment as an effective way to analyze literature.
- Use group and individual instructional strategies to enable students to actively construct understanding of foundation species effects on ecosystem function by building descriptive models.
- Assess understanding of ecosystem functions by giving students novel examples to apply their understanding and test predictions.

## ■ Instructional design

### *Prepare for building models*

Engage students by showing them the photographs in

Figures 1, 2, and 4 in Ellison *et al.* Students then describe the changes they see in hemlock, whitebark pine, and American chestnut forests and predict why these changes occurred (think individually, then share with their neighbor, ie “think–pair–share”; <http://tiee.ecoed.net/teach/tutorials/neighbor.html>). Select several pairs to report to the class; both individuals from the pair should be prepared to speak. Follow with a discussion of how scientists often synthesize and condense data into descriptive models that integrate processes. Show and discuss the components of several examples of such models, including ones derived from the examples in Panel 2 of Ellison *et al.*

### *Active homework*

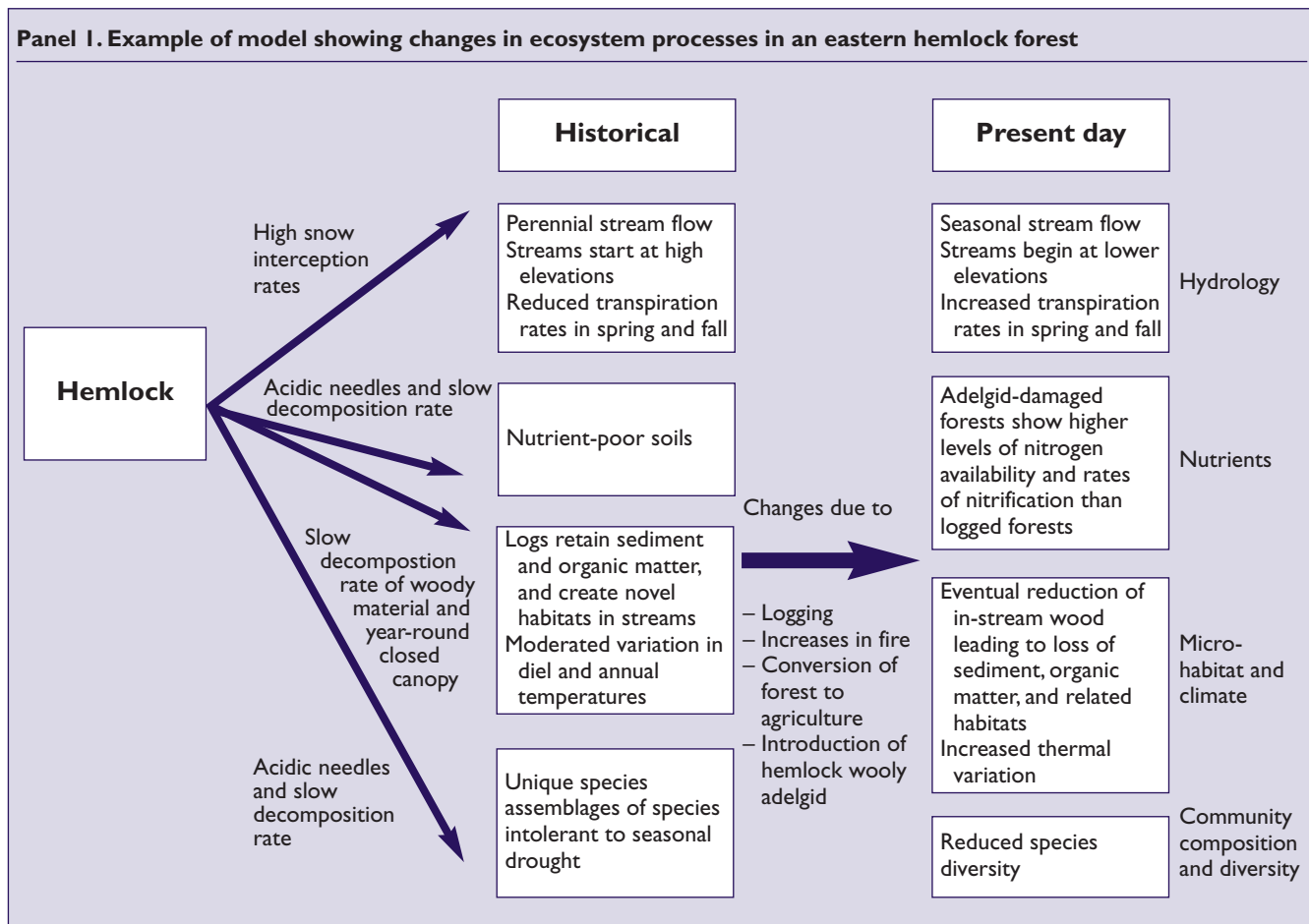
For homework, students form three-person groups. Each group member is responsible for constructing a model about how the removal of the foundation species affected ecosystem function of one of the three forest examples in the paper. Students are instructed to include information on the ecological processes and the biotic and abiotic factors that influenced the change from the historical situation to present-day conditions (eg Panel 1 for the hemlock forest). Students bring two copies of their models to class, one to hand in (for a grade or check) and the other to use when they explain the model to their group.

### *In class*

Students share the details of their models within their groups and look for commonalities and differences in the causes and effects of foundational tree removal. Based on this, they create a summary table (formative assessment), listing the causal factors that influenced declines of foundation species for each of the three ecosystems (Panel 2). Groups then present their findings (post-it posters are a useful tool) along with an instructor-led discussion on the varieties of pathways and effects leading to ecosystem change.

An assessment of whether students fully understand the material is to ask them to apply their knowledge of ecosystem processes to a different system. For example, the instructor could present data from Jackson *et al.* (2001), showing how removal of predators as a result of overfishing has fundamentally altered the functioning of the world’s coastal ecosystems in a similar manner to that seen in the removal of foundation species. Another example involves work in the Sonoran desert (McGregor *et al.* 1962; Pierson and Turner 1998) that reveals the keystone role of saguaro populations. Based on instructor-supplied material or their own literature searches, students predict

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the consequences of predator loss in ocean systems, or of a foundation species in the desert, and then construct a descriptive model that describes the resulting ecosystem changes. This assessment may be done by individuals or groups. Ideally, results will show if students can make connections about the factors influencing the changes in ecosystem structure from their work on the Ellison *et al.* paper.

**Final note**

Students have been building conceptual models in their minds for as long as they can remember. However, what they have not done often, if ever, is build explicit models so both they and their peers can understand and use them. Modeling provides a venue for students to critically read and process information about ecological problems from the literature. It also allows instructors to assess students' thinking.

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**References**

Bloom BS. 1956. Taxonomy of educational objectives, handbook I: the cognitive domain. New York, NY: David McKay Co Inc.  
 Finelli C, Ebert-May D, and Hodder J. 2005. Collaborative learning – a jigsaw. *Front Ecol Environ* 4: 220–21.  
 Gillen CM, Vaughn J, and Lye BR. 2004. An online tutorial for helping nonscience majors read primary research literature in biology. *Adv Phys Edu* 28: 95–99.  
 Jackson JBC, Kirby MX, Berger WH, et al. 2001. Historical overfishing and the recent collapse of coastal ecosystems. *Science* 293: 629–37.  
 Levine E. 2001. Reading your way to scientific literacy. *J Coll Sci Teach* 31: 122–25.  
 McGregor SE, Alcorn SM, and Olin G. 1962. Pollination and pollinating agents of the saguaro. *Ecology* 43: 259–67.  
 Pierson EA and Turner RM. 1998. An 85-year study of saguaro (*Carnegiea gigantea*) demography. *Ecology* 79: 2676–93.  
 Starfield AM, Smith KA, and Blelock AL. 1994. How to model it: problem solving for the computer age. Edina, MN: Burgess International Group Inc.

**Panel 2. Causal factors influencing decline of foundation species**

Causal factors	Hemlock	Whitebark pine	Chestnut
Native pest or pathogen		Yes	
Introduced pest or pathogen	Yes	Yes	Yes
Increased rates of fire	Yes		
Reduced rates of fire (suppression)		Yes	
Logging	Yes		
Conversion of forest to agriculture	Yes		