

MONITORING CHANGES IN EXOTIC VEGETATION

Robert D. Sutter
Director of Biological Conservation
Southeast Regional Office
The Nature Conservancy
Chapel Hill, NC 27515

Ecological monitoring provides critical information for management decisions by measuring changes in managed and unmanaged populations, communities and ecological systems. It integrates ecology, goal and objective setting, sampling design, sampling methods, and statistical analysis. It is a topic that I, with a team of Nature Conservancy ecologists, teach in a six day workshop as part of the USFS Continuing Education Program. It is attended by land managers from public agencies and The Nature Conservancy. Here I will provide an overview of the most important monitoring issues, modified to address the management of exotics. I have subtitled the presentation **The 7 Habits of Highly Effective Eliminators of Exotic Vegetation**, borrowing from the title of Stephen Covey's (1989) bestseller.

1. Choose Your Battles Wisely. Exotics make up a large percentage of the species diversity in each state (Rejmanek and Randall 1994) and most land managers manage sites that have numerous exotic species. It would be overwhelming and impossible to attempt to eliminate or control all exotic species at a site—there is not enough funding, expert personnel, and time. This requires that exotic species be prioritized for control and subsequent monitoring.

Prioritizing control effort involves examining the biology and distribution of exotics to identify criteria that reflect their invasiveness. A ranking system that uses an analytical approach has been developed by Hiebert and Stubbendieck (1993). Invasive species:

- 1) alter ecosystem functions. Examples include species that either reduce or increase fire likelihood or intensity or that alter the water table or hydrologic regime;
- 2) become established in undisturbed natural communities;
- 3) outcompete native species after natural disturbance; and
- 4) prevent or depress the regeneration of native species.

Species that have low invasiveness, and thus low priority for management and monitoring, are those: 1) whose numbers are stable or decreasing, 2) that colonize only disturbed areas and do not move into undisturbed habitats, and 3) that will be controlled or eliminated with natural succession or re-establishment of natural processes (especially restoration of fire or hydrologic regime).

The assessment of exotics needs to be framed within the context of the ecological communities they have invaded. Higher priorities should be given to exotics which occur in rare or relatively undisturbed ecological communities.

The feasibility of controlling or eliminating exotics also needs to be factored in before management actions are initiated.

2. Follow the Latest Paradigm. The word paradigm is being overused in the ecological literature. The concept of the word, however, is very important. It means the assumptions one uses when viewing, explaining, and understanding the world. It is our current frame of reference. The current ecological paradigms greatly influence the way we approach the management of natural resources.

This current ecological paradigm includes the following concepts:

- **Biological Diversity** - the concern of conservationists is shifting away from an emphasis on single species management to one of managing ecological communities to protect all native species. For exotic management this means equal concern should be given to restoration of native diversity as to the removal of the nonnatives.
- **Natural Processes** - the role of natural disturbance regimes has been recognized as one of the most important determinants of species composition and community structure, with the role of management to mimic these natural processes. For exotic management, the native natural processes should be assessed in the management of exotics. Using natural processes to control exotics assists in the restoration of the ecological community (Pollak and Kan, in prep). Management regimes using natural processes may also be the most resource efficient.
- **Spatial Scale** - the role of spatial scale is important in understanding the dynamics of populations (metapopulations, dispersal, viability), the patterns of species richness and the dynamics and patterning of natural processes.
- **Temporal Scale** - the role of temporal scale is important in understanding population dynamics and natural processes. This has resulted in longer time-frames to explain population and community changes and a shift to longer-term management and monitoring.
- **Interconnectedness/Interrelationships** - a greater awareness that there are more connections out there than you can guess and that management should consider trophic relationships, predator-prey relationships, soil fertility, hydrologic regimes in watersheds, acid deposition, etc.
- **Low Predictability** - the complexity of natural systems makes it difficult to predict future events or conditions. This is why adaptive management is so important, that we monitor our management rather than relying on ecological assumptions.
- **Human Impact** - is more insidious than we have previously thought, impacting natural communities at many temporal and spatial scales through direct and indirect means. Managers of exotics already know this.
- **Humility** - that nature and the management of any site is more complex than we currently understand. Humility is the primary value behind adaptive management.

3. Begin with the End in Mind. What are your expectations for management and how you define success? For the control of exotic species, as it should be with any adaptive management project, it can be summarized in two questions: What is your management objective? and What is your monitoring objective?

Management Objective: What is your vision of what you want the site to look like after management? Is the exotic species eliminated? Are all exotic species eliminated? What does a controlled population of an exotic species look like? The answers to these questions are determined by the biology of the exotic species, the resources available to the land managing agency, and characteristics of the ecological community.

Monitoring Objectives are specific and quantifiable. They address what is measured (what species, group of species, communities, environmental parameters), where it is measured (defines the sampling universe, are the measurements going to take place throughout the whole Smoky Mountain National Park or just within the Little River drainage?), what methods will be used (point intercept for cover, photopoints), the frequency of measurements, and the precision of your measurements.

The concept of precision in monitoring deserves additional discussion. Precision is the closeness of samples to one another. (Accuracy, on the other hand, is the closeness of samples to the true value, a value we rarely know.) Estimates of precision are communicated by confidence intervals or a measure of variability, such as the standard deviation.

Two examples of monitoring objectives with their stated precision:

For estimating a population parameter: The monitoring design will be able to detect a 20% change in the population density of exotic species *X* in a specific natural area between 1997 and 1999 with 90% confidence.

For detecting change over time: The monitoring design will be able to detect a 20% decline in the density of exotic species *X* in a specific natural area between 1997 and 1999, with 90% certainty that the change will be detected if it occurs (power) and a 10% chance of concluding a change took place when it did not (false-change error or Type I error rate).

4. Design For Precision. Monitoring does not always involve sampling. In many cases one can count or measure all the individuals within a population of interest. When your population of interest is too large to measure everything, then one needs to sample. Sampling is the process of selecting a part of something with the intent of showing the quality, style, or nature of the whole. The role of sampling is to provide information about the population in such a way that inferences about the total population can be made. This inference is the process of generalizing to the population from the sample, usually with some measure of how good the generalization is (its precision).

The precision of sampling is determined by the sampling design. Sampling design is the selection and spatial arrangement of sample units used to measure specific variables in a population, community, or ecosystem. The sampling design used in a monitoring study should maximize the ability to distinguish real changes, trends, or differences from random variation. Many sampling design decisions appear to be made arbitrarily, uncritically, or by following general sampling procedures. These decisions should be made with the precision of the data in mind.

There are six major sampling design decisions one makes when developing a monitoring study (Sutter 1996). These decisions involve determining:

- the sampling universe: the population, community, or area of biological interest to which inferences are to be made;
- the placement of sample units (plots, lines, individuals) within the sampling universe, randomly of course;
- the selection of sampling units, either individuals, points, lines, plots;
- the selection of permanent or temporary sampling units;
- the sampling frequency; and
- the number of samples that need to be collected.

The following equation illustrates the relationship among sampling components that influence the level of precision.

$$\text{Power} = f(\alpha, ES, n, \sigma^2)$$

where: Power, the certainty of detecting real change, is a function of alpha, effect size (your desired precision as minimal detectable change), sample size, and the variance.

What can you control as you design your monitoring study? You can control the number of samples and the effect size you would accept, and you have some control over variability in the way you define your sampling universe and with the placement, permanency, and shape and size of the sampling unit.

5. Use Methods to Avoid Madness. There are numerous sampling methods one can use to monitor changes in exotic populations. One can ask several questions to help determine which methods to use.

1. Which level of monitoring is appropriate?

- Qualitative or Semi-quantitative Monitoring: quick, inexpensive monitoring that has a significant subjective component, is observer-dependent, provides data that can not be statistically analyzed, and can only detect changes that are dramatic. Includes the following methods: mapping of populations, presence/absence of population or plants, estimates of individuals, estimates of cover, and photomonitoring.
- Quantitative Monitoring: repeatable, analyzable, but usually does not address changes in individuals, and is time-consuming and expensive. Includes measures of individuals, cover, or frequency in sampling units.
- Quantitative Age or Stage Class Monitoring: or demographic monitoring, the strengths of quantitative monitoring with more data on individuals and the biology of the species, greater predictability, but very time consuming and expensive. Includes following individuals over time to assess their life history characteristics and obtain demographic parameters (survival, mortality, fecundity) of the population.

In reality, one mixes methods from two or more of these monitoring levels. One can map the location of an exotic species at a site, establish permanent photopoints, and quantitatively measure cover in permanent plots. See Menges and Gordon (1996) for more information on levels of monitoring.

2. What specific parameters are best to be monitored?

- Abundance Parameters: numbers, density, cover, frequency.
- Condition Parameters: measures of vigor, performance, fecundity.
- Structure Parameters: size or age class information.

The parameters one chooses is determined by the biology of the species and the management objective. Exotics that occur as discreet individuals can be counted, while rhizomatous species are best measured by cover. Frequency measures are probably the least useful for exotics, since complete elimination is difficult. Measures of condition are important when the process controlling an exotic species will take a long time and benchmarks are needed for short-term assessments (vigor measurements such as for plant height or reproduction).

6. Adapt Accordingly. Any management action is an experiment. We rarely know the exact results from managing natural resources. This uncertainty and the complexity of natural systems requires an adaptive management approach. Manage, and then monitor and evaluate the results. If the results are not meeting the management objectives, adapt the management or alter your management objectives.

7. Patience. The Zen of exotics management: controlling exotics is like planting a tree, it may take several generations for it to bear fruit. So in the mean time, do effective management and good monitoring. Do what you can so that fruit is born, or maybe better said, fruit will not be born for future generations.

REFERENCES

- Covey, S.R. 1989. *The 7 Habits of Highly Effective People*. Fireside: New York.
- Hiebert, R.D. and J. Stubbendieck. 1993. Handbook for ranking exotic plants for management and control. National Park Service, Midwest Regional Office, National Resources Report NPS/NRMWRO/NRR-93/08.
- Menges, E.S. and D.R. Gordon. 1996. Three levels of monitoring intensity for rare plant species. *Natural Areas Journal*. 16(3): 227-237.
- Pollak, O. and T. Kan. In prep. The use of prescribed fire to control invasive exotic weeds at Jepson Prairie Preserve.
- Rejmanek, M. and J.M. Randall. 1994. Invasive alien plants in California: 1993 summary and comparison with other areas in North America. *Madrono* 41(3): 161-177.
- Sutter, R. 1996. *Monitoring in Restoring diversity, strategies for reintroduction of endangered plants*. Edited by D.A. Falk, C.I. Millar, and M. Olwell. Island Press: Covelo, CA.