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## ISSUES – FIGURE SET

# Ecology of Disturbance

Charlene D'Avanzo, School of Natural Sciences
Hampshire College, Amherst, MA, 01002
cdavanzo@hampshire.edu

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

**Figure Set 4: Fir Waves: Regeneration in New England Conifer Forests**

**Purpose:** To demonstrate an example of disturbance on a landscape scale.
**Teaching Approach:** "Turn-to-your-neighbor"
**Cognitive Skills:** (see Bloom's Taxonomy) — comprehension, interpretation
**Student Assessment:** Minute paper

## BACKGROUND

In this classic paper on landscape-scale disturbance, Sprugel questions the simplistic notion of climax generally accepted in the 50's and 60's. In his introduction Sprugel says: "ecologists spent much time and effort searching for, describing, and classifying 'climax' ecosystems … even though there was often little or no evidence that stable systems of this sort would ever come into existence under natural conditions. In fact, many studies have indicated that natural disturbance plays a far more vital role in ecosystem dynamics than that attributed to it by the classical climax theory."

To address this issue Sprugel studied balsam fir communities, the uppermost tree zone in the northeast U.S. It was well known that in these high-altitude fir forests "waves" of crescent-shaped bands of dead trees were found in systematic patterns. The waves are areas of standing dead trees with mature and healthy forest surrounding them. From left to right the cross section in Fig.1 shows a mature forest an adjacent area of dead and dying trees, an area where dead trees are being replaced by fir samplings of successive age, and a second area of dead trees. The paper also includes several photographs of the fir waves.

Sprugel's main site was Whiteface Mountain in New York; Whiteface is the most northerly peak in the Adirondacks and in his study locale 99% of trees are balsam fir. He also worked in New Hampshire and Maine. Sprugel measured direction of tree die off by taking transects through the waves; here he also determined tree ages by coring them. For another part of the study he marked trees for several years and classified them into improved or deteriorated categories by examining browning of tips and overall browning.

Sprugel found that waves move in the direction of the prevailing wind. He next considered the cause of tree death and, using data on wind speeds in a conifer forest, reasoned that wind velocity at the edge of a tree canopy was over 50% higher than that within the forest. Rime-ice, ice formed when water droplets hit solid surfaces and immediately freeze, was a well known phenomenon on Whiteface Mountain. (The paper includes Weather Bureau statistics that riming occurs there on about 1/3 of days from October through April.) Rime accumulates more on trees exposed to wind.

Sprugel's conclusion is that trees at the leeward edge of the canopy opening in the wave are exposed to winds and die from loss of needles and branches due to heavy ice accumulation. He also describes winter desiccation and lowered rates of production in summer as a result of needle cooling. As these trees die, adjacent firs experience the same conditions and begin to die. The overall direction of the wave motion is therefore directly related to wind direction.

Regeneration of waves occurs at about 60 year intervals and thus all stages of regeneration and deterioration can be found in the forest. In this sense the system is steady-state.

### Literature Cited

Sprugel, D. G. 1976. Dynamic structure of wave-regenerated *Abies balsamea* forests in the north-eastern United States. Journal of Ecology 64: 889-911.

**STUDENT INSTRUCTIONS**

Talk to students next to you or around you and discuss the Figure or Table. Remember to follow the step-one-step-two approach we have practiced in class.

Sprugel (1976) studied balsam fir communities, the uppermost tree zone in the northeast U.S. It was well known that in these high-altitude fir forests "waves" of crescent-shaped bands of dead trees about 50 m in size were found in systematic patterns. The waves are areas of standing dead trees with mature and healthy forest surrounding them, and they can easily be seen from a distance.

Sprugel's main site was Whiteface Mountain in New York; Whiteface is the most northerly peak in the Adirondacks and in his study locale 99% of trees are balsam fir. He also worked in New Hampshire and Maine. Sprugel measured direction of tree die off by taking transects through the waves; here he also determined tree ages by coring them. For another part of the study he marked trees for several years and classified them into improved or deteriorated categories by examining browning of tips and overall browning.

From left to right the cross section in Figure 4A shows a mature forest, an adjacent area of dead and dying trees, an area where dead trees are being replaced by fir samplings of successive age, and a second area of dead trees.

## FIGURES

| **WAVE EDGE** | Sept. '71 | June '72 | Sept. '72 |
|---|---|---|---|
| General vigor | | | |
| Improved | 5 | 2 | 1 |
| Deteriorated | 14 | 16 | 26 |
| Number Dead | 7 | 12 | 20 |
| **WITHIN FOREST** | Sept. '71 | June '72 | Sept. '72 |
| General vigor | | | |
| Improved | 1 | 1 | 1 |
| Deteriorated | 1 | 2 | 3 |
| Number Dead | 0 | 0 | 0 |

Table 4. Changes in wave-edge trees (n=99) and comparison trees within the forest. From D. G. Sprugel 1976. Dynamic structure of wave-regenerated *Abies balsamea forests* in the north-eastern United States. Journal of Ecology 64: 889-911.

Figure 4A. Cross section through a regeneration wave. From D. G. Sprugel 1976. Dynamic structure of wave-regenerated *Abies balsamea forests* in the north-eastern United States. Journal of Ecology 64: 889-911.

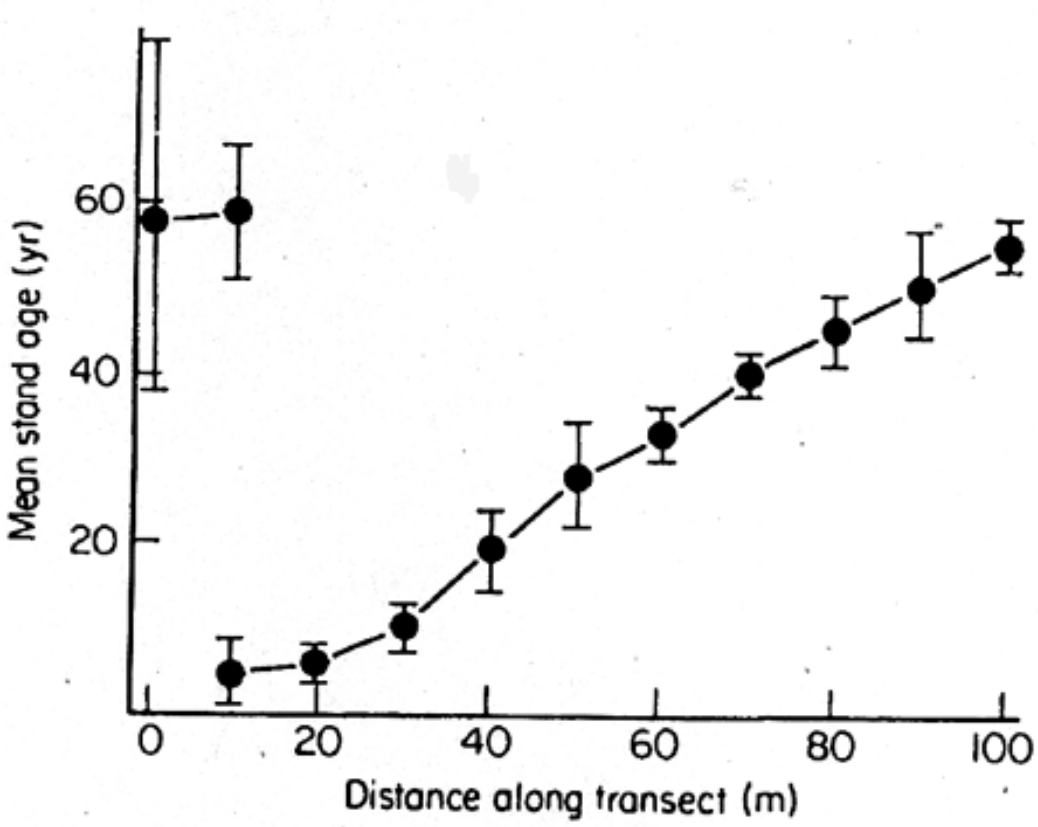


Figure 4B. Average age of trees in a stand (± standard deviation) along a transect through a wave. From D. G. Sprugel 1976. Dynamic structure of wave-regenerated *Abies balsamea forests* forests in the north-eastern United States. Journal of Ecology 64: 889-911.

## FACULTY NOTES

The data here are quite straightforward and therefore can be easily used in a brief turn-to-your-neighbor exercise even in a large class.

This is a "neat" study in the sense that fir waves are intriguing and common in the northeast but were clearly a puzzle before Sprugel's study. The paper is written in the older, conversational style and Sprugel clearly outlines the logic of his thinking and evidence he uses. You can therefore easily explain to students step by step the logical development of his ideas about wind and rime ice.

This is also a useful paper if you are presenting the historical development of ideas about succession and critiques of Clementsian "stable climax" concept. You can also use the minute paper question below to stimulate a discussion about the meaning of "stability" in ecology.

### Discussion Questions:

- Imagine that you are walking around in the balsam fir forest in upstate New York that Sprugel studied. Describe the sizes of the trees (e.g. are they all the same size?).

- Sprugel did this study to challenge the notion that young forest communities develop over time into stable climax systems. He said: "For years, it was generally assumed that in the absence of disturbance the vegetation on any site would eventually reach a self-reproducing steady-state equilibrium, in which all system properties would be relatively constant through time." Explain Sprugel's statement and how the fir wave study addresses the issue of "stable climax systems".

- In addition to counting and measuring trees, Sprugel also measured prevailing wind directions and wind speed. Why was this so important to the study?

- 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'). What does "stability" mean in the context of Sprugel's study?

### Literature Cited

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.

**Student Assessment: Minute Paper**

This is a very useful way to get quick feedback at the end of a class. Many faculty have students write their "paper" on a 3x5 card that students drop in a box as they leave the class. After discussion of the study in class, ask students to write a several sentence response to the following:

> Explain the logic of Sprugel's study - the step by step approach that he used to reach his conclusions.

**Evaluating an Issue: How do you know whether it is working?**

On-going (also called formative) evaluation of the approaches your are using is critical to the success of student-active teaching. Why try out new ideas if you don't know whether or not they are working? This is a brief overview of formative evaluation. For more information, go to the Formative Evaluation essay in the Teaching Section.

**Course Goals:**

Formative evaluation only works if you have clearly described your course goals - because the purpose of the evaluation is to assess whether a particular technique is helping students reach these goals. For instance, most of us have "learn important ecological concepts and information" as a course goal. If I reviewed the nitrogen cycle in a class, for evaluation I might ask students to sketch out a nitrogen cycle for a particular habitat or system. Each student could work alone in class. Alternatively, I might ask students to work in groups of 3 and give each group a different situation (e.g. a pond receiving nitrate from septic systems, an organic agricultural field, an agricultural field receiving synthetic fertilizer). The students could draw their flows on a large sheet of paper (or an overhead transparency) and present this to the rest of the class.

**The Minute Paper:**

Minute papers are very useful evaluative tools. If done well they give you good feedback quickly. Minute papers are done at the end of a class. The students are asked to respond anonymously to a short question that you ask. They take a minute or so to write their response in a 3x5 card or a piece of paper. You collect these and learn from common themes. In the next class it is important that you refer to one or two of these points so that students recognize that their input matters to you. The UW - FLAG site (www.wcer.wisc.edu/nise/cl1/flag/) gives a good deal of information about using minute papers including their limitations, how to phrase your question, step-by-step instructions, modifications, and the theory and research behind their use.