CHAPTER 2
ECOSYSTEM MANAGEMENT

The notion of ecosystem management is evolving; so too are the concepts and principles underlying it. Frameworks for ecosystem management suggest that ecosystem management requires: (1) goals to establish a direction and purpose; (2) an assessment of resources at multiple resolutions, timeframes, and geographic extents; (3) decision variables and decisions; (4) a strategy for implementing decisions; (5) a monitoring program to evaluate the outcomes of these decisions; and (6) adaptive management approaches (see Bormann and others 1994, Haynes and others 1996). Ecosystem management seeks to integrate biophysical and social disciplines.

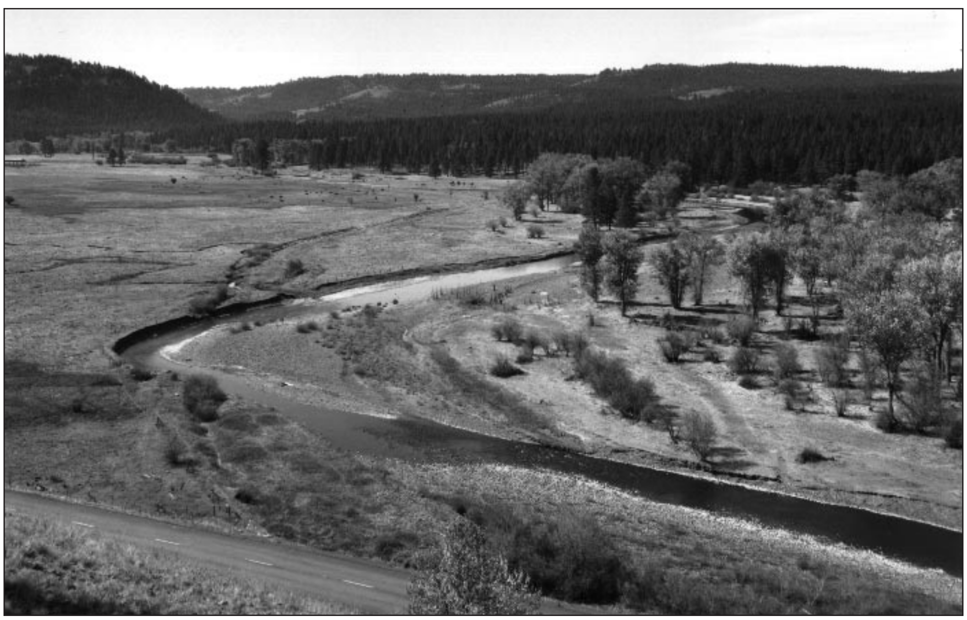
Ecosystem management goals for Federal lands in the Basin reflect changing societal values, new information, and the desire to maintain the integrity of ecosystems, including the maintenance of long-term ecosystem health and the provision of products and services within an ecosystem's capabilities. Ecosystem management can be approached from the standpoint of managing ecosystems based on scientific knowledge and an understanding of what society wants the results of management actions to be. Scientific approaches can be used to characterize biophysical and social processes, and to measure outcomes. Public participation processes are one of many ways to determine the acceptance of management actions used to achieve specific goals. Monitoring can be used to determine baseline conditions, whether implementation achieves objectives, and whether assumed relations are valid.

Four broad principles have guided the SIT's efforts to understand ecosystems. The reasoning behind these principles is explained in greater detail in the *Framework*. First, ecosystems are dynamic; they change with or without human influence. Existing ecosystem conditions are a product of natural and human history--including fire, flood, and other disturbances; climatic shifts; and geological events such as landslides and volcanic eruptions. Second, although ecosystems are dynamic, there are limits to their ability to withstand change and still maintain their integrity, diversity, and productivity. Third, our efforts are guided by an increasing understanding of how larger ecosystem patterns and processes relate to smaller ecosystem patterns and processes. Fourth, there are limits in our ability to predict how ecosystems may change. Photos 1a and 1b illustrate that terrestrial and aquatic ecosystems are dynamic.

These principles suggest that scientists and land managers carefully observe and study ecosystems and adjust their actions as new information becomes available. They also reflect an appreciation that people are part of, and not separate from, ecosystems. Determining society's current and future expectations for public land outputs (goods, functions, and conditions) is the fundamental determinant of stewardship.

As described earlier, the general planning model for the implementation of ecosystem management has four iterative steps: monitoring, assessment, decision making, and implementation (see fig. 2). It is an adaptive model that combines both bio-

Photo by J.D. Lacey



Photos 1a and 1b—This Blue Mountain photo pair shows the change in stream, meadow, and riparian conditions between 1919 and 1992. Notice the forests in the background are more densely stocked. (Source: Skovlin and Thomas 1995.)

physical and socioeconomic processes and goals. Societal expectations for outputs (including ecological conditions) are an important feature. The model also recognizes that management objectives differ between public, tribal, and private lands. For private lands, this becomes more complicated as individual owners differ in land management objectives and how they respond to market and non-market (including regulatory) incentives. This model provides a context for how the different types of information might be integrated in conjunction with management goals.

Ecosystem Management Goals

Humans have diverse goals for ecosystem management, which in turn reflect diverse cultural perspectives. These goals are in the domain of public choice and not science. They are the result of decisions that follow from democratic and institutional processes and are stated or inferred in laws, regulations, policy statements, decisions, and budget direction. For example, the legislation guiding the management of FS- and BLM-administered lands in the early 1900s centered on protecting resources and reducing flooding. Goals shifted more toward providing commodities and stabilizing employment during the middle of the century. Concurrent with the environmental movement of the 1960s and 1970s, the emphasis shifted away from implicit goals toward establishing a planning process that developed specific goals. This shift is illustrated in current procedural laws requiring federal agencies to identify and disclose the effects of management activities on Federal land (NEPA 1969), and to develop long-range land use or general management plans (RPA 1974, NFMA 1976, and FLPMA 1976).

Currently, land and resource management plans which establish detailed goals, objectives, and standards are developed by the FS and BLM for each administrative unit (generally a national forest or BLM resource area). Legal mandates require Federal land managers to manage habitat to maintain viable populations of existing native and desired non-native vertebrate species (36 CFR 219.19). Regulations also require Federal land managers to provide for diversity of plant and animal communities, including endemic and desirable naturalized plant and animal species consistent with the overall multiple use objectives of the planning area [36 CFR 219.26 and 219.17(g)]. Managers are also required to consider the American Indian treaties and the associated trust responsibilities. The Chief of the Forest Service recently emphasized the importance of managing the National Forests to maintain the integrity of ecosystems (Thomas 1994).

This direction provides insights into the goals of ecosystem management for the agencies managing Federal lands, but it does not provide a formal, clear statement of ecosystem management goals. In the absence of explicitly defined goals by the agencies and society, we assumed that the general purpose for ecosystem management is to maintain ecosystem integrity or system integrity, where system integrity is defined as the degree to which all components and their interactions are represented and functioning. Ecosystem, in this sense, is being used in its broadest form, where it encompasses social as well as biophysical components.

Ecosystem integrity and resiliency are rooted in scientific concepts that inherently reflect human values (see for example, Haynes and others 1996, and Wickium and Davies 1995). These human values include the normative purpose of maintaining the integrity of a combined natural and cultural ecosystem. Ecosystems are defined as having high integrity when their components have no substantive impairment in structure, composition, or function. In this sense, a living system exhibits integrity if, when subjected to disturbance, it maintains its capacity for self-organization. For the biophysical, social, and economic components of ecosystems, resiliency is defined as the capacity of these components to adapt to change. These end-states may include some that are judged by management and the public as being “normal and good” but that may not be pristine or naturally whole. Thus, there is a social context to ecological goals, and an ecological context to social goals.

Science can predict how systems respond to change, but it cannot state that one change is better than another. Judgments about whether a system condition is good or bad must be made within the context of social values. This raises the question of how to measure integrity, since the judgment of how resilient or complete an ecosystem is depends on subjectively chosen indicators. In that sense, the integrity of ecosystems is more an expression of environmental policy than scientific theory (Woodley and others 1993). Managers may be reluctant to include societal issues and values in the definition (and evaluation) of ecosystem integrity. However, because maintaining the integrity of ecosystems is a management goal, it by definition, needs to reflect the values of both managers and users. Finally, to define the integrity of ecosystems is to define a set of biophysical and social characteristics to be monitored for change from or toward specified values.

The *Framework* lays out how the SIT assumed the overall purpose of ecosystem management--to restore and maintain ecological integrity and social and economic resiliency--and six societal goals for ecosystem management that would provide benchmarks for evaluating changes in ecosystem integrity and social and economic resiliency. The six assumed goals are:

- Maintain evolutionary and ecological processes.
- Manage with an understanding of multiple ecological domains and evolutionary timeframes.
- Maintain viable populations of native and desired non-native species.
- Encourage social and economic resiliency.
- Manage for places with definable values: a "sense of place."
- Manage to maintain a mix of ecosystem goods, functions, and conditions that society wants.

These goals represent normative judgments about what best indicates ecosystem integrity, and social and economic resiliency. By addressing these goals, risk and uncertainty from unpredictable events may be reduced. The goals also acknowledge important social values derived from noncommodity use of natural resources. They acknowledge the extensive range of values and choices involved in managing for the integrity of ecosystems and social and economic resiliency.

The remainder of this section presents a discussion around each goal in the context of the Basin. It summarizes early SIT discussions where tentative findings were used to clarify our descriptions of the goals. The underlying documentation for the various statements in the section are given in the *Component Assessment.*

Goal 1. Maintain evolutionary and ecological processes

An ecological process is a sequence of events relating environmental, living, and nonliving components of an ecosystem. It may result in some outcome that in turn affects and is part of other processes. For example, some past management practices have increased erosion and sedimentation, which resulted in increased amounts of soil in streams and river pools. This reduced the amount of food available for fish species and the ability to spawn successfully, resulting in fewer fish available to humans and other species that depend on them. Ecological processes include those that operate at very small spatial and temporal extents, such as the growth of cells, and those that operate at very large spatial and temporal extents, such as plate tectonics. Ecological processes such as hydrologic cycles, nitrogen cycles, carbon cycles, and plant succession are essential for maintaining the productive capacity of the air, land, and water upon which life depends.

History demonstrates the propensity of humans to alter ecological processes. An example in the Basin is the emphasis on harvesting of large trees.[3] Large trees were typical in landscapes maintained by low-intensity surface fires. Harvest of these trees over the last two centuries did not parallel the pre-

[3]The definition of large trees varies by vegetation type. For ponderosa pine and Douglas-fir it generally means diameters greater than 21 inches (53 cm). The selection of a specific diameter is related more to available data sets than to ecological definitions.

European disturbance regime, and consequently altered associated vegetation structures and disturbance processes. The resulting landscapes were less diverse (more simplified), more chaotic in terms of disturbance intensity, and less tolerant of fire, insects, and diseases. An additional ramification of this harvest strategy was that road development was often concentrated on landscape settings sensitive to erosion and sediment transport.

Continued human population growth in the Basin will increase demand for recreation and for housing in urban/wildland interface zones. This makes it increasingly difficult to maintain ecological processes and to reduce risk to human life and property. For example, in the Snake Headwaters ERU the human population density on private land is expected to increase from 20 to 50 people per square kilometer (30-80 people/sq. mile) increasing risk to ecological processes. The ERUs with highest projected development in the urban/wildland interface and fire-prone zones include the Snake Headwaters, Owyhee Uplands, Upper Snake, Northern Glaciated Mountains, and Lower Clark Fork.

In general, past forest management on Federal lands dispersed multiple uses across all landscapes, emphasizing commodity production. This has led to areas where ecological processes within landscapes are not fully functioning and have lower capacity to meet human needs and values.

The prerequisite to management actions is an understanding of the basic biophysical conditions and processes within an area (geology, soil, climate, landform) and their associated hydrologic and vegetation disturbance regimes, in relation to native biota and human habitats. To meet this goal, the highest priority for maintaining ecosystem processes would be in areas where the processes have been the least disrupted. The highest priority for restoration would be in areas where systems can be recovered and the knowledge and technology for recovery are available. A high priority for research would be to identify those areas where systems are degraded or in jeopardy, and where the methods and the technology for recovery can be developed.

Among the ERUs dominated by forest land, the Blue Mountains and the Lower Clark Fork have the greatest potential for restoring and maintaining ecosystem processes. Many vegetation and hydrologic processes have been impaired in these ERUs, but they still have high diversity of native plant and animal species, although populations are small and scattered. Proactive management at the watershed scale could provide significant improvements while diminishing further risks. Restoration programs slated for the urban/wildland interface zone pose the lowest risks to ecological integrity when applied in previously roaded portions of dry forest, shrub, and grass vegetative zones.

Among the ERUs dominated by rangeland, the Upper Snake, Owyhee Uplands, and Northern Great Basin have the highest potential for a posi-

A disturbance is an event that changes the trend of ecosystem development; disturbances are inherent to ecological processes. When disturbance regimes occur with an intensity, periodicity, or spacial extent outside their accustomed character, evolutionary trends are compromised. For instance, fuel accumulations and shifts to more fire-susceptible tree species have resulted in less frequent, but more intense forest fires that can disrupt nutrient cycles, food chains, and decomposition processes. Floods are a disturbance essential to developing and maintaining riparian conditions. They establish cross-section stream bed characteristics, flush debris and accumulated fine sediment, and deliver material for soil development to the flood plain. Because floods may be detrimental to human life and property, in flood plains we attempt to control or minimize their impact; in so doing we often disrupt the accustomed processes.

tive response to restoring and maintaining ecosystem processes. These ERUs have high rates of decline of vegetation and hydrologic processes, but retain high residual native species diversity. The Owyhee Uplands and Upper Snake also have high potential for increases in human population. Much could be accomplished through proactive management in the urban/wildland interface. Management could likely meet human and ecological objectives, while diminishing further risks to ecological integrity.

Goal 2. Manage with an understanding of multiple ecological domains and evolutionary timeframes

An ecological domain is a large unit of land containing repeating patterns of life forms, climate, and physiographic features. The Northern Rocky Mountains, Great Basin, and the Interior Columbia Basin are examples of ecological domains. There are broad differences among ecological domains in their biophysical conditions, evolutionary processes, and their ability to provide goods and services for people. Evolutionary processes control how systems adapt and change in relation to time and disturbances. Ecological evolution is the integrated development through time of cellular processes, species, communities, and landscapes in relation to disturbances and their surrounding environment.

Similarly, landscapes evolve as a result of interactions between geology, climate, soils, landform, hydrologic regimes, humans, wildlife, and vegetation. Knowledge of the factors and relations comprising the biophysical and socioeconomic characteristics of ecological domains provides understanding of the evolutionary interactions of disturbances (such as fire, insects and disease, timber harvest and management, grazing, drought, floods, volcanic eruptions) with climate, geology, landform, and soils. This knowledge gives us the ability to understand how systems evolved and developed. In addition, there is the issue of intergenerational transfers: how will the Basin's ecological systems provide ecosystem goods, functions, and conditions for present and future human generations?

Species have evolved over the past thousands or millions of years adapting in part to changes in their environment. But human-caused disruptions of evolutionary processes in the Basin, such as the introduction of exotic species, can take place within decades. Such introductions can disrupt the relations of native species with their environment and alter evolutionary pathways. Another driver of an evolutionary process is climate change. Climate in the Basin has been highly variable over time. Drought (<70% of average annual precipitation) is relatively common, especially on rangelands where some plant and animal species (and their ecological functions) have adapted to wide fluctuations.

Managing natural resources in the context of multiple ecological domains can help explain the relations and dependencies that occur among ocean and terrestrial systems. The importance of ocean conditions, which are linked to global atmospheric circulation patterns, to anadromous salmonid life cycles has become understood in the last 15 years. Traditionally, research attributed variation in population size to freshwater conditions. Recent work strongly suggests that the abundance of salmonids and other fishes may be affected by short- and long-term variation in atmospheric and ocean circulation patterns. Northeast Pacific Ocean conditions shifted in the mid-1970s and salmonid populations along the entire west coast of North America have responded to these regional changes. One consequence of this is that management actions directed at restoring freshwater habitats of salmonids need to include the context and information about the fluctuating numbers brought on by climate and oceanic changes.

There is a need to recognize that management activities may affect ecosystems over multiple ecological domains and multiple timeframes. It is difficult to predict ecosystem trends and the ultimate outcomes of management actions. The practical implication of this is that today's management actions can reduce options for future generations. At the same time, large events are inevitable, and responses to these events play a major role in ecosystem development. Investment strategies for resource production or restoration can be designed to improve success and reduce risk of investment loss, given this type of understanding. By planning activities in the context of multiple ecological domains and evolutionary timeframes, natural resource management can provide buffers to large events (such as volcanic eruptions, fires, and floods) that may have significant ecological effects.

To date, natural resource management strategies in the Basin generally have not considered broad spatial and temporal views of how species, communities, and landscapes evolved in relation to ecosystem processes. Most project activities on FS- or BLM-administered lands are, at most, watershed-, single species-, or issue-specific and do not usually consider the broader context in which management actions operate. At the largest extent current management usually covers a single Forest or BLM District and has resulted in less complex landscape patterns. In part, this is the consequence of the institutional framework of the FS and BLM that is focused on decentralized short-term and issue-specific results. Although there are notable exceptions, previous management practices rarely considered managing the structure and composition of whole landscapes in a manner that was consistent with biophysical conditions and disturbance processes that maintained a mosaic of conditions over landscapes. As a result, a single large event (such as fire, floods, or volcanic eruptions, as well as the introduction and spread of exotic species or diseases) could eliminate a plant or animal community. Management activities that consider only short-term results may interrupt millennia of evolutionary processes in a span of decades. This short-term vision may lead to ecosystems developing in unforeseen ways, causing increased likelihood of unpredictable events.

Humans have the potential to increase the rate of change of evolutionary processes. Human activities have altered terrestrial and aquatic ecosystems in the Basin to the extent that restoring the original conditions through management activities is nearly impossible in many areas. Humans are currently responsible for moving more material about the surface of the earth than any other geomorphic process. They have introduced exotic species and toxins that have spread into native communities that are not well-adapted to the newcomers. Road building, urbanization, and pollution have reduced the diversity, resiliency, and productivity of the Basin. Exposure and erosion of soils that had co-developed with their vegetation cover alter the succession and productivity of many Basin ecosystems.

Goal 3. Maintain viable populations of native and desired non-native species

There is public concern that ecosystem management maintain viable populations of native and desired non-native species. In a broad sense, viability can be considered as the likelihood of continued existence of well-distributed populations of a species throughout its current range, to specified future time periods (Marcot and Murphy, in press). A population can be defined as a set of plant or animal organisms of a given species, occurring in the same area, that could interbreed. A population with high viability persists in well-distributed patterns for long periods (century or longer). A viable population is able to survive fluctuations in demographic, genetic, and environmental conditions and maintain its vigor and potential for evolutionary adaptation over a long period of time (Soulé 1987).

Each species in an ecosystem has specific ecological functions. These functions are linked to other species and functions. Removal of a species may eliminate or compromise a function for which there is no functional substitute or equivalent. The functions of individual species are not completely understood or known, and therefore effects of their removal on ecosystem integrity are not known.

Viability is important because an ecological community, landscape, and ecoregion with a rich complement of viable populations of plants and animals has a greater capacity to maintain its ecological community structure in the face of disturbances. Maintaining the viability of individual species and species richness (number of species) alone are not adequate objectives for managing for biodiversity. Ensuring viable populations is also necessary for long-term ecological integrity. Viable populations help meet Trust responsibilities and keep the agencies within the framework of the Endangered Species Act (ESA) and other legal mandates.

There is no one static condition that constitutes a set of native species. Human activities as well as natural changes affect the ebb and flow of species and communities. Native is not necessarily permanent, so it is a challenge to define a particular "native" baseline from which changes can be measured.

Desired non-native terrestrial species include introduced vertebrate game species, invertebrates introduced for controlling introduced pest invertebrates or plants, and non-native plants. Chukar, gray partridge, wild turkey, and ring-necked pheasant (see appendix E for listings of species common and scientific names) are the primary desirable non-native terrestrial vertebrate species in the Basin, particularly in the agricultural regions. Changes in agricultural practices to "clean farming" have resulted in lower populations in many areas, notably the Columbia Plateau. Introduction of these non-native species may have adverse effects on other vertebrates (primarily birds), invertebrates, or plants, but ecological information is scant. Plant species that have been brought into rangelands and forests, including crested wheatgrass and other grasses used for range conversion or restoration, are desirable or undesirable depending on one's preference for commodity production versus maintaining native communities.

Desired non-native fishes, (such as brook trout and stocked rainbow trout), are spread widely throughout the Basin and form the basis for recreational fishing. The thousands of large and small reservoirs and the warm waters of the lower major river systems within the Basin have created an important bass and walleye fishery, which harms anadromous salmon recovery because of the walleye's predatory behavior. These warm water fisheries continue to increase in economic importance.

Angling for native fishes has become highly regulated either as part of the Snake River anadromous chinook recovery plan or, (as in the case of John Day steelhead trout) as maintenance of genetic diversity. For native resident fish, regulations include catch and release, designated wild fish streams, and special closures around migration or spawning times. For American Indians, the significance of salmon and steelhead transcend economic values. The social and ecological pressures to provide desired non-native species and to maintain native species will continue to challenge decision and policy makers at all levels of government.

The societal choice to maintain or restore species viability hinges ultimately on human land uses and human needs versus the needs of other species. For example, there has been widespread national support for the protection of rare plant communities on public lands. There is also sentiment for modifying endangered species laws to maintain local economies and communities while at the same time having effective habitat conservation strategies.

Private landowners play an integral role in maintaining species viability. For example, private landowners often control the water rights and generally own the historically most productive reaches of streams in the broad valleys and at low to mid-elevations, while public lands are concentrated in the upper reaches and headwaters. Providing spawning and rearing habitat at different seasons and in different locations within a subbasin is important to the likely persistence of all salmonid life history stages and forms. Dams, road networks, urbanization, and agricultural development have precluded a continuous ribbon of productive fish habitat, good riparian conditions, and fish passage up and down the river systems in the Basin. However, opportunities are numerous in the Basin to restore small reaches as way stations in the network that will be essential to fish moving up and down river systems to appropriate habitats.

Goal 4. Encourage social and economic resiliency

Resiliency, here, means adaptability, not necessarily a return to some prior state or condition. In the social sense, adaptability means the capacity for humans to change their behaviors, economic relationships, and social institutions such that economic vitality is maintained and social stresses are minimized. Resilient communities are those that tend to have a diverse economic base, forward-looking leadership, a pleasing look and "feel," a cohesive sense of community, and the physical capacity for expansion (such as, roads, sewer, and water). Resilient communities are adaptable to changes in federal policy; indeed, some Basin communities would be largely unaffected by any changes in Federal land management. Communities that lack the above-stated qualities are ill-equipped to deal with change.

Communities (within the Basin) differ in their dependency on Federal lands and policies. There are formalized requirements to consider (though not to perpetuate) community dependency in the National Forest Management Act of 1976 (NFMA 1976). These requirements identify local economic relations to federally managed lands that deal with the supply of materials and commodities. However, communities may depend on and benefit from federal ecosystem goods, functions, and conditions in other ways. For example, a national forest may provide significant amenity resources, resources that provide the scenic backdrop and physical setting attractive to business owners and their workers. Such communities may be dependent on natural resources, but in ways different than traditional extractive definitions imply. For example, communities may be economically dependent on government facilities, such as FS and BLM offices, defense bases, or research programs. Resident Federal workers themselves contribute to their communities economically and by providing experience and knowledge that might not otherwise be available in a small town. Native American communities can be both economically dependent and culturally dependent on the landscapes that provide links to ancestors. In addition, a community may depend on federally managed resources as a source of clean water for domestic, agricultural, and commercial purposes.

Residents of natural resource-based communities are concerned about the uncertainties of flows of commodities under current management. These concerns lead to an anxiety that revolves around people wanting to retain their community structure and accustomed lifestyles. In these communities residents believe that perpetual access to federal timber, grazing, and minerals is critical to their personal economic stability and the future of their community. Shifts in either demand for, or supply of, natural resources (timber, grazing) can cause unanticipated changes in a community's economic base and social and economic well-being.

Communities with higher levels of social and economic resiliency, can adapt to changes in management of forests and rangelands. This permits forests and rangelands to be managed with greater flexibility and options in an attempt to meet broad societal demands, and to promote ecosystem processes and functions. Less adaptable communities may become sensitive to changes in demands for commodities, leading to community instability, stress, and anxiety. If communities cannot adapt to change, there may be social and political pressure to maintain flows of resource commodities inconsistent with broader societal goals and with maintaining the integrity of ecosystems. Within the Basin, resilient communities tend to be those that are larger, those with active community leadership, or those that have confronted change. Agricultural and ranching communities tend to rate lower in resiliency when compared to other types of communities.

Goal 5. Manage for places with definable values

An important element of ecosystem management is the growing appreciation of intangible spiritual, cultural, and individual meanings that people assign to physical environments. Sense of place can encompass the feelings and emotions one has for favorite or special places based on one's experience, the spiritual values that American Indians identify with landscapes, or even the unique character or identity that people associate with specific communities. In other words, sense of place is the meanings and qualitative attachments that people give to specific locations on a landscape.

The relationships between humans and their cultural landscapes are also being increasingly identified. For example, landscape meanings can be sacred to American Indians, but identifying them for an ecosystem assessment is difficult because of a cultural reluctance to expose such locations and their meanings. Other cultures and communities of interest may assign different meanings to the same place, as when Asians may define a place as an important source of herbs, while Latinos may define the same place as an important source for tree boughs.

For people across the nation, there may be locations that contain important cultural and individual meanings, for example, the place where the Battle of White Bird Hill occurred, the Lewis and Clark campsites along the Lochsa River, or the Seven Devils area (see photo 2). While these places share a consistent definition, not all people may have the same depth of understanding, and

Photo by J. Rohling

Photo 2—The area called the Seven Devils has both cultural and recreational significance.

individually recognized boundaries may not coincide. The different ways people define places (with quantifiable measures and physical processes or with unquantifiable emotional significance) can cause barriers in communication, and sometimes conflict.

With the projected Basin population growth and increased demand for recreation, scenery, and commodities, meanings of place for different communities may change rapidly and increasingly come into conflict. In general, humans prefer meaningful places to be stable or evolve slowly, a preference in contrast to the anticipated rapid rate of change. Rapid population growth and shifts in the economic base away from natural resource commodities may also affect community character.

Goal 6. Manage to maintain the mix of ecosystem goods, functions, and conditions that society wants

Ecosystems have many values to society. There are ecosystem goods that are removed such as minerals, timber, forage, mushrooms, huckleberries, wildlife, and fish (see photos 3 and 4). Some goods are not removed when used, but instead remain to be enjoyed by more than one person—these include a whole host of goods associated with recreation activities such as beautiful scenery and wildlife to view, and primitive country to experience. Finally there are goods that are valued simply for their existence such as salmon, grizzly bears, gray wolves,

Photo by USDA, Forest Service, Pacific Northwest Region

Photo 3—Forest Service employee examining a log deck with a purchaser. FS- and BLM-administered lands accounted for 46 percent of harvest in the Basin in 1991.


Photo by K.D. Swann

Photo 4— American Indian picking huckleberries in an area of traditional cultural significance.

and large old trees. In addition to the goods listed, ecosystem functions include beneficial processes such as carbon sequestration, hydrologic cycles, and nutrient cycles. Ecosystem conditions include states people want to find on the land, including old-growth forests, clean air, clean water, unroaded areas, and scenic integrity.

Conflict over goals for ecosystem management has increased as the desired mix of ecosystem goods, functions, and conditions has expanded and changed over time. Because society's wants and needs will continue to evolve and knowledge about ecosystems will continue to improve, managers try to provide options for maintaining ecosystem integrity. Federal laws, regulations, and judicial conditions set the context for ecosystem management. Land managers can also keep abreast of society's wants and needs by working with stakeholders at all levels to define the mix of ecosystem goods, functions, and conditions that are deemed necessary. This will help society and managers recognize the trade-offs among ecosystems' outputs. Using adaptive strategies and sensing what society wants will bring a higher probability of achieving the ongoing goal of ecosystem integrity.

In this goal it is important to define both society and ecosystem goods, functions, and conditions. Society is broadly defined—it includes interests wherever located (in the Basin or across the country) and future generations. The point is to include in the analysis all values society holds for these lands. Interests of future generations can be explored through the options available to them under different management directions. The analysis applies to what the Federal lands in the Basin can provide society, and shows important variations among ecological regions within the Basin. The distribution of the value of ecosystem goods, functions, and conditions between various components of society—the "who benefits?" issue—needs to be explored as well.

Differences exist in the distribution of ecosystem benefits between generations: some management approaches favor current generations, others favor future generations. Similarly, some approaches to ecosystem management favor local over national interests, or vice versa. The challenge is to identify desired ecosystem goods, functions, and conditions. Current political/institutional approaches were designed in a past era with less knowledge about the time and space consequences of management activities. Future ecosystem management needs to consider longer timeframes and larger areas. Moreover, current natural resource institutions and structures need to be examined.

Ecosystem Management Concepts

The implementation of ecosystem management depends on many concepts, some familiar and others unique. Among these latter concepts are notions of risk and risk management, scale, land classification, and biophysical templates. The purpose of this section is to briefly review these concepts.

Treatment of risk and uncertainty

Risk assessments help managers develop a sense about the likelihood of outcomes of various management strategies. In these assessments, analysts also have to make judgments about the risks associated with various indicators and findings. Contemporary ideas of risk, uncertainty, and ignorance acknowledge the traditional distinctions [for example those made by Knight (1921)], but generally use a practical definition of risk as either (1) the possibility of loss or injury or (2) events or circumstances that result in a chance of loss or injury. This distinction is useful to help managers develop a sense of the possible outcomes of management strategies. For example, in the ecological integrity section scientific and management uncertainty was estimated regarding ecosystem response to forest and rangeland management. We also provide statements regarding uncertainty in projections or interactions.

Risk management

Ecosystem management with its emphasis on spatial and temporal hierarchy facilitates risk management in the sense that it focuses discussions and management responses at the level that the risk occurs. The use of risk in this discussion is technically not risk in the sense of just the situation where all possible outcomes can be specified [see Knight's (1921) definition]. Rather, it is a more general characterization of the risks associated with a set of outcomes, a knowledge that not all outcomes can be characterized in advance, [see Faber and others (1992) for a discussion of the concept of ignorance] and some notion of the societal acceptability of those risks.

The greatest flexibility for management is attained to the extent risks (meaning events or activities that pertain to the likelihood of not reaching desired goals) can be managed at the lowest level possible. For example, a risk would be considered a "regional risk" if it could not be adequately addressed by making incremental, individual decisions at lower levels; such as activities that threaten anadromous fish populations. Insuring the viability of a wide ranging fish species includes providing high-quality suitable habitat for the species well distributed throughout its range. Making individual, separate decisions regarding where the species habitat will be emphasized will not insure that the habitat is well distributed. That is, unless the decision is made regarding which portion of all the potential habitat will be managed to insure quality habitat for this species. The alternative would be to conservatively manage all habitat by not permitting any of it to be adversely altered, thus, reducing flexibility for management. By strategically making the decision of where, specifically, the species habitat would be emphasized, management has potentially more options to consider as new decisions are made.

A method of partitioning the risks through a risk management approach can retain flexibility at the field level (figs. 6a and 6b). Figure 6a shows different amounts of risk at four geographic ex-

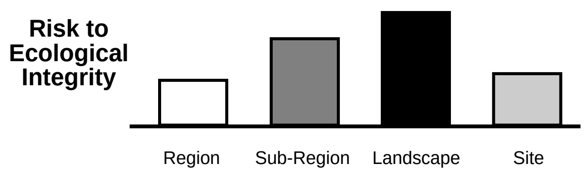


Figure 6a—Example of partitioning risk to ecological integrity across multiple geographic extents.

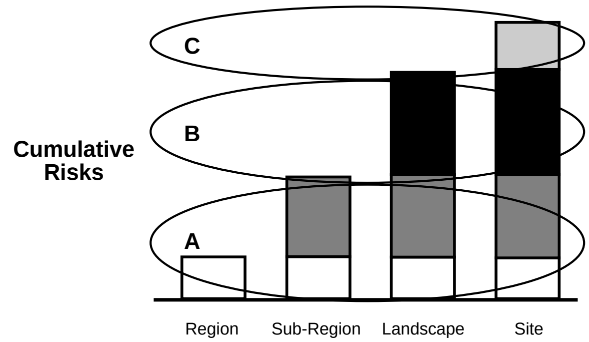


Figure 6b—An example of cumulative risks to ecological integrity at multiple geographic extents. Ovoids A, B, and C represent analysis and decision levels that address risks associated with those levels.

tents: region, sub-regional, landscape, and site. Figure 6b shows cumulative risks for these same geographic extents. Each site faces the cumulation of risks from all the greater geographic extents. The three ellipses define the analyses and potential decisions addressing each group of risks. The broadest extent of risks are addressed in regional and/or sub-regional assessments (ellipse A in fig. 6b). From these, the regional guides, forest plans, and BLM district plans can be developed and/or revised. The next step is assessments that focus on risks of the watersheds or landscape geographic extent (ellipse B in fig. 6b). The most detailed level of analysis is the site or project analysis (ellipse C in fig. 6b). Given the regional and landscape analysis as context, the remaining risks that need to be addressed are those specific to the particular site. When considered together, all the risks, individual and cumulative, have been addressed through a multi-level analysis and decision process.

One purpose of risk management is to allow flexibility at the local level to the extent compatible with managing risks. For example, establishing standards and guidelines at levels above the local site results in using averages or blanket prescriptions across a wide array of conditions, so for some sites the standards will be too high or for other sites too low. By attempting to manage risks at the levels that they occur, the possibilities for this sort of miss will be reduced and desired outcomes can be achieved with greater frequency. Decisions that address all risks across a large geographic area result in fewer management options at the site level and increases the probability that a decision will be wrong for a particular site. This can best be reduced by managing the risks at the lowest level, thus allowing the greatest flexibility at the local level.

Managing directly to achieve opportunities, desired outcomes, and the provision of goods and services might result in new risks of failure in achieving the goals. For example, there may be management opportunities to increase recreation use associated with riparian areas but that use could increase risks to fish spawning beds in the same riparian areas. There is nothing inherently wrong with setting out to achieve some goals that are oriented toward commodity output. Managing the full complement of risks associated with all management goals then dictates that the new risks to ecological objectives, created through achieving the outcomes (outputs), be evaluated to determine how these affect the cumulative risks associated with not achieving ecological goals for the area. It may require some additional analysis and could result in changes in the way the practices are applied, the provision of other goods and services, or the total risks to the systems being analyzed. It becomes an iterative process, analyzing risks to

Table 1—Attributes and characteristics typically associated with broad resolution, regional assessments.[1]

Attributes	Landscape ecology	Terrestrial	Aquatic	Social/Economic
Geographic extent	River basin	River basin	River basin	States
Data resolution[2]	≥ 100 ha	≥ 100 ha	≥ 400,000 ha Sub-basins	State, County
Organizational hierarchy	Multiple watersheds	Community & species associations	Watersheds, communities of species	State, County
Map scale	≥ 1:100,000	1:2,000,000 1:1,000,000	1:100,000	1:1,000,000
Time period[3]				
Short term	1-10 years	1-10 years	1-10 years	1-5 years
Long term	10-300 years	10-100 years	10-100 years	5-50 years

[1]The general size of these assessments is millions to billions of km^2 and the general use is for national and regional planning and policy-making.

[2]Defining vegetation components is typically on a resolution of 100 ha while the aquatic components are defined by river systems (≥ 400,000 ha).

[3]Short- and long-term time periods for historical and projected patterns and processes differ between types of assessments.

resources, determining the effects on outputs (outcomes), modifying actions that result in new projections of output levels, determining risks to ecological goals, adjusting as appropriate, and cycling through the analysis until the risks to ecological goals are acceptable and the output levels are achieved to the extent possible.

In risk management, the final step involves determining the societal acceptability of risks.[4] It may be that even the broad magnitudes of risk (for example of species extinction) are not societally acceptable. On the other hand, reducing risks to future generations of, say, catastrophic fire might be highly desirable. Given the cumulative nature of these risks, there is danger that land managers too often take societal acceptability of land management actions for granted. By attempting to manage the risks, we increase the probability of societal acceptance of our management actions.

[4]We acknowledge that social acceptability is the result of interactions within our pluralistic cultural, legal, and regulatory systems. It is not always clear that reaching overall societal acceptability of ecosystem management objectives and actions is feasible without conflict.

Scales

The term "scale" can have several meanings. These different meanings often are confusing when referring to geographic extent, timeframe, data resolution, and map scale. To avoid this confusion when describing assessments, we use two-part names designating both the geographic extent and the resolution of the data. Tables 1, 2, and 3 show the relations between the different definitions where we refer to geographic extent, with examples such as regional, sub-regional, landscape, and site. Map scale represents a ratio of a distance on a map to the distance on the ground, for example 1:1,000 kilometers map scale. This document provides information based on two types of assessments, a broad-regional assessment and a mid-sub-regional assessment. Different disciplines used different notions of geographic extent, timeframe, resolution, and map scale (tables 1, 2, and 3).

Table 2— Attributes and characteristics typically associated with mid-resolution, sub-regional assessments.[1]

Attributes	Landscape ecology	Terrestrial	Aquatic	Social/Economic
Geographic extent	Multiple watersheds	Province	Multiple watersheds	County
Data resolution	≤ 100 ha	1-5 ha	15,000 ha watershed	County
Organizational hierarchy	Watershed	Species groups	Species groups	County
Map scale	1:100,000 1:24,000	1:100,000 1:24,000	1:100,000 1:24,000	1:100,000
Time period[2]				
Short term	1-10 years	1-10 years	1-10 years	1-5 years
Long term	10-300 years	10-100 years	10-100 years	5-50 years

[1]The general size of these assessments is thousands to millions of km^2 and the general use is for state, regional, and local planning and policy-making.

[2]Short- and long-term time periods for historical and projected patterns and processes differ between types of assessments.

Table 3—Attributes and characteristics typically associated with fine resolution, landscape assessments.[1]

Attributes	Landscape ecology	Terrestrial	Aquatic	Social/Economic
Geographic extent	Watershed	Watershed	Watershed	Household
Data resolution	≤ 25 ha	1-5 ha	Streams	Household
Organizational hierarchy	Streams and vegetation patterns	Species	Species	Household
Map scale	1:24,000	1:24,000	1:24,000	1:100,000
Time period[2]				
Short term	1-10 years	1-10 years	1-10 years	Months-5 years
Long term	10-100 years			

[1]The general size of these assessments is tens to hundreds of km^2 and the general use is for multi-forest/district, forest/district, or area planning and policy-making.

[2]Short- and long-term time periods for historical and projected patterns and processes differ between types of assessments.

Data resolution pertains to the amount of information incorporated in the data for a given area. As an example, using a hand lens to examine a rotting log yields more detail (higher resolution) than taking pictures from an airplane. The degree of resolution generally focuses on ecosystem patterns and processes that are best addressed at a particular geographic extent. For example, in regional and sub-regional scale assessments, it may be difficult to adequately address ecosystem patterns and processes using only low resolution information, such as habitat conditions for species with limited distribution or small home ranges (O'Neill and others 1986). Similarly, assessments of economic patterns in rural communities may be more appropriate at landscape or larger geographic extents. In terms of map scale, resolution is the degree that different features may be distinguished.

Assessments made on a regional geographic extent show general trends and rates of change in resource condition, and describe broad-based existing conditions for key biophysical, economic, and social components. Such assessments describe social trends including trends in human population increases and urban versus rural economic growth. These assessments usually contain low resolution information on the spatial patterns of resources (for example, species distributions or mineral deposits) and associated risks to resource values (for example, fire and insect hazard).

Mid, sub-regional assessments provide more specific information than regional assessments. Mid-resolution data are usually used to provide information on patterns of vegetation composition and structure for sub-regional assessments. Similarly, the mid-resolution data describe trends in social well-being for communities of interest stratified by counties or groups of counties. For the Basin, mid, sub-regional assessments provide basic information about communities of interest, counties, and communities (places) across the Basin.

Assessments at the landscape extent or specific site extent provide the greatest detail (tables 1, 2, and 3). These assessments may cover landscapes, watersheds, individual project sites, or specific human communities. These assessments typically rely on high-resolution data regarding geology, soils, vegetation, streams, social aspects and economic systems. These assessments include information on individual communities and existing land uses, such as recreation and mining sites.

Assessments conducted over multiple geographic extents are important when describing ecosystems. For example, assessments made at the landscape or site geographic extents cannot adequately address general patterns and processes, such as habitat conditions for wide-ranging species or global climatic processes. In addition, regional and sub-regional assessments provide a necessary context for landscape assessments and more localized decisions. Together, assessments (ranging from site specific to regional geographic areas) provide a comprehensive setting in which to make the best-informed management decisions.

Conducting assessments at different geographic extents using appropriate data with appropriate resolution also can promote more effective stakeholder participation and learning. Many people see their interests affected primarily at the local level. They may choose not to participate in sub-regional or regional assessments because of an assumption that their local concerns will be diluted or unnoticed. Moreover, without the sub-regional and regional assessments, stakeholders and decision makers may have difficulty assimilating the magnitude and complexity of highly detailed, or localized landscape to site specific assessments. Conversely, stakeholders whose interests are national or regional may find it difficult to participate effectively in multiple landscape assessments based on high-resolution data.

Undertaking assessments at multiple geographic extents promotes the inclusion of more interests into the assessment process. It also serves to provide decision makers with the appropriate information for particular levels of decision making. Depending on the issues and policies being addressed, the type of assessment, data resolution, and geographic extent can overlap (tables 1, 2, and 3).

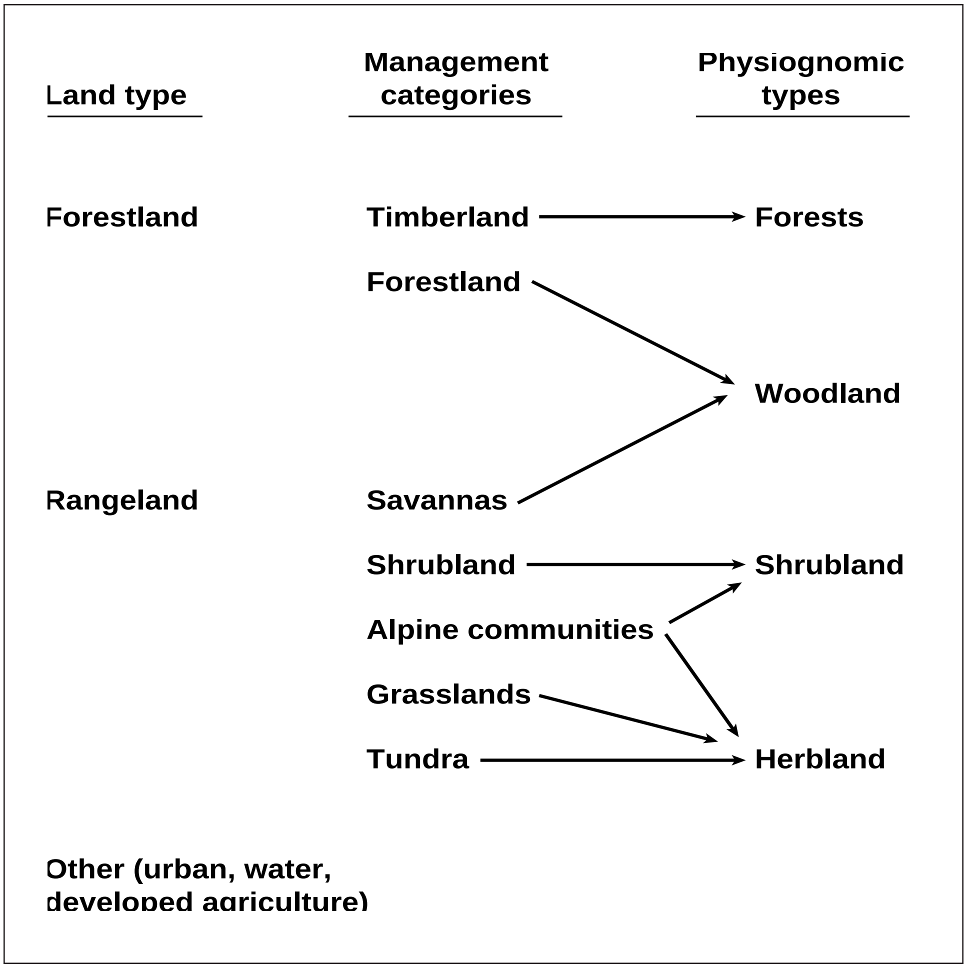


Figure 7—Typologies of land classifications.

Land classifications

Scientists and land managers use different terms when they describe the land base. In this integrated assessment we did not attempt to reconcile the terminologies but we do make clear how they fit together. The links between different typologies of land classification are shown in figure 7. On the left side are broad land classes as perceived by the public. In the center are management categories used by forest and range managers. These categories have formal definitions. Timberland is forestland that produces or is capable of producing crops of industrial wood, and that is not withdrawn from timber harvest by statute or administrative regulation. It is capable of producing more than 20 cubic feet per year of industrial wood. Wilderness areas are an example of forestland that may be capable of growing 20 cubic feet per year but have been withdrawn (placed in reserved status) by Congressional action. Forestland is land with at least 10 percent of the area containing forest trees of any size. Forestland includes transition zones such as Pinyon-juniper in the Southwest portion of the Basin, and forest areas adjacent to urban and developed lands. Rangeland management categories are delimited by the types of native vegetation (climax or natural potential) that dominate a site. The five categories listed are those found in the Basin. The right column lists the four classifications of plant communities used in the landscape characterization in the ICBEMP study. The links between terms are shown although there are slight differences in exact definitions. For example, the definition of the woodland plant community relies more on a percent canopy than on a measure of growth. In this integrated assessment, forestland is a close proxy for woodland.

Biophysical template

The biophysical template is described by the interaction of disturbance and successional processes, and constrained by the spatial and temporal dynamics of the geologic, landform, hydrologic, soil, and climate processes. It controls the spatial and temporal dynamics in which species have evolved. The concern among ecologists is the lack of use of the biophysical template as a reference condition. Current biophysical conditions represent the accumulated effects of succession and disturbance regimes that have been significantly changed since the settlement of the Basin. The result has been both losses and gains of species, fragmentation of habitats, disturbance events that have higher intensities than co-developing soils and stream channels, loss of productivity, establishment of non-native species, and less favorable conditions for some native species.

Implicit in the goals for ecosystem management is working with the complexity of the biophysical template to provide people with ecosystem goods, functions, and conditions they want. Such an approach requires an understanding of rates of change and the evolutionary nature of the values that determine the biophysical template.

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