

## Disturbance in Forests

### I. Definitions Revisited

In forest ecology, disturbance is used in the same sense as Sousa (2001) where a disturbance is an event not an agent that involves the removal of biomass or mortality. The BIG difference with Sousa 2001 in terms of the language of disturbance is that the forest literature almost universally considers all sources of damage and mortality as disturbances. The term is not exclusively reserved for physical agents. Herbivory, insect outbreaks, pathogen irruptions, senescence, and competition are included along with storms, floods, and fires as causal agents of disturbance (Frelich 2002).

Conceptually, forest ecologists certainly recognize the distinction. Theoretical and simulation models of forest dynamics explicitly acknowledge the difference between predictable biological causes of mortality and less predictable disturbance-caused mortality (Pacala 1996, Clark 1991) but the distinction does not hold in the empirical studies.

### II. Scaling of disturbances (after Paine et al. 1998)

Temporal: Generation time of population of interest (population dynamics); generation time of dominant organisms, usually defined in terms of productivity, for community or ecosystem scale questions.

Spatial: Dispersal kernel (e.g., seed shadow) of dominant organisms.

### III. The regime of disturbance

In forests, **severity** usually includes consideration of the collateral disruption of ecosystem structure (e.g., exposure of mineral soil, loss of soil organic/mineral nutrient capital, death of advance regeneration and buried seeds). See Peterson and Pickett (1995) and Battles and Fahey (2000) for examples where the severity of the disturbance in terms of collateral damage is thought to influence the recovery.

For discrete events, also commonly see the size distribution of the “disturbed” patches as well as the abundance of these patches.

**Areal extent** – usually reported in terms of fraction of forest stand impacted by a disturbance (e.g., gap fraction). Often requires a specific definition when a disturbed patch has recovered (sometimes referred to as residence time).

### IV. Frequency and size:

Exponentially decreasing in frequency with size or some roughly unimodal size distribution. Unimodal often an artifact of definition of disturbance.

### V. Spatial patterns

Infer process from pattern: compare random vs clumped vs uniform

Predictability of disturbance: some places in landscape more disturbed than others.

Physical and biological explanations (fir waves: Sprugel 1976, Silvertown and Dodd 1999.)

Are disturbances contagious? (Runkle 1991, Young and Hubbell 1991, Yavitt et al. 1995)

Are the disturbances isotropic?

Suggest that before anybody embarks on a spatial analysis read Hurlbert 1990.

## VI. Periodicity

Rotation time: length of time required to disturb an area equivalent to the whole landscape of interest (synonyms: fire cycle, mean recurrence interval, return time)

Turnover time: mean time between disturbances at any point in the forest/landscape (White and Pickett 1985).

Hartshorn's (1989) alternative definition: number of years to cover a unit area of the forest using the average annual disturbance rate (%/yr).

## References

- Battles, J. J., and T. J. Fahey. 1996. Spruce decline as a disturbance event in the subalpine forests of the northeastern United States. *Canadian Journal of Forest Research* **26**:408-421.
- Battles, J. J., and T. J. Fahey. 2000. Gap dynamics following forest decline: A case study of red spruce forests. *Ecological Applications* **10**:760-774.
- Battles, J. J., T. J. Fahey, and E. M. B. Harney. 1995. Spatial patterning in the canopy gap regime of a subalpine *Abies-Picea* forest in the northeastern United States. *Journal of Vegetation Science* **6**:807-814.
- Clark, J. S. 1991. Disturbance and Population Structure on the Shifting Mosaic Landscape. *Ecology* **72**:1119-1137.
- Frelich, L. E. 2002. Forest dynamics and disturbance regimes. Cambridge Studies in Ecology, Cambridge University Press, Cambridge and New York.
- Hartshorn, G.S. 1989. On overview of neotropical forest dynamics. In A.H. Gentry (ed). *Four Neotropical Forests*. Yale University Press, New Haven, CT.
- Hurlbert, S., H. 1990. Spatial distribution of the montane unicorn. *Oikos* **58**:257-271.
- Pacala, S. W., C. D. Canham, J. Saponara, J. A. Silander, R. K. Kobe, and E. Ribbens. 1996. Forest models defined by field measurements: Estimation, error analysis and dynamics. *Ecological Monographs* **66**:1-43.
- Paine, R., T., M. Tegner, J., and E. Johnson, A. 1998. Compounded perturbations yield ecological surprises. *Ecosystems* **1**:535-545.
- Peterson, C., J., and S. Pickett, T. A. 1995. Forest reorganization: A case study in an old-growth forest catastrophic blowdown. *Ecology* **76**:763-774.
- Runkle, J. R. 1991. Gap Dynamics of Old-Growth Eastern Forests Management Implications. *Natural Areas Journal* **11**:19-25.
- Silvertown, J., and M. Dodd. 1999. The demographic cost of reproduction and its consequences in balsam fir (*Abies balsamea*). *American Naturalist* **154**:321-332.
- Sprugel, D. G. 1976. Dynamic Structure of Wave Regenerated *Abies-Balsamea* Forests in the Northeastern USA. *Journal of Ecology* **64**:889-911.
- Yavitt, J. B., J. J. Battles, G. E. Lang, and D. H. Knight. 1995. The canopy gap regime in a secondary neotropical forest in Panama. *Journal of Tropical Ecology* **11**:391-402.
- Young, T. P., and S. P. Hubbell. 1991. Crown Asymmetry Treefalls and Repeat Disturbance of Broad-Leaved Forest Gaps. *Ecology* **72**:1464-1471.