Landscape Analysis in Ecosystem Management: Modeling Process and Pattern

22551

by Steve Garman, Terrestrial Ecologist, Oregon State University

The following was presented in a BMNRI seminar in La Grande, Nov. 14. Videotapes of the talk are available through the Institute.

We will be looking at using pattern as a surrogate for disturbance and understanding the underlying disturbance mechanisms. Disturbance is a really important process across landscapes. It serves to increase the structural composition or heterogeneity of the landscape. For instance, fire maintains the high-elevation meadows in the Cascades. Windthrow creates structural diversity at a large extent ranging from a couple of meters to hectares. Flooding is an important disturbance process that maintains hardwood component. Biotic pathogens such as pine beetle create structural and compositional heterogeneity at the landscape level.

The functional significance of these disturbance processes are very important for wildlife species and a whole variety of ecosystem processes. Some species have adapted to early seral habitat and some have adapted to late seral habitat. We need both on the landscape to maintain the population of vertebrates. You can say the same about many different ecosystem processes and properties.

Natural disturbance and historical range of variability are basic to ecosystem management and sustainability issues today. The bottom line is if we can design our land use management schemes to fit within the frequency, severity, and size of natural disturbance, we will probably produce a much healthier ecosystem over the long term.

A working concept of this HRV (historic range of variability) of natural disturbance is the Augusta Creek Watershed analysis management system. This is a 7,600-ha watershed in the south-central Cascades. Researchers looked at scarred stumps to come up with the fire regime history. They went back 400 years in looking at the fire regime. Based on what they found, they came up with different zones: areas of infrequent and hot fires, areas of lots of fires of low severity. They used this as a template on which to base timber harvest schedules for the next 200-400 years.

We can't spend 3 or 4 years doing a really detailed study everywhere like we've done at Augusta Creek. In the future, I think we will do less field work because of the expense and because of improved GIS remote-sensing technology. You can get a lot of information from satellite and other remote imagery.

With this increase in remote-sensing technology, we are going to rely on pattern as an indicator of process. An example is the 1-m resolution map of the H.J. Andrews Experimental Forest. We can identify riparian zones by the presence of hardwoods. A more complex issue is the patterns created by fire or insects. The question is whether a process creates an identifiable pattern. Along with Gay Bradshaw, I began investigating the pattern-process interaction. We were interested in our ability to statistically document pattern as it relates to a particular process, and test whether the order of processes in a given area affects the resulting pattern.

We designed a spatial landscape simulation in a very simple system as a theoretical assessment of the question. We were interested in simplifying a complex problem. We used two disturbances to look at this question: wildfire, and Douglas-fir bark beetle infestation. These two are related by their association with coarse woody debris, yet they are not totally interdependent. The vegetation dynamics model was a simplified version of a process-based stand model. We were able to simulate the stand structure including snags and logs, the within-stand conditions of 0.1-ha cells (roughly 30m x 30m). It is a stochastic model, which means every cell can have a different species and size-class distribution, a different amount of logs and snags. We simulated a 200-year-old landscape as the starting point. We evaluated the amount of log mass in each of the cells and came up with the mean amount of log mass and then used that as a scaling factor in simulating the disturbances.

Our wildfire model was a spatial variant of the BEHAVE system. It spreads from cell to cell as a function of the amount of logs. You randomly select a location on the landscape where the fire starts. It moves according to the maximum rate and direction of spread, which are randomly selected. It will tend to form an elliptical shape as a function of log mass. Upper story mortality is dependent on the amount of log mass in a cell. The more log mass, the more the overstory trees are killed—the small ones first, the tall ones last.

The bark beetle would infest a cell if the cell exceeded a certain log mass criteria, which was part of the scaling factor. There also had to be a Douglas-fir stem greater than 60 cm. So we set up the interaction between the amount of coarse woody debris and the tendency of bark beetles to spread from that to live, large Douglas-firs and spread across the landscape as a function of the continuity of log mass of the large Douglas-firs. It is very far from a detailed, biological model of the spread of bark beetle.

We also imposed a drought condition. That affected the ability of the beetle to spread across the landscape. Under the no-drought situation, the beetle spread threshold of log mass was higher than for the drought situation. That was the system. It is fairly simple. We then designed a simple experiment with two levels of fire and beetle initiation and drought. The low level of fire was a single wildfire burning 10% of the landscape. The high level of fire was three wildfires each burning 30% of the landscape. Beetle attack was either one initiation or five initiations of beetle infestation. There were two levels of drought for 8 possible experimental combinations. Paired simulations were then done with either fire or beetle attack occurring first (at the same site of initial outbreak) making 16 possibilities. We

Continued on page 6

Mechanisms that Drive Bird Species Diversity in Yellowstone National Park

by Andy Hansen, Assistant Professor of Biology, Montana State University

The following was presented in a BMNRI seminar in La Grande, Dec. 5. Videotapes of the talk are available through the Institute.

The Greater Yellowstone Ecosystem is Yellowstone National Park and the surrounding Federal land. The term was originated by Frank and John Craighead to describe the range of the Yellowstone grizzly bear, but it has evolved to denote places of strong linkages between ecological and human communities. "Greater ecosystems" are characterized by nature reserves and gradients in land use that radiate out from them. We often think of them as the last refugia for native species. These places are growing very rapidly in human population. How is that type of human population growth influencing the ecology of these greater ecosystems?

If we can understand relations between abiotic factors and biodiversity and human settlement patterns, we can come up with better management strategies that will sustain both ecological systems and human systems.

Colleagues and I have been trying to understand what drives patterns of bird diversity in the Yellowstone system. We've focused on the effects of natural disturbance and logging on landscape structure. We've considered how both of these as well

Continued on page 7

Landscape Analysis...

Continued from page 5

had five replications of each for a total of 80 simulations.

The important thing to remember is that we have a big disturbance that is occurring either once or multiple times under either mild or severe conditions (drought and amount of dead logs). The property of these disturbances is what we are emphasizing, it is not intended to be a true simulation of wildfire and bark beetles.

For the detection of the pattern, we used a couple of simple metrics. The spatial metric "nearest neighbor" and "total edge," which is simply the circumference of a patch. Those are fairly easy metrics you can get from the FRAGSTATS software. Through remote sensing, we determined "total mean basal area." We wanted to determine the ability of spatial and non-spatial statistics to differentiate between ecologically different processes and the temporal ordering of those processes. The pixels we used were 0.1 ha. The cover categories were >50 sq m per ha (meaning it is old growth), 10-50 sq m, and <10 sq m. This is the initial landscape with a low-intensity wildfire. The pattern generated was a function of the amount of log mass on the site. We based our patch metrics on the 3 patch types, which were a function of the underlying log mass. A patch is a set of adjacent or diagonal cells of the same type. So we simulated the condition to form the patches and then used spatial metrics to describe the patterns. Various programs can be used to perform the patch assessment.

We formed the pattern for a single wildfire and then added the single bark beetle outbreak to it. This gave a very different pattern than forming the bark beetle pattern first and then adding the wildfire. We found that the order not only affected the intensity of the process but the distribution of the processes across the landscape and the resulting connectivity.

What we learned was:

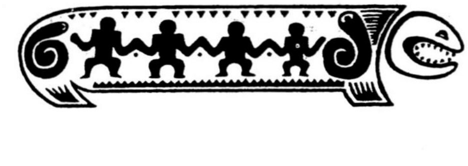
1. The ecologically similar disturbance (same type, same intensity and frequency, same ordering) can give us some visually very different landscapes depending on the random location.

2. When the fire occurs first, the area of overlap with the second disturbance is homogenized. The fire predisposes the landscape by creating more debris so that the bark beetle is more able to propagate. It doing so, it reduces the amount of basal area, decreases the amount of edge, and increases the distance between patches of similar type. This is consistent regardless of the number of initial fires. With multiple fires, the metrics could distinguish between the temporal ordering of the disturbance types. Under the low severity conditions, our metrics could not distinguish the order of the disturbance types. But, there are some thresholds within which, we can tell the difference in the process and order by looking at the resulting pattern.

This method of identifying process from pattern doesn't always work. I think you can appreciate the simplicity of our simulations. We have simplified the complex process and basically have come up with a hypothesis: there are conditions in which very simple pattern metrics can tell us something about underlying process, but not always. We need to know how to do that.

The resolution of the data makes a difference in the conclusions you reach. The resolution should match the size of the disturbance you are interested in. There are many patch and landscape metrics you could use other than the three we used. They fall into three groups: shape, extent, and connectivity. You have to be careful in choosing the metrics for your assessment to see if the result makes sense. Check them by generating some landscape patterns that are obviously different and see how well the chosen metric reflects that difference.

My intention is to give you some insights about how to use GIS and remote sensing technology and use pattern as a surrogate for disturbance processes. Do some ground measurements and compare those with remote sensing to see how well you can fit the disturbance processes with a particular pattern. Choose a scale that is appropriate to the process you are examining. Be careful in choosing the metrics you use in describing the pattern on the ground. Some of them seem to correspond to the images you get, and some don't. Develop correlates with your pattern and then test it in another area.❖



Natural Resource News

Putting Science to Work!

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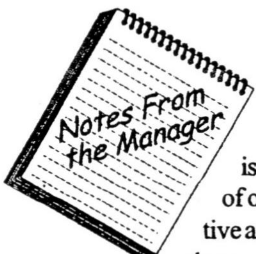
Landscape Ecology and Management Topics Seminars

The fall seminar series was presented by BMNRI at the Forestry and Range Sciences Lab as a series of brown-bag lunches. Topics included assessment of broadscale land use effects on fishes, modeling process and pattern relations from remotely sensed data, and factors that drive bird species diversity. Text of the talks by Danny C. Lee, Bruce E. Rieman, Steve Garman, and Andy Hansen is presented in this issue. The talks were videotaped and are available for loan through the Institute by calling (541)962-6525.❖

"Putting Science to Work"



You've probably noticed that this issue of the Natural Resource News looks quite a bit different than past issues. We're adopting a new look to all of our products to make them more distinctive and attractive. We've also adopted a new slogan at the Blue Mountains Natural Resources Institute, "Putting Science to Work," that we believe captures the main concept behind the Institute. Putting science to work is really what the Institute is all about. The Institute strives to effectively use existing scientific knowledge to help solve natural resource problems in the Blue Mountains. When that knowledge doesn't exist, we conduct our own applied research to fill the knowledge gaps. You'll be seeing our new look and slogan on more and more of our products.

I hope you enjoy this issue of the Natural Resource News. It provides you with the text of this fall's seminar series on landscape ecology and management, as well as articles related to the upcoming release of the ICBEMP products. This issue also provides updates on other Institute activities, the activities of both Institute Initiatives, a list of available back-issues of Institute products, and a calendar of upcoming events.

I have been doing a lot of traveling in Oregon and Washington this fall, trying to get better acquainted with the many partners and collaborators of the Institute, and updating folks on the Institute's activities and plans. I've learned just how big 19 million acres is, and am beginning to learn how many people are supporting the Institute's activities! One highlight for me this fall was conducting a "Blue Mountain Video Marathon" at the Forest Service Pacific Northwest Station and Region head-

Continued on page 3

Inside This Issue

***Blue Mountains Natural Resources Institute Goal:** To enhance the long-term economic and social benefits derived from the area's natural resourcesin a way that is ecologically sensitive and sustainable*