

HOW DO DISTURBANCE-GENERATED PATTERNS INFLUENCE THE SPATIAL DYNAMICS OF ECOSYSTEM PROCESSES?



MONICA G. TURNER ✦ DEPARTMENT OF ZOOLOGY
UNIVERSITY OF WISCONSIN ✦ MADISON

WILLIAM H. ROMME ✦ DEPARTMENT OF FOREST SCIENCES
COLORADO STATE UNIVERSITY ✦ FORT COLLINS

DANIEL B. TINKER ✦ DEPARTMENT OF BOTANY
UNIVERSITY OF WYOMING ✦ LARAMIE

✦ BACKGROUND

Our studies following the 1988 Yellowstone fires demonstrated that succession was surprisingly more variable in space and time than even current theory would have suggested, and that initial spatial patterns of disturbance may persist to produce long-lasting changes in vegetation. Our focus now is on explaining the spatial and temporal patterns of succession and understanding how these patterns influence ecosystem function. The most interesting new questions revolve around the degree to which the spatial variation in postfire vegetation in particular, the six orders of magnitude variation in pine sapling density, ranging from 0 to greater than 500,000 saplings/ha controls the spatial variability in ecosystem processes across the landscape. In our current research, we are conducting studies in both Grand Teton and Yellowstone National Parks to answer four major questions:

1. Does the spatial heterogeneity of processes such as ANPP, nitrogen mineralization, and decomposition change with time since fire? How quickly do spatial patterns in processes develop following a large fire?

2. How does the spatial pattern of coarse woody debris vary across the post-1988 landscape, and what is the importance of this variation for ecosystem function? Are patterns of coarse woody debris abundance related to both prefire stand structure and postfire sapling density?

3. Do the enormous differences in postfire tree density produce differences in carbon and nitrogen availability across the landscape? Or, is nutrient availability governed largely by broad-scale (i.e., 10 s of km) abiotic gradients (e.g., climate, substrate) and/or fine-scale (i.e., less than 10 cm) heterogeneity in resources or the microbial community, such that nutrient variability is not sensitive to the spatial variation in plant community structure?

4. Does the disturbance-created mosaic leave a persistent functional legacy? What mechanisms in vegetation development may contribute to convergence (or divergence) in ecosystem structure and function across the landscape as succession proceeds?

◆ FINDINGS AND STATUS

Studies in Grand Teton National Park

Question 1: We initiated field studies during summer of 2001 in ten 0.25-ha plots located within two fires that occurred during the summer of 2000: the Moran Fire, on the west side of Jackson Lake at the base of Mount Moran; and the Glade Fire, in the Rockefeller Parkway lands just south of the boundary of Yellowstone National Park. Within each of these fire sites, five study plots were established in areas of stand-replacing fire, three in crown fire and two in severe-surface burns. We are studying the development of postfire vegetation, sampling the number and species of tree seedlings and the percent cover (by species) of all other vegetation; the availability of inorganic nitrogen using ion-exchange resin that is incubated in the field for a year in small soil cores; the concentration of nitrogen in the vegetation of different species in the burned plots and adjacent unburned locations; and the presence and abundance of soil microbial functional groups. We are using a cyclic sampling design derived from spatial statistics and designed to detect the spatial scale of variation in nutrient availability, and we are remeasuring these sites through successional time. We are also estimating herbaceous aboveground net primary production and leaf area in these recently burned stands because we expect the rate of recovery of these processes to influence nitrogen and carbon availability. Changes in spatial patterns and in mean rates of all response variables were tracked through time by repeating the measurements in 2001, 2002, 2003, and finally in 2004.

We reported some preliminary results from this study in our 2003 annual report. We are now in the process of completing all of the analyses from 2001-2004, identifying the major spatial and temporal patterns, and preparing manuscripts for publication in ecological journals.

In 2003, we initiated a small fertilization study in the Glade Fire in which replicate plants of several target species received a modest fertilizer amendment. Plant growth was measured in 2004, and will be measured again in 2005 to determine whether there is a response to the treatment. Although nitrogen is considered to be limiting to vegetation growth throughout the subalpine forests of the Rocky Mountains, studies have not empirically demonstrated this limitation in early successional postfire forests.

Studies in Yellowstone National Park

Question 1. Fires again burned in the Yellowstone ecosystem during the summer of 2003. Previously, all of our measurements of nutrient cycling were begun at least on year following fire. To estimate net nitrogen mineralization rates soon after stand replacing fire, we initiated studies of nitrogen mineralization rates and vegetation in areas that burned during the summer of 2003. Three 0.25-ha plots were established in the East Fire (near the East Entrance Road in Yellowstone) in late September of 2003, and were paired with comparable unburned plots located east of West Thumb. These areas were re-sampled in early October, 2004, and data analysis is underway.

Question 2. All of the field studies related to this question were completed in 2004 (e.g., final collection of litter bags in stands of differing lodgepole pine sapling density). We provided some preliminary results in our 2003 annual report, and final data analysis is underway.

Questions 3 & 4. No additional field studies were conducted in relation to these questions in 2004. Final data analysis and preparation of manuscripts is underway.

◆ ACKNOWLEDGMENT

This research is supported by a grant from the Andrew W. Mellon Foundation. We greatly appreciated housing and logistical support provided by the UW-NPS Research Center at the AMK Ranch.