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ISSUES – FIGURE SET

Ecology of Disturbance

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Controlled fire, © Konza Prairie LTER, Manhattan, KS {www.konza.ksu.edu/gallery/hulbert.jpg}

THE ISSUE:
ecological understanding of disturbance on different scales and in a variety of settings

ECOLOGICAL CONTENT:
disturbance, species diversity, scale, ecosystems, intertidal ecology, and forest ecology

STUDENT-ACTIVE APPROACHES:
turn-to-your-neighbor, pairs-share, citizen's argument

STUDENT ASSESSMENTS:
essay quiz, diagram with essay quiz, pressing question, oral presentation, minute paper

OVERVIEW

In this **Issue**, students will examine published data that address the ecological consequences of environmental disturbance. Disturbance is a useful topic in the teaching of ecology and about disputes in science.

In my experience disturbance is an especially useful concept-as-tool for ecology teaching. That is in part because the ecology of disturbance opens the door to a fascinating and rich body of literature. Papers on disturbance deal with numerous concepts — diversity, stability (in all its meanings), scale, patch dynamics, landscape, succession, life history characteristics and adaptations, plus ecosystem-level experiments and nutrient dynamics. In addition, controversies related to disturbance rage in the ecological literature (e.g. diversity-stability hypotheses) and in the newspapers (e.g. fire management).

Another reason why the topic of disturbance "works" in ecology classes is because students, like most of us, are immediately intrigued by dramatic disturbances such as fire, hurricanes, landslides. Some may have experienced the effects on such phenomena first hand and can describe these to the rest of the class. In this way faculty can use disturbance to introduce more abstract topics such as diversity and stability. The ongoing diversity-stability debates are useful lead-ins to discussions about "why scientists disagree". Such disagreement surprises students who are still in the black-and-white stage of intellectual development — who believe that there are right or wrong answers to questions and disagreements are due to simple causes such as faulty equipment used by one of the scientists in the dispute.

The diversity/stability debates.

Some of the controversy about how disturbance affects diversity arises from imprecise definitions. Recognizing this helps students understand more subtle reasons for intellectual arguments. In A Critique for Ecology, Peters (1991) illustrates a definition problem with the term stability:

> *"Despite long-standing interest in stability (Brookhaven Symposium 1969, May 1974) the term has never been satisfactorily defined. Part of the difficulty in doing so reflects the dynamism of open biological systems ….[they] constantly react to both external and internal changes…[and] cannot be preserved like works of art. Instead stability must be defined in dynamic terms. Such contradictions foster misunderstanding…The definitions of Orians (1975) are indicative. Orians (1975) suggests that stability may mean many different things: the absence of change ('constancy'), the length of survival ('persistence'), resistance to perturbation ('inertia'), speed of return after perturbation ('elasticity'), the displacement from which return is possible ('amplitude'), the degree of oscillation ('cyclic stability'), and the tendency to move towards a similar end point ('trajectory stability'). These independent concepts are sometimes related, and sometimes not (Orians 1975); some, like constancy and resilience, may even be inversely related."*

Peters's sharp words underline the need to carefully define terms — and discuss their meaning and confusion — in an ecology class.

For definitions of some of these terms see Pimm (1991) who defines stability, resilience, persistence, resistance, and variability. Pimm also discusses different mind sets of field and mathematical ecologists in studies on disturbance and stability. Texts with useful terminology include Molles (1999) and Smith (1996).

Issues of scale.

In the ecological confusion category, the definition of the term 'scale' might be a close second to 'stability', in his classic paper on spatial scaling, Wiens (1989) writes that:

> *"…many ecologists have behaved as if patterns and the processes that produce them are insensitive to differences in scale and have designed their studies with little explicit attention to scale … [for] nearly 100 field experiments in community ecology … half were conducted on plots no larger than 1 m in diameter, despite considerable differences in the sizes and types of organisms studied. Investigators addressing the same questions have often conducted their studies on quite different scales. Not surprisingly, their findings have not always matched, and arguments have ensued."*

Wiens goes on to explain how these confusions have lead to debates about size of nature reserves, competition in animal community structure, and coevolution. The paper refers to numerous field studies designed to look at different degrees of scale. Schneider (2001) has also written a review on the concept of scale in ecology.

As an introduction to new aspects in ecology.

Studies of disturbance also bring students to the relatively new areas of landscape and restoration ecology. Landscape ecologists focus on spatial patterns in landscape with particular emphasis on disturbance (e.g. Forman and Godron 1986). Restoration ecologists apply ecological knowledge to the reparation of highly (and usually humanly) disturbed locales.

Disturbance of different scales.

I have selected several studies in which ecologists look at disturbance on different scales. Sousa's and Lubchenco's work focuses on tide pools and boulders in the rocky intertidal zone. The Minnich and Sprugel studies are landscape scale, and the Hubbard Brook experiment is at the ecosystem scale. In regard to more applied issues Russell writes (see Fire Issue) about the role of Native Americans in changing the landscape, Bormann and Liken's work concerns clear-cutting and also large manipulations in ecology research, and the Minnich study points out problems with fire management.

Selected References on Disturbance.

Brookhaven Symposium in Biology. 1969. Diversity and stability in ecological systems. *No. 22*, Brookhaven National Laboratory, Upton, N.Y.

Connell, J. H. 1978. Diversity in tropical rainforests and coral reefs. Science 199: 1302-1310.

Forman, R. T. T., and M. Godron. 1981. Patches and structural components for a landscape ecology. BioScience *31*: 733-740.

Lubchenco, J. 1978. Plant species diversity in a marine intertidal community: importance of herbivore food preference and algal competitive ability. American Naturalist 112: 23-39.

May, R. M. 1974. Stability and Complexity in Model Ecosystems, 2nd ed. Princeton University Press, Princeton, N. J.

Molles, M. C., Jr. 1999. Ecology Concepts and Applications. McGraw-Hill, New York.

Orians, G. 1975. Diversity, stability and maturity in natural ecosystems. *In* W. H. Van Dobben & R. H. Lowe-McConnell, eds. Unifying Concepts in Ecology. Dr. W. Junk, The Hague.

Peters, R. H. 1991. A Critique for Ecology. Cambridge University Press, Cambridge, England.

Pimm, S. L. 1991. The Balance of Nature? University of Chicago Press, Chicago.

Schneider, D. C. 2001. The rise in the concept of scale in ecology. BioScience *51*: 545-553

Smith, R. L. 1996. Ecology and Field Biology, 5th ed. Harper Collins Publishers, New York.

Valiela, I. 1995. Marine Ecological Processes. Springer-Verlag, New York.

Wiens, J. A. 1989. Spatial Scaling in Ecology. Functional Ecology 3: 385-397.

FIGURE SETS

These are published figures from peer-reviewed research journals and monographs that engage students in data analysis and critical thinking organized by teaching approach, Bloom's Taxonomy cognitive skills, class size, and time. The student-active approaches listed here are suggestions and examples; modify them as appropriate for your teaching.

Figure Set and Ecological Question	Student-Active Approach	Cognitive Skill	Class Size/Time
(1) Intermediate Disturbance Hypothesis (Sousa 1979; Lubchenco 1978)	pairs share	comprehension interpretation application analysis	small medium/ intermediate
(2) Hubbard Brook Study (Bormann & Likens 1978)	take home/group	comprehension interpretation	small medium/ long
(3) Ecology of Fire (Bormann & Likens 1979; Minnich 1983)	citizen's argument	comprehension interpretation application	any/ intermediate
(4) Fir Waves: Regeneration in New England Conifer Forests (Sprugel 1976)	turn to your neighbor	comprehension interpretation	any/ short

RESOURCES

Here are a number of web sites that provide information on the issue of Ecological Disturbance:

Fire

- National Fire News (www.nifc.gov/fireinfo/nfn.html)
- NFN current information (www.nifc.gov/fireinfo/nfnmap.html)
- TOMS images (jwocky.gsfc.nasa.gov/aerosols/today_plus.html)
- Science News article (www.sciencenews.org/20010224/bob8.asp)
- Burn photos (plantbio.berkeley.edu/%7Ebruns/fire5.html)
- U.S. Fish & Wildlife Service (fire.fws.gov/)
- ESA Fact Sheet on the Ecology of Fires (PDF) (www.esa.org/education/edupdfs/fireecology.pdf)
- Assoc. of Fire Ecology (www.ice.ucdavis.edu/afe/)

Fir Waves

- Fir waves and life history evolution in the Adirondacks (www.open.ac.uk/science/biosci/research/ecology/silvertown/J_Silver/abies.htm)

Species Diversity

- Natural History Museum Worldmap (www.nhm.ac.uk/science/projects/worldmap/diversity/species.htm)
- ESA Biodiversity fact sheet (PDF) (www.esa.org/education/edupdfs/biodiversity.pdf)
- Fish & Wildlife Service (endangered.fws.gov/)
- Virtual Library (conbio.net/VL/browse/)
- Chronicle of Higher Education article (chronicle.com/free/v47/i07/07a02401.htm)
- Biodiversity & Ecosystem Function Online (www.abdn.ac.uk/ecosystem/)
- National Wildlife Federation (www.nwf.org)

Miscellaneous

- ESA Issues papers (www.esa.org/issues.htm)
- econet (www.igc.org/home/econet/index.html)
- Hubbard Brook (www.hubbardbrook.org)
- Littorina (www.marlin.ac.uk/demo/Litlit.htm)