Chapter 3 - Ecological Goals and Indicators

The first aim of ecosystem management should be "Do no harm," and only through monitoring can we assess whether restoration practices are really creating the desired conditions in the forest. Ecological monitoring of restoration projects is needed to find out if the project treatments are helping achieve improved forest conditions.

This chapter describes common forest restoration goals and provides indicators that can be used to monitor progress toward those goals.

Ecological measurement methods are discussed in Chapter 5.

Choosing ecological monitoring goals and indicators

The ecological variables a group chooses to monitor will depend upon the objectives of its restoration project. Each project will have a unique forest site and restoration goals that reflects the values of its surrounding community and community of interests.

A number of publications are available that describe how to choose ecological monitoring approaches and variables. These publications can also help explain monitoring methods and provide guidance for interpreting the information collected in the monitoring effort.

- *Monitoring Plant and Animal Populations*, by Elzinga and others, describes monitoring design and implementation for a wide range of ecological variables.
- Methods for monitoring of wildlife are presented in Morrison and Krausman, *Wildlife Restoration: Techniques for Habitat Analysis and Animal Monitoring*.
- *The Once and Future Forest* (1998), by Sauer, describes the entire process of multiparty monitoring for community restorations of natural ecosystems.

For Collaborative Forest Restoration Program projects in ponderosa pine forests, projects need monitoring to ensure that the two primary ecological objectives of the work are being met:

- A reduction of the threat of destructive crown fire, and
- A restoration of forest ecosystem integrity.

Each community will want to choose a set of monitoring variables that are most useful for their particular project. Some indicators are more easily measured and give a more rapid overall picture of the effect of restoration treatments. These indicators are more cost-effective—yielding useful data that provides information about more than one restoration goal. These indicators are:

- tree density and stem area
- density of large trees
- height from ground to tree crown
- understory plant species % cover and % bare ground
- snag density and stem density
- surface fuels characteristics

Communities may want to consider using these six measures and adding other indicators to tailor their monitoring to other needs and concerns. If all restoration projects in the region measure these indicators, we may develop a common basis for understanding what is happening in ponderosa pine forests across the region.

Goals, Indicators and Measures

The following sections provide detailed descriptions of sample ecological monitoring goals and indicators. In addition to the indicators listed below, photographs taken of the site at permanent points, before treatments and at intervals after treatments, can give a very useful impression of how conditions are changing in the forest. Methods for repeat photography at permanent points are described in the Riparian Community Health section in Chapter 5.

1. Goal: Reduce the threat of large, high-intensity wildfire, create conditions conducive to low-severity fires, and re-establish low intensity surface fire regimes.

Rationale: Southwest forests have changed dramatically in the last century. As fires have become less frequent on the landscape, many changes have occurred, including increased tree density, especially of small trees, changes in tree species composition, more continuous tree canopies, and the encroachment of trees into meadows. Many of these changes increase the risk of high-intensity wildfires as well as having other ecological effects.

A primary goal of restoration is a reduced threat of crown fire, the type of intensely hot fire that moves rapidly through the tree tops and causes widespread tree mortality. Several forest structural attributes are good indicators of fire behavior and an increased probability of both crown fire and surface fires. These structural attributes include the number of trees (e.g., tree density), how close together their crowns grow (e.g., canopy closure), the height from the forest floor to tree crowns, and the amount of fuel on the forest floor.

An equally important goal of restoration is the restoration of low-intensity surface fires in the forest understory. Without successful reintroduction of surface fires that occurred naturally in southwestern ponderosa pine forests, many of the positive ecological changes brought about by various treatments will be short-lived, since new fuels will continue to accumulate. Fire can be reintroduced through prescribed burning or natural ignitions, depending on the landscape setting and proximity to a wildland-urban interface. (See Overstory Sampling in Chapter 5 for measurement methods.)
Indicators:

- **Tree stem density and area**. The number of trees per acre, or *stem density*, influences the probability of active crown fire. Many small stems serve as fuel for fires and a high number of small trees can influence the intensity of fires. The release of heat from the burning trees can damage plants and soils. The total ground area covered by tree stems is another indicator of the probability and intensity of active crown fires. Both stem density and area are important indicators for implementation monitoring of thinning projects.

- **Canopy closure**. The amount of shade that trees provide, measured as percent canopy closure, is an index of the continuity of the tree canopy. High levels of canopy closure also increase the probability of active crown fire through the spread of fire from tree crown to tree crown.

- **Height from the ground to tree crown.** The distance from the forest floor to the base of the live tree crown influences the probability of a surface fire spreading into the canopy. Greater distance to the limbs and foliage of the tree means greater distance between surface and canopy fuels. The greater the height, the less likely it is for surface flames to spread into the canopy and become an active crown fire.

- **Surface fuels cover and depth**. Needles, litter, duff, grasses, and herbs in the understory and on the surface of the ground provide fuel for fires. The percent cover of these surface fuels influences the probability and rate of spread of a surface fire. Greater surface fuel cover increases the probability that a low-intensity fire will be able to burn throughout a stand. Fuels also influence the rate of spread and intensity of a surface fire, as well as the probability of a fire spreading from such fuels into the canopy. Surface fuels need to have enough depth to carry a surface fire, but not so much depth that fires are carried into the crowns of trees. Several systems have been developed to describe surface fuels, and the system of the National Wildfire Coordinating Group provides a photo series for easier identification (NWCG 1997). The series provides a basis for quantifying and describing changes in surface fuels.

- **Spatial distribution of canopy closure and canopy breaks.** Canopy openings in the forest are a natural feature of ponderosa pine forests, though they have been reduced in size in many densely stocked forests. Clumpiness (clumps of trees growing relatively close together, interspersed with open areas) in the forest is also a natural feature with many ecological functions. This mixed structure of clumps of trees and small openings helps deter the spread of crown fire and is beneficial for certain wildlife species, yet it is time-intensive to measure.

2. Goal: Preserve old and large trees, both living and dead.

Rationale: Old and large ponderosa pine trees have a disproportionately high ecological value due to their relative scarcity, high canopy volume, and diverse structural attributes. Large dead standing trees are also important for the habitat they provide for wildlife. Tree rings contained in old trees are an important scientific resource revealing historical climate patterns, fire histories and ecosystem dynamics. (See Overstory Sampling in Chapter 5 for methods).

Indicator:

- **Density of large trees, old trees, and large dead trees**. Old ponderosa trees can be identified by either the presence of yellow or yellowing bark or age greater than 120 years. The limbs are often heavy and twisted, with flattened crowns with gnarly branches at the top. Large trees need to be defined within the context of the stand in which they occur, for example, the largest 10% or 20% of the trees in the project area. For projects smaller than about 10 acres, or where large or old trees are rare, a complete census of all large, old, and large dead trees should be conducted.

3. Goal: Enhance Native Plant Populations and Reduce Invasive, Non-Native Plant Populations.

Rationale: The native grasses and forbs in ponderosa pine forests are an important part of the forest ecosystem. Much of the biodiversity of the forest is contained within this understory plant community. Understory plants provide food and cover for microorganisms, insects, small mammals and other wildlife, protect the soil surface from erosion, and provide forage for grazing animals. Restoring these functions is an important part of forest restoration.

Another crucial function for understory plants is their contribution to fuel levels. When grasses and forbs are dry, they burn readily, and enable fires to burn on the forest floor. Without sufficient understory vegetation, fires will not spread and will not perform their natural functions to kill overabundant seedlings and small trees. For these reasons, a healthy, native understory plant community is an important restoration goal.

Invasive, non-native plant species can change the structure, function, and species composition of the forest understory. For example, the non-native cheatgrass (*Bromus tectorum*) may displace native species because it uses soil moisture early in the spring before native plants are actively growing. Once cheatgrass achieves a dense enough cover it can change the timing of surface fires so that the fires occur when native grass and forbs are actively growing and are more vulnerable to injury. Cheatgrass is not preferred forage for grazers, and it may be less able to protect the soil surface from erosion because it is a shallow-rooted annual.

Because invasive, non-native plant species may have negative effects on desired native plant species both directly through competition for space, light, water, and nutrients, and indirectly through changing the timing of fire, the containment and control of non-native plant species is an important restoration goal. (See Understory Sampling in Chapter 5 for methods).

Indicators:

- **Understory plant species cover.** Species cover is a measurement of the amount of ground surface covered by a particular species within a small area (usually 1 square meter). The amount of cover can be calculated for each species, or by groups, such as (1) grasses, (2) forbs, (3) sedges, and (4) shrubs. At the same time that plant cover is measured, it is possible to simply note the amount of the sampling area not covered by plants or small branches. The percent of the ground that is bare is an important indicator for understanding how much soil erosion may be happening.

- **Understory plant species richness.** Species richness is a count of all the plant species found in a given area. Species richness can be measured by making a list of all the species identified in plots and counting the number of species listed. It is important to distinguish between native and non-native species.

4. Goal: Conserve wildlife populations and their habitats.

Rationale: There are two primary goals of restoration with respect to wildlife, depending on the type of project implemented. For projects specifically designed to restore habitat for wildlife, the goal is to create conditions that ensure viable populations of native animal species. This includes restoring habitat for species that have been adversely affected by past management practices. For projects in which wildlife habitat is not the primary consideration, the goal is to minimize undesirable impacts on wildlife populations. Special attention should be given to species that are sensitive to treatments that change forest structure and composition.

Wildlife monitoring may best focus on indirect methods to monitor restoration effects on wildlife. These indirect measures include 1) the use of surrogate species, such as indicator, keystone, umbrella species, to represent other target species; 2) the use of habitat conditions as an index of population status; and 3) the use of various indices, such as browse, scat, feeding cones, and mast crop. Mast is fruits, seeds, and nuts, typically from woody plants, that are highly valued food for one or more wildlife species.

Habitat attributes can be measured to assess how suitable the site is for wildlife. For example, large trees are an important habitat attribute for many wildlife species. Large trees are used by

Goshawks; they provide nest, perch, and forage sites for songbirds; they are used by wild turkeys for roosts; they provide nest sites, food, and cover for squirrels; they provide nest and roost sites for Mexican spotted owls; and they provide feeding sites for bark-foraging birds. When they die, large trees become large snags, which provide the dead wood needed for cavity-nesting birds. *Witches broom*, a clump of brushy twigs in ponderosa pine trees that results from infestation by dwarf mistletoe, is used extensively by wildlife. Furthermore, some wildlife benefit from cover, crown continuity, interlocking crowns, and root structure support of large trees.

Dense clumps of trees, whether large or small in diameter, are important for wildlife habitat. Clumps of young smaller trees provide cover for bears, turkeys, deer, and elk. Clumps of trees of various sizes and ages ensure future clumps of large and old trees.

Cover by grasses and forbs is another important habitat attribute for many species. Grasses and forbs provide food and cover for numerous species of small mammals, ground-foraging and ground-nesting birds, elk, deer, and nectar feeding birds and moths. In addition, mast-producing woody plants, including oaks, junipers, pines, other hardwoods and shrubs provide food for numerous seed, nut, and fruit-eating species. Oaks also tend to have cavities, even when alive, that provide nesting sites for numerous species. (See Appendix section on Wildlife Sampling for methods)

Indicators:

Bird relative abundance and species richness. Birds are relatively easy to observe directly and indirectly (through song), compared to other wildlife species. Groups like the Audubon Society take an annual bird census and have developed reliable methods for measuring abundance and species richness

- **Wildlife presence indices.** Wildlife leave behind clues that they were in the forest, such as scat, pellet groups, tracks and other evidence. This evidence is an important indicator of wildlife presence.
- **Habitat attributes.** If forest habitat is suitable, there is some chance the wildlife species will be present or will choose to move in. The following is a list of eight habitat attributes, including some that were previously described in this chapter (referenced by the goal section in which they occur).

    - **Snag density**, which supports cavity-nesting and cavity-roosting wildlife (goal 2)
    - **Downed woody debris abundance**, which provides habitat for small mammals and reptiles (goal 1, surface fuels)
    - **Large tree density**, for the nesting, perching, roosting, and foraging sites they provide, as well as the cover, crown continuity, interlocking crowns, and root structure support they offer (goal 2)
    - **Clumps of old and large trees** provide habitat for numerous species to perform the functions above, and to support a higher number of each species (goal 1)
    - **Clumps of young smaller trees**, which provide cover for numerous species and may develop into future clumps of large trees
    - **Forest openings**, which provide habitat for selected species. Grass and forb cover, which provides food and cover for numerous species (goal 3)
    - **Density of Mast-producing woody plants** (oaks, junipers, pines, other hardwoods and shrubs), and their percent cover, which indicates that food is available for numerous species (goal 3)

5. Goal: Conserve soil resources.

Rationale: Soils form the basis of ecosystem productivity and watershed health. It is therefore important to monitor changes in soil conditions. When soils are exposed to prolonged, high-intensity fires or are disturbed by compaction or displacement, they are more likely to be invaded by non-native plants, be less hospitable for tree seedling establishment, and to yield higher, quicker water runoff.

Soils are the foundation for the forest and the ecosystem as a whole. Soil resources include soil nutrients, microbes, mycorrhizal fungi, cryptogamic crust, roots, seeds in the soil, invertebrates, wildlife, and homes for a variety of animals. (See Soil Conditions Sampling in Chapter 5 for methods)

Indicators:

- **Surface bare soil**. The amount of bare soil is a good indicator of potential for accelerated soil erosion. It is possible to determine whether the potential for soil erosion has increased or decreased by monitoring this indicator.

Soil loss from small watersheds. Some projects may encompass a small watershed basin or be located at the head of a larger basin. In these circumstances, it is possible to monitor sediment yield to assess changes in soil erosion rates and watershed effects. This is an especially useful indicator if the soils are naturally prone to erosion, the ground cover is already sparse, or the planned treatments are on steep slopes or otherwise have potential to accelerate soil erosion.

- **Soil compaction.** Compaction can limit the amount of water that can infiltrate into the soil. When this happens, water that trees and understory plants need will runoff before it can be absorbed. Compaction can also make the soil so hard that roots have difficulty penetrating and can hold back activity of microorganisms that create healthy soil.

6. Goal: Conserve and protect watersheds.

Rationale: The term ‘watershed’ implies an area or scale larger than the forest stand, which is the scale at which most indicators in these guidelines are measured. It is sometimes possible to miss the larger ecological picture if we focus only at the scale of the forest stand. Certain indicators can be measured that integrate over the landscape scale. One of those indicators, riparian community health, can be fairly easily sampled in order to give insight into processes happening at the landscape scale.

Indicators:

Riparian community health. The plant growth alongside streams, called the riparian community, is often very different from plants in the drier forest area, and it is especially important to wildlife communities. Riparian communities are especially rare in the Southwest, where water is scarce. Often the only available water in the landscape is found here. At times during the year, some streams in riparian communities can go dry, but even if they do not have flowing water, these communities are important and should be monitored. One of the simplest but most useful monitoring techniques for tracking change in the riparian community is to take photographs before treatments and at intervals after treatments.