## Natural Resources and Environmental Issues

Volume 5 *Ecosystem Management of Natural Resources in the Intermountain West* Article 15

1-1-1995

# Ecosystem management: a framework for management of our National Forests

Christopher D. Risbrudt
*USDA Forest Service, Northern Region, Missoula, MT*

# Ecosystem Management:

## A Framework for Management of Our National Forests

***Christopher D. Risbrudt***
Deputy Regional Forester
United States Department of Agriculture
Forest Service, Northern Region
P.O. Box 7669
Missoula, Montana 59807

***Abstract***

*The USDA Forest Service has altered its traditional method of land management to include the concept of ecosystem management (EM) while not discounting or changing its mission for multiple use. It requires that ecosystem considerations be factored into every aspect of natural-resources management.*

*EM incorporates concern for biodiversity, and application of ecosystem and landscape concepts in resource management. It increases use of scientific knowledge in the management of natural resources, and an understanding of processes that cause change and how they affect and are affected by the activities of people. Demands placed on ecosystems by man have been significant and have changed the landscape, some recently, others over centuries. EM responds to human dependance on ecological systems by insisting that ecosystems be kept resilient and capable of recovery after disturbance.*

*Understanding landscape dynamics and ecological processes is key to EM planning efforts. It is necessary to understand how ecosystems are arranged spatially on the landscape and how they are connected—how materials and energy flow between them and how one ecosystem influences another.*

*Photosynthesis by green plants drives all ecosystem processes. Accumulation of biomass on the landscape through the 20th century and fire-management policies have caused a problem in the Northern Rockies. Success of the Forest Service in firefighting has resulted in a disturbance regime unlike what forest species adapted to over the past 10,000 years. As a result, forest composition and structure in the Northern Rockies, and associated fuel patterns, have changed. The ecological consequence is that fires can have a dramatically different outcome than they did prehistorically. With fewer fires and increased fuel loads since settlement, fires now have a more devastating effect on the landscape.*

*Key to EM is conserving biodiversity. The approach selected by the Forest Service is a multi-faceted strategy that emphasizes managing regional-level landscapes within natural system variation. Managing ecosystems and landscapes, conserving biodiversity, and producing goods and services for mankind requires that land managers analyze ecosystems at much broader scales to achieve these goals. The more landscapes are kept near or at their range of natural variability, the greater the potential for maintaining sustainability.*

*The only way to achieve an understanding of ecosystems and gain acceptance for this style of management is with a team approach, where everyone has an opportunity to understand and participate in the development of EM strategies.*

### INTRODUCTION

Although ecosystem management (EM) may not yet be a commonly understood concept by the public, it is having a significant impact in government circles. The President of the United States talked about EM in his Forest Plan for the Pacific Northwest. The Forest Service has adopted it to guide the agency in its management of national forests and grasslands. Since the Forest Service administers 191 million acres, making it the second largest federal land manager after the Bureau of Land Management, EM is making its influence felt.

EM does not change or discount one of the principal missions of the Forest Service, which is management of land for multiple uses. The difficulty for land managers has been choosing which uses and values to favor and which values to limit. Clearly, the national forests cannot accommodate all demands from the public at the levels desired, nor can it be expected that public demands will remain the same. Society's expectations are changing, with greater insistence that ecosystem considerations be factored into every aspect of natural-resources management.

In response to these changing needs and demands, the Forest Service has adopted the EM approach to provide a stable foundation for management based on sound ecological principles. This framework for management refocuses on the "sustainable" part of the Multiple Use, Sustained-Yield Act which became policy for the regulation of national forests in 1960. There is a greater emphasis on decisions with a view to the future, promoting sustainable production over the long run. This approach recognizes the limitations in short-term solutions at the expense of long-term sustainability. It is an approach to land management that places the productivity of resources in the context of desired conditions for ecological systems.

EM incorporates management for biodiversity and the application of ecosystem and landscape concepts toward resource management. It requires not only the increased use of scientific knowledge in the management of natural resources, but an understanding of the processes that cause change and how they affect, and are affected by, the activities of people.

## A DIFFERENT APPROACH TO LAND MANAGEMENT

Human cultures have developed within ecosystems and are sustained by them. People have impacted all ecosystems. Some impacts are recent, others have endured for centuries. The long-term well being of humans depends on sustainable ecological systems, requiring that we keep them resilient and capable of recovery after disturbance. Because of the dependence of the world's population on ecosystems for survival, and because of the agency's Congressional mandate concerning multiple-use, the Forest Service does not manage ecosystems for the sake of the ecosystems alone. Ecosystems are managed to produce the goods, services and values people need. Under ecosystem management, land managers will still provide opportunities for recreating, grazing livestock, harvesting trees, and all the other uses of the national forests and grasslands.

The key differences between EM and more traditional management are: (1) understanding the dynamics of natural systems; (2) assessing and managing at various temporal and spatial scales; (3) a strategy for conserving biodiversity; and (4) more consideration of ecological functions.

One of the first problems faced by land managers is defining an ecosystem. Simply, an ecosystem is a community of organisms and its environment that function as a whole. Forests are ecosystems, but so are ponds, rivers, rotting logs, rangelands, whole mountain ranges and the planet. Ecosystems occur at many scales, from micro sites to the biosphere. Ecosystems include interdependent plants, animals, people, the physical environment, and the ecological processes that link them.

Forest Service managers have traditionally looked site-specifically at stands and timber compartments. They have followed the scientific process of breaking large problems down into small, understandable ones. In making our decisions at the smaller scale, we have more or less accepted the consequences at the larger scales. Looking at the smaller scale forced us to consider the cumulative effects of our decisions.

In EM, land managers make decisions at the larger scale and accept more of the consequences at the stand level. This is a significant change in decision making.

## ECOSYSTEM CHARACTERISTICS

The science of landscape ecology involves three basic components of landscapes or ecosystems--composition, structure and function. Composition and structure are what we can see in a landscape. Function relates to energy processes such as fire, hydrological processes such as floods, and matter and energy exchange through the food chain.

To understand ecological processes and landscape dynamics, it is necessary to look not only at ecosystems and how they are spatially arranged in the landscape, but also at how they are connected—how materials and energy flow between them, and how one ecosystem influences another.

Photosynthesis by green plants drives all other ecosystem processes. It is the primary process that produces biomass, the amount and type of which changes through time. Most forest ecosystems produce about one ton per acre of new green biomass each year.

## NATIONAL FOREST FIRE MANAGEMENT IN AN ECOSYSTEM PERSPECTIVE

In the Northern Rockies, and throughout the Intermountain West, we are struggling with the accumulation of biomass on our landscapes. Some preliminary estimates show that we have one-third more biomass per acre today than we had in the past 10,000 years—since the end of the Ice Age. The current accumulation of biomass is well outside the range of natural variation. Over the past 50-60 years, the composition and structure of our forests has changed to conditions unlike those at any time in the past. In our relatively cool and dry environment, biomass does not decay as fast as it accumulates. Fire is the major agent that processes this accumulation.

One of the biggest impacts Europeans have had on western forests and ecosystems is the change in fire management that occurred after the turn of the century. In fact, that is one of the reasons the Forest Service was created. The Forest Service's reputation was built early-on through firefighting and it is still based on this practice to a large degree.

Through our management actions, we have been changing the fire cycle. Since 1908, the Forest Service has extinguished 72,000 lightning-caused fires, and 34,000 person-caused fires (Figure 1). If these fires had continued without interference from Europeans, the landscapes of the Northern Rockies would look considerably different. As a result, we are in a different kind of disturbance regime than the one to which the forests adapted over the past 10,000 years.

To describe how composition and structure of our forests have changed, we need to look at fuel models. The Forest Service has developed 13 fuel models that represent different conditions and enable us to predict wildfire behavior more effectively. These models can also be used to describe how our forests have changed over time. For this discussion, we need consider only four of the 13:

(1) Fuel Model Two—an open, park-like stand of large trees with a single overstory. Grass in the understory burns fast, but at low intensity and does not kill the overstory trees.

(2) Fuel Model Five—young tree and shrub successional stage with a moist, green canopy. Even in August, these fuels generally do not burn. In drought years, fires in this vegetation type will typically creep around and go out.

(3) Fuel Model Eight—sapling and pole-size trees with little dead standing and fallen wood. In a normal year, fire in this fuel type generally would not spread to the crowns of overstory trees, but will thin out stands. However, in drought years like 1988, tree canopies become very dry in August and September and can burn with a crown fire.

**USDA Forest Service, Northern Region**
**Total Fires, 1908 to 1992**

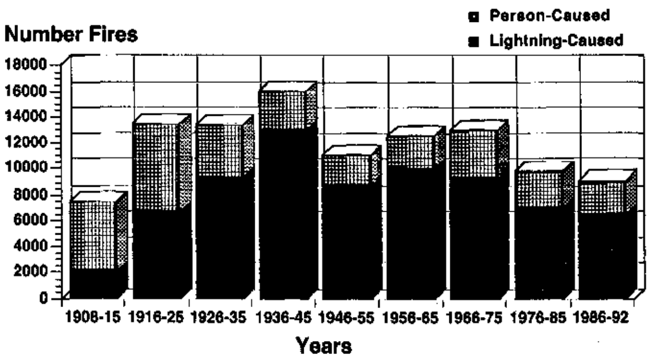


Figure 1. Number of forest fires occurring in the Northern Region of the USDA Forest Service, 1908-1992.

(4) Fuel Model Ten—large trees in the overstory and layers of small and intermediate trees in the understory with dead standing and dead down fuels. Crown fires can occur in this fuel model in any normal year due to dead fuels and understory fuel ladders, and will burn at high intensity in drought years.

Prior to European settlement, nearly half of the south-facing slopes could be represented by Fuel Model Two, and most fires occurred in this type (Figure 2). When fires sweep through Fuel Model Two forests with normal frequency, they process the biomass, preventing large amounts from accumulating. Today, however, the forests have changed to conditions represented by heavy fuel models and fuel loads. Now, when a fire occurs, the fuel ladders carry the fire into the crowns of large trees and the trees are killed.

The ecological result from a fire in a forest represented by the heavy fuel models is different from what would have taken place on these same slopes 100 or more years ago. What has occurred in these habitats is a change in conditions from open, park-like environments to predominantly Fuel Models Eight and Ten. The disturbance regime has changed from frequent, low-intensity surface fires in the park-like stands to high-intensity crown fires in the closed, multi-layer forests. The former were not lethal to the overstory while the latter are (Figure 3).

Cool and moist north-facing slopes—dominated by larch, lodgepole pine, and subalpine fir—present a different situation. Because of the moisture and temperature regimes, there has always been a high percentage of tree cover on these aspects (Figure 4). We are not as far outside the range of natural variation in tree cover on these slopes as we are on

**Successional Stages on South Aspect Ponderosa Pine / Douglas-fir Habitat Types**

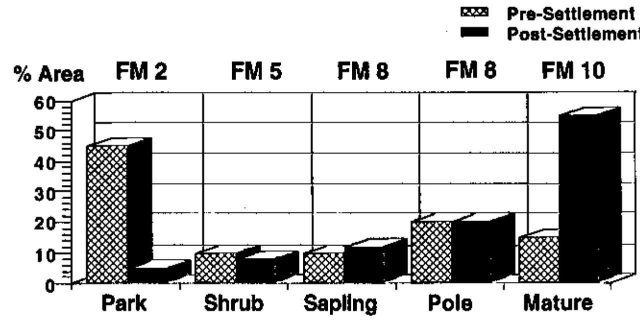


Figure 2. Estimated percentage of land area, both before and since European settlement, in five habitat types on south-facing slopes of the Northern Region of the USDA Forest Service.

**Change in Warm, Dry Ponderosa Pine / Douglas-fir Habitats**

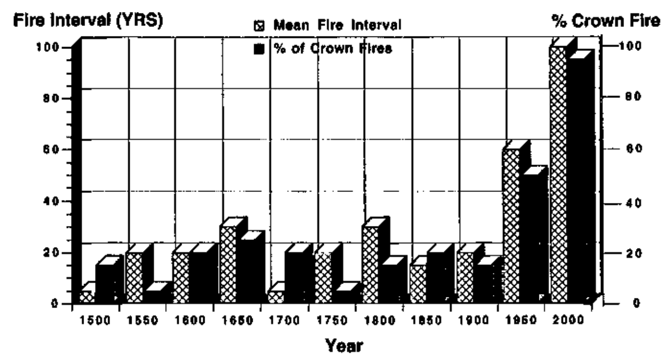


Figure 3. The mean forest-fire interval in years, and the percentage of fires that crowned, on south-facing slopes of the Northern Region of the USDA Forest Service, 1500 A.D. to the present.

**Tree Cover in Moist SAF Types, 1800-2000**

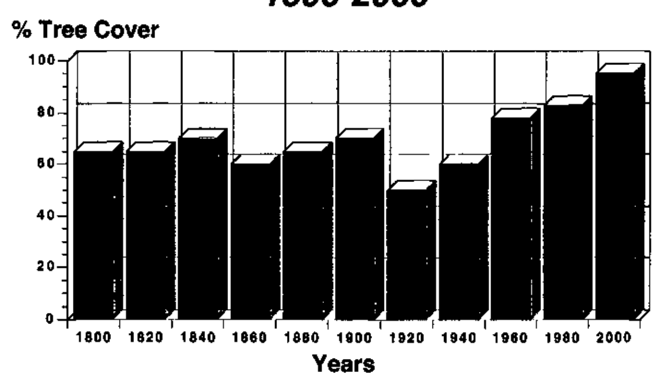


Figure 4. The percentage of tree cover on north-facing slopes of the Northern Region of the USDA Forest Service from 1800-2000.

south-facing slopes. However, by changing the fire cycle, we have significantly changed other features of forest composition and structure (Figure 5). North aspects had spotting and creeping fires in areas of light, moist fuels and crown fires in patches of heavy, dry fuels. Because of the accumulation of more dead material in recent decades, continuous crown fires have resulted (Figure 6).

To summarize, prior to European settlement forest fires on north slopes were patchy, and there was very little burning in riparian zones because of moist and cool environments. A tree here and there that would burn. South aspects had frequent fires of low intensity which, for the most part, did not kill the large trees.

Today, with heavy fuel loads, fires often go into the crowns regardless of where they start (Figure 7). Fires generate so much energy that they dry out riparian zones and burn entirely across them. That did not happen prehistorically to any large degree in the Intermountain West. It is a very different ecological result from what happened in the past. Such fires actually kill fish in some cases.

**Successional Stages on North Aspect Lodgepole / Larch Habitat Types**

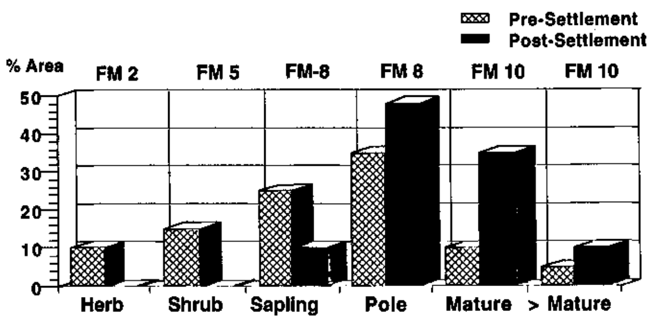


Figure 5. Percentage of land area, both before and since European settlement, in six successional stages on north-facing slopes of the Northern Region of the USDA Forest Service.

**Fire Intervals & Crown Fires on North Aspect Lodgepole / Western Larch Types**

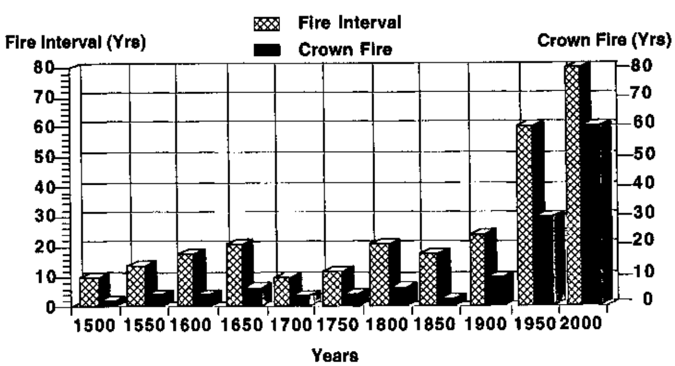


Figure 6. The mean forest-fire interval in years, and the percentage of fires that crowned, on north-facing slopes of the Northern Region of the USDA Forest Service, 1500 A.D. to the present.

**Change in Net Crown Fire Patch Size**

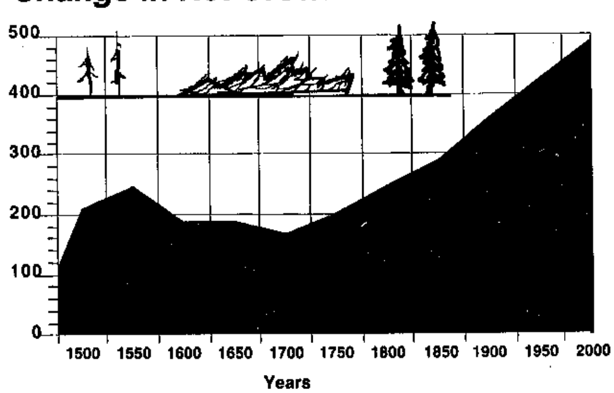


Figure 7. Average size in acres of patches created by crown fires in the Northern Region of the USDA Forest Service, 1500 A.D. to the present.

As a result, the pre-Columbian mosaic pattern of forest vegetation is lost in all three environments: north- and south-facing slopes and riparian zones. Riparian areas are very important for wildlife and fisheries habitat, and for travel and security areas. So are open park-like, south aspects and ridgetops. When we lose the vegetation in these areas to crown fires, it is a major impact on many species.

When heavy fuels burn and heat the soil to high temperatures, the result is hydrophobic soils. Such soils cannot absorb water and the resulting heavy runoff induces major erosion. Small areas with hydrophobic soils were natural in prehistory, but not as large as what we often see today following wildfires in areas of heavy, continuous fuels.

It is obvious that we have dramatically changed the landscape because of our fire- management activities. In fact, it can be argued that the largest human impact on forest ecosystems in the Rockies has not been timber harvesting, but fire management. These changes have occurred because we did not understand the structure and function of pre-Columbian ecosystems, and the ecosystem consequences of our management decisions.

Today, the wildfires that land managers are facing are often of a type for which we do not have the technology, manpower, or equipment to control. Often these fires occur in areas with human development where it is very difficult to save houses and other structures from loss. Given enough fuel accumulation, we no longer ask whether we can put out a wildfire, but how hot it will be, how extensive it will become, and how many houses and other resources will be lost?

## BIODIVERSITY CONSERVATION STRATEGIES AND ECOSYSTEM MANAGEMENT

A key goal of EM is conserving biodiversity, commonly defined as the variety of life and its accompanying ecological processes. The scientific community has developed several conservation strategies or approaches.

The species approach uses the Endangered Species Act to emphasize recovery of species once they become rare and in danger of extinction. The approach is important to the recovery of rare species, but is not pro-active at keeping other species from becoming rare.

We spend a million and a half dollars each year on the grizzly bear alone in the Northern Region of the Forest Service, an area encompassing the states of Montana, northeastern Idaho, and portions of western North and South Dakota. There are some 600 species listed under the Act, and another 3,600 species that are candidates for listing. Thus the species approach is potentially a very expensive strategy, and we are looking for a better one.

A second approach, the indicator-species approach, is oriented to selecting a species that indicates the health of a group of associated species or connected habitats. The theory is that if we manage for the indicator species, all associated species will be conserved. However, it is very difficult to pick one or two good representatives species. Tracking numbers of selected species also does not reveal everything we need to know about ecosystems.

The ecosystem-function indicator approach is based on selecting an indicator of functional habitats, such as snags or community features that can be monitored, and associating their status with that of dependent or coexisting species. This approach has some of the same characteristics as the indicator-species approach, although it has a closer relationship to ecological functions and processes.

The natural-community-representation approach was developed and implemented by the Nature Conservancy, and by public land-management agencies in land- management allocation to natural areas. This approach emphasizes maintaining a complete array of ecosystems and managing them for natural composition and structure. It is a sound approach for conserving a multitude of species and ecological relationships, but it is often the case that not enough lands can be set aside to preserve entire ecosystems.

The ecosystem-management approach is advocated by the Ecological Society of America, the Council on Environmental Quality, and the USDA Forest Service. It is a multi-faceted strategy that includes all of the aforementioned approaches and emphasizes managing regional-level landscapes within natural system variation. It will conserve the species that are native to those landscapes.

It is important to understand natural system dynamics and how they relate to the various conservation strategies. If we manage landscapes within the range of natural variability, we will conserve the species that are native to those landscapes.

## MANAGING WITHIN NATURAL RANGES OF VARIATION

How do land managers go about understanding ecosystems and landscapes? How can they manage them to conserve biodiversity and produce goods and services for mankind? The answer to both of these questions is that land managers need to analyze ecosystems at much broader scales than they have in the past in order to achieve these goals. The more that landscapes are kept near or at their range of natural variability, the greater the potential for maintaining sustainability (Figure 8). To today's forest user, the landscapes dominated by closed forests might look more natural. However, we know fire will eventually play its role and affect changes on the landscape whether managed by man or not.

A disturbance-regime analysis may tell of a need for change in management. For example, an area or landscape of lodgepole pine with a mix of 60 percent ground- and 40 percent crown-fire environments is within the natural range of variation. Due to fire exclusion and accumulation of fuels, the majority of the landscapes in the Northern Rockies have now shifted to a crown-fire environment (Figure 9). The landscape is now outside of the natural range of variation to which the species in these ecosystems have adapted. If management is continued outside natural ranges, there may

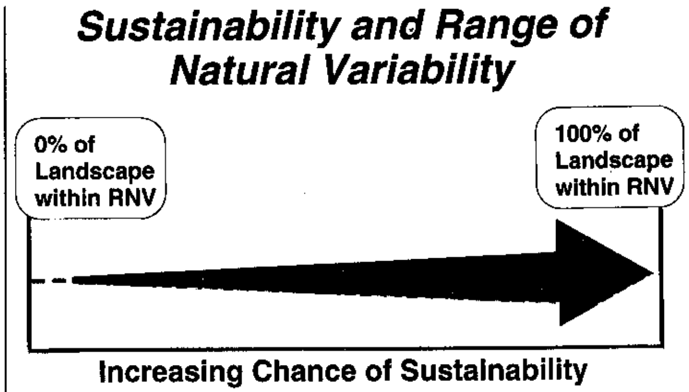


Figure 8. Schematic representation of the principle that the higher the percentage of landscape functioning ecologically in its natural range of variation—i.e. the range within which its component species evolved—the higher the probability that it can be used sustainably to maintain biodiversity and produce goods and services useful for humans. since fire suppression by European settlers, forest maturation, and build-up fuel loads, the extent and intensity of contemporary fires are outside the range of natural variation typically experienced by ecosystems in the Northern Rocky Mountains.

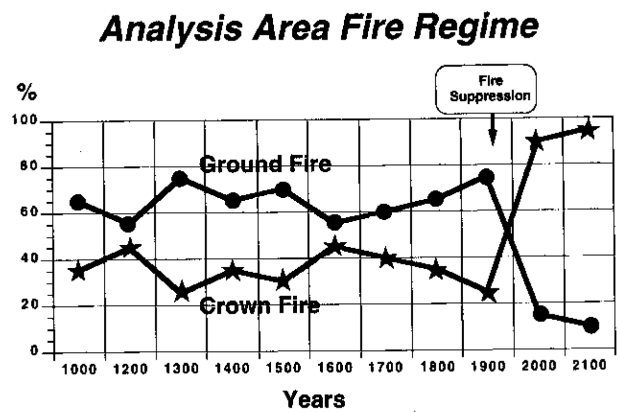


Figure 9. Percentage of forest fires developing as crown fires and as ground fires in the Northern Region of the USDA Forest Service, 1,000 A.D. to present. Prior to fire suppression by European settlers, most of the fires (e.g. two-thirds) were ground fires and only about a third crowned. Since European settlement, crown fires are now on the order of 90 percent of all fires.

be a continued addition of species to the threatened-, endangered-, and sensitive-species lists. A shift in management will be needed in this area to emphasize different stand and landscape structures.

However, whether we manage ecosystems to return them to their prehistoric ranges of variability, or to maintain them outside of those ranges, depends on a host of economic, social, political and ecological factors. These factors may or may not prevent their management within the range of natural variability. In order to address this question, the Forest Service's Northern Region has started a region-wide analysis to address: (1) ecosystem- and landscape-function fire and other disturbance regimes; (2) composition- vegetation types; (3) structure-vegetation patterns.

| Ecosystem Element | Analysis Scale: Global | Physiologic Region | River Basin | Stand |
|---|---|---|---|---|
| Air quality | ● | ● | ● | |
| Water quality | | ● | ● | |
| TES viability | | ● | ● | ● |
| Soil productivity | | | ● | ● |

Figure 10. With ecosystem management, different ecosystem parameters—air quality, water quality, viability of threatened and endangered species, and soil characteristics—are measured and analyzed at different spatial scales.

The objective is to achieve ecosystem management goals by conducting these region-wide analyses, providing tools for site-specific analysis, assisting land managers with an understanding of natural system dynamics, and analyzing environmental, economic, and social costs and benefits.

Different types of analyses are used at different geographic scales (Figure 10). For example, air quality is analyzed at coarse scales over large geographic areas. Water quality is analyzed at intermediate geographic scales. Threatened-, endangered- and sensitive-species viability must be analyzed at both broad and project-level scales.

These different analytic scales are important for understanding landscape and ecosystem relationships and for setting management priorities. Large-scale analyses and assessments are more efficient and effective than the current way of doing business. Biodiversity, or habitat fragmentation, can be addressed once at the larger scales instead of addressing every project on each district.

In summary, the adoption of ecosystem-management concepts and principles commits the Forest Service to make the following changes in its current management approaches: (1) develop broad-scale analyses that consider landscape connections; (2) characterize and consider the range of natural variability for ecosystem composition, structure, and function; (3) promote EM which utilizes all conservation strategies as a "coarse filter" in order to conserve biodiversity.

## CONCLUSION

Ecosystem management means building a new basis for managing national forests and grasslands in the Northern Region and other regions of the Forest Service. These ecosystems will be managed as large landscape units rather than aggregates of individual components. What happens at the stand level will, in large measure, depend upon its contribution to the larger system.

The challenges are many. Larger landscapes, with multiple land ownerships, will be most successfully managed with a high degree of voluntary cooperation between landowners. As in the past, there are no other alternatives than to make necessary decisions. There is no time to research all of the questions before EM concepts are applied to the land, but research must play a key role to assist managers in making decisions. Land managers are committed to a learn-as-you-go approach so that future generations have more options to meet their needs in a sustainable way.

The only way to achieve an understanding of ecosystems and gain acceptance for this new style of management is with a team approach, where everyone has an opportunity to understand and participate in the development of EM strategies.