# *Utilitarian and Ecosystem Perspectives*

# Concepts of Forest

T.E. Kolb

*Several factors lead to the failure of many southwestern ponderosa pine forests to meet criteria needed to satisfy an ecosystem definition of a healthy forest. For example, high stand density and forest floor accumulations make these forests increasingly vulnerable to widespread destructive fires.*

By T.E. Kolb, M.R. Wagner, and W.W. Covington

The term "forest health" is being increasingly used in the context of forestry and natural resource management. For example, the term has been the subject of several articles in the *Journal of Forestry* and a recent Society of American Foresters task force report, *Sustaining Long-Term Forest Health and Productivity* (Society of American Foresters 1993). "Forest health" is also increasingly used in government mandates concerning forest management. For instance, the Forest Ecosystems and Atmospheric Research Act of 1988 mandated surveys to monitor long-term trends in the health of forest ecosystems (Burkman and Hertel 1992). Moreover, forest health has emerged as a central objective for the desired future condition of forests; to some extent it replaces management for sustained commodity output (USDA Forest Service 1993a, Society of American Foresters 1993).

Despite its widespread use, forest health is frequently used without a clear definition, making its application to forest management difficult. Where the term has been defined (McIntire 1988, Monnig and Byler 1992, USDA Forest Service 1992, USDA Forest Service 1993a), alternative definitions and viewpoints of forest health have not been thoroughly discussed. Given its growing use and importance as a management objective, the overall concept

# Health

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needs to be more thoroughly examined. Foresters and other natural resource professionals are and will be participants in public debates over land management that use health analogies and metaphors. The potential for miscommunication is great. Therefore, it is essential that a common definition and conceptual understanding be agreed on. The need for clarity is even greater when a healthy forest is viewed as a desired future condition and maintenance of forest health is viewed as a constraint that may limit forest uses on public lands.

This article discusses different definitions of forest health, problems in scaling the concept of health from individual trees to ecosystems, and the relationship between forest health and pest management. Southwestern ponderosa pine *(Pinus ponderosa)* forests are often used as an example. The central point is that ambiguity should be minimized by defining the term, or at least by discussing the concepts included, each time it is used.

## Conventional Definitions

Although forest health is a relatively new term in forestry, notions of land health have existed for millenia (Norton 1991). Most contemporary views of forest health stem from the writings of Aldo Leopold (Leopold 1949, Callicott and Flader 1992). In several essays, Leopold decried widespread symptoms of land "sickness," such as reduced vegetation cover and the ensuing soil erosion, resulting from land abuse. He argued for the practice of land health in which practitioners would seek to maintain the sustainability of ecological conditions and processes by conserving the ecological integrity or coevolved diversity of the land. Leopold supported the restoration of sample native ecosystems present before industrialization of the American landscape. These restored areas were to serve both as laboratories and as standards for comparison in the practice of land health (Flader 1974).

More recent definitions of forest health range between utilitarian and ecosystem perspectives. From a utilitarian perspective, a desired state of forest health can be considered "a condition where biotic and abiotic influences on forests (e.g., pests, pollution, silvicultural treatments, harvesting) do not threaten management objectives now or in the future" (USDA Forest Service 1993a, p. vi). That is, a forest is considered to be healthy if management objectives are satisfied, and unhealthy if they are not. "Consistency with objectives" is a central theme in many utilitarian definitions of forest health (Monnig and Byler 1992; Society of American Foresters 1993; Wilson and Tkacz, in press) and is rooted in the traditional definition of pests as species that interfere with intended uses of forests (Barbosa and Wagner 1989). This theme has been criticized because, on one hand, a healthy forest depends on meeting management objectives; on the other hand, a healthy forest is a management objective according to recent ecosystem management philosophies (Wagner, in press). Thus, this utilitarian approach to defining forest health suffers from circular logic, where a desired state of forest health depends on the occurrence of a healthy forest!

The utilitarian definition takes into consideration a landowner's management objectives and recognizes the inevitable influence of humans on forests. Moreover, the utilitarian definition implies that a healthy forest can be described by many standards. A single forest condition could be viewed as healthy from one perspective or use but unhealthy from another. For example, a common component in southwestern ponderosa pine forests is dwarf mistletoe *(Arceuthobium vaginatum)*. Dwarf mistletoe is known to reduce the


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growth of ponderosa pine (Beatty 1982) and increase mortality (Hawksworth and Geils 1990), and would be viewed as unhealthy from the perspective of wood fiber production. However, bird abundance and species richness is higher when dwarf mistletoe is present (Bennetts 1991). Consequently, the presence of dwarf mistletoe may constitute a healthy condition from the perspective of bird species habitat and diversity. Thus dependency on objectives can create obvious problems in generating a definition of forest health.

The utilitarian perspective is especially appropriate in situations with unambiguous management objectives for management units. However, this situation is largely restricted to private industrial forestlands that emphasize the production of wood fiber, and wilderness areas that emphasize the preservation of biodiversity and natural processes. Managing for multiple objectives, which occurs on most National Forest System lands, complicates the prioritization of objectives. Some authors have proposed simplifying the formulation of objectives—and consequently the evaluation of forest health—by returning to a management philosophy that allocates land to categories of similar uses (Seymour and Hunter 1992, Wagner, in press).

Such difficulties indicate the need for an ecosystem perspective that emphasizes the basic ecological processes that create and maintain forest conditions to potentially satisfy a range of diverse objectives. For example, "A forest in good health is a fully functioning community of plants and animals and their physical environment" and "A healthy forest is an ecosystem in balance" (Monnig and Byler 1992, p. 16). These statements are a good starting point for thinking about forest health from an ecological perspective. Terms such as "balance" and "function" effectively steer us toward the complex relationships that ecosystems exhibit. However, these definitions specify conditions that can be difficult to understand and measure: In balance with what? What is meant by fully functioning?

Other ecosystem definitions include the idea of resilience: "A healthy forest is one that is resilient to changes" (Joseph et al. 1991, p. 7); "The term forest health denotes the productivity of forest ecosystems and their ability to bounce back after stress" (Radloff et al. 1991, p. 42); or "Forest health can be defined as the ability of a forest to recover from natural and human-caused stressors" (USDA Forest Service 1992, p. 10). While resilience to catastrophic change at the landscape level may be a desired component of a healthy forest, measuring the degree of resilience is difficult. Although lack of resilience is evident a posteriori when a forest has been significantly altered by stress or disturbance, the a priori presence of resilience is difficult to quantify. In other words, we really don't know the degree of resilience of a forest until it has been exposed to and changed by stress or disturbance. This difficulty in measuring resilience suggests the problems associated with its use in defining forest health.

*The health of a stand must consider many more dimensions than the health of a single tree.*

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**An Alternative Definition**

A more useful definition of forest health from an ecosystem perspective should include specific types and rates of ecological processes, and numbers and arrangement of structural elements that characterize diverse, productive, forest ecosystems in major biogeographic regions. Haskell et al. (1992) suggest that a healthy ecosystem should be free from "distress syndrome." This syndrome is characterized by reduced primary productivity; loss of nutrient capital; loss of biodiversity; increased fluctuations in key populations; retrogression in biotic structure (a reversal of the normal successional processes whereby opportunistic species replace species more specialized in habitat and resource use); and widespread incidence and severity of disease (Rapport 1992).

Unfortunately, quantitative information on rates of many essential ecosystem processes that create and maintain diverse, productive forest ecosystems is presently not available for many regions. Although monitoring and assessment programs are planned, a quantitative approach to defining forest health will likely require many more years of research and monitoring.

In the absence of detailed quantitative information on desired rates of ecosystem processes, present definitions of forest health from an ecosystem perspective must at least include a qualitative statement of the types of processes, structures, and resources needed to support productive forests in the sense of satisfying at least some of society's objectives. For example, we consider a healthy forest ecosystem to have the following characteristics:

- the physical environment, biotic resources, and trophic networks to support productive forests during at least some seral stages;
- resistance to catastrophic change and/or the ability to recover from catastrophic change at the landscape level;
- a functional equilibrium between supply and demand of essential resources (water, nutrients, light, growing space) for major portions of the vegetation; and
- a diversity of seral stages and stand structures that provide habitat for many native species and all essential ecosystem processes.

Specifications within these four criteria allow for definitions that span the gap between natural landscapes (i.e., preindustrial or presettlement characteristics) and artificial landscapes (e.g., intensively managed for industrial uses).

This definition implies that a useful ecosystem concept of forest health must consider patterns and rates of change in forest composition and structure, or successional processes. Leopold recognized the temporal variability of forest vegeta-

tion when he wrote that "health is the capacity of the land for self-renewal" (Leopold 1949, p. 259). Any definition of forest health must consider the capacity for forest replacement within the timespan of successional processes.

Acceptable rates and patterns of forest replacement following disturbance will vary widely among different ecosystems and climatic regions, but should reflect historical rates and patterns (Monnig and Byler 1992) to the extent that these rates and patterns meet human needs. For example, a long succession to forest cover following disturbance is not necessarily an indication of poor forest health if slow succession is characteristic because of naturally harsh environmental conditions. This definition also recognizes that catastrophic change in vegetation composition and structure following stress or disturbance is inevitable over portions of a landscape. However, catastrophic change may be undesirable when it occurs at spatial scales other than those experienced over a long historic time period.

An emphasis on the balanced availability of resources for portions of the vegetation, instead of for all the vegetation, recognizes succession as a natural process that can occur at least in part because of changes in resource supply to vegetation components. For example, the emergence of late-successional species is partially a consequence of the decline of early-successional species as they fail to acquire resources at levels sufficient to meet their high nutritional and metabolic demands. We should not automatically assume that all instances of decline by a single species, or groups of species with similar ecological characteristics (i.e., early-successional or pioneer types), reflect poor forest health. Evaluation of forest health must be made within the context of successional processes and ecosystem dynamics.

### The Problem of Scale

Much of the current ambiguity about forest health has arisen from attempts to take a concept developed at the individual organism level and apply it to a landscape process. Most dictionary definitions of "health" emphasize the condition or functioning of a single organism. Extension of this concept to a complex system, such as a forest, is based on making an analogy between the functioning of an organism and an ecosystem. For example, Kessler (1992) compared the health of a human with the health of a forest ecosystem. This presents both scientific and practical problems (Ehrenfeld 1992). From a scientific perspective, it is difficult to determine a normal state for communities whose characteristics are often in flux because of disturbance. From a practical perspective, attempts to define health in rigorous scientific terms may diminish its present value as an intuitive, general concept. In fact, Ehrenfeld concluded that health is not a valid ecological concept, although it does have value as a bridge between scientists and nonscientists regarding attainment of values from ecosystems. Although the limitations of the term suggest that it should not be used in a rigorous ecological context, it is likely that "health" will continue to be used to describe and mandate management objectives for forests.

Health has been applied to forest ecosystems at several scales ranging from an

## A Definition of Forest Health

At a recent town-hall meeting preceding a symposium on ecosystem management in Spokane, Washington, Gray Reynolds, deputy chief of the USDA Forest Service in charge of the National Forest System, offered the following definition of forest health: "Forest health is a condition of forest ecosystems that sustains their complexity while providing for human needs" (Sampson et al. 1994).

This definition is the product of interdisciplinary collaboration among more than 50 natural resource professionals. In 1993, the 6 authors of the *Forest Health Conditions in Idaho* report (O'Laughlin et al. 1993) developed a draft definition, which was scrutinized by the 12 technical reviewers of that report. Reviewers' feedback was incorporated before the definition was presented to a forest health workshop in November 1993. The 35 scientists and resource managers participating in the workshop—cosponsored by American Forests, Idaho Department of Lands, Boise National Forest, Boise Cascade Corporation, and the University of Idaho's College of Forestry, Wildlife and Range Sciences—further refined the definition.

The authors defined forest health broadly, purposely avoiding descriptions of ecosystem complexities and the ways forests can fulfill human aspirations. Although definitions are a necessary first step in communicating, words are not as important as the concerns they represent. This definition is offered so the important work of preventing unhealthy conditions and restoring healthy conditions in forests can begin in earnest.

Forest health is a useful communication device for building interdisciplinary bridges among professionals and for relating biological and managerial complexities to something people can understand. As it does in other contexts, the health concept can inspire human imagination to not only recognize forestry problems but seek solutions to them.

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individual tree to the landscape level. The concept becomes more ambiguous as the system to which it is applied becomes increasingly complex. One definition of health, absence of disease (Haskell et al. 1992), actually leads to a precise definition for individual trees because disease can be defined as a "deviation in the normal functioning of a plant caused by some type of persistent agent" (Manion 1991, p. 8). In this context, the health of a tree can be evaluated by such indicators as crown condition, growth rate, and external signs of disease-causing agents. A dead or dying tree is not healthy.

The health of a stand must consider many more dimensions than the health of a tree. The health of a stand relates to the management objectives for that stand (utilitarian perspective) and to the long-term functioning of the organisms and trophic networks that constitute the stand (ecosystem perspective). Tree mortality in a stand would not indicate an unhealthy condition as long as the rate of mortality was not greater than the capacity for replacement. Stand objectives such as wildlife habitat, soil and water protection, and preservation of biodiversity do not require that all trees be healthy. A dead tree is not healthy, but it may be part of a healthy stand.

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And again, the health of a forest ecosystem or landscape is more complex than the health of a stand. The health of an ecosystem depends both on society's objectives for the forest (utilitarian perspective) and on the interaction of biotic—including human—and abiotic processes that produce the range of habitats required for continued existence of native species (ecosystem perspective).

### A Need for Sideboards

The concept of forest health must have clear bounds. Many forest pest management specialists think of themselves as forest health specialists. For example, the current emphasis of the USDA Forest Service's National Center of Forest Health Management is the development of pest management strategies and technologies (USDA Forest Service 1993b). However, based on our definition of forest health, forest health specialists would require broad training in physiology, ecology, and ecosystem science.

We suggest restricting the term "forest health" to the examination of the role of biotic and abiotic agents in ecosystem-level processes. Pest management would then be a subdiscipline emphasizing the role of biotic and abiotic agents in the production of commodity outputs. Entomologists and pathologists would continue and hopefully increase their examination of the role of insects and diseases in ecosystem-level processes.

### The Southwestern Ponderosa Pine

Given our definition of a healthy forest ecosystem, when is a forest considered unhealthy? The type of thinking needed to answer this question can be illustrated by using ponderosa pine forests in southwestern United States as a case study. The four essential elements in our definition of forest ecosystem health are (1) physical and biotic resources to support forest cover; (2) resistance to catastrophic change and/or ability to recover after catastrophe; (3) functional equilibrium between supply and demand of essential resources; and (4) diversity of seral stages and stand structures. The physical and biotic resources are in place to support ponderosa pine forests in most areas of the Southwest that have historically supported them, except perhaps some riparian sites. Using this criterion, these ponderosa pine forests are probably healthy. However, it would be difficult to argue that this forest type is healthy under the other three criteria.

A significant threat of catastrophic change in forest composition and structure at the landscape level exists in much of this forest due to pine bark beetles *(Dendroctonus* spp., *Ips* spp.). These insects are well known to reach outbreaks when forest stand density exceeds the carrying capacity of the site (Sartwell and Stevens 1971, Barbosa and Wagner 1989). Conditions are favorable for pine bark beetle in northern Arizona and "it is probably only a matter of time before another large outbreak occurs" (Wilson and Tkacz, in press). Tree mortality associated with widespread bark beetle outbreaks often increases the risk of severe, stand-replacing wildfire over large areas.

The present high stand density and forest floor accumulations in many southwestern ponderosa pine forests, compared to presettlement conditions (Covington and Moore 1992, 1994), has increased the destructive potential of wildfires until there is a significant risk of eliminating forest cover at the landscape level. These factors have also probably created an imbalance between demand and supply of water, nutrients, and growing space for major portions of the vegetation (Covington and Sackett 1986), especially herbaceous vegetation (Covington and Moore 1994). Nutrient cycling rates are likely low because of fire exclusion and the lack of compensating factors such as microbial decomposition. This creates a situation in which large nutrient reserves in forest floor material are in a form unavailable to plants (Covington and Sackett 1990).

The relatively homogeneous nature of the southwestern ponderosa pine forest does not provide a balanced diversity of seral stages and stand structures. Underrepresented types include native prairie vegetation, tree regeneration, and old-growth (USDA Forest Service 1993c). Forests tend to be even-aged with a dense, uniform canopy and little recent regeneration. These conditions were created in the early part of this century by grazing practices, fire exclusion, and other environmental conditions favorable to pine establishment. Thus, many southwestern ponderosa pine forests fail to meet three of the four criteria needed to satisfy our ecosystem definition of a healthy forest.

### Forest Health Summary

Although problems arise in using health concepts to describe the complex array of factors that influence ecosystems, the growing use of the term demands that natural resource managers understand health issues. Individual views of a healthy forest may vary considerably between utilitarian and ecosystem perspectives, as well as over spatial scales. However, the ecosystem perspective of forest health does not necessarily conflict with the utilitarian perspective if both are applied to large landscapes with a mosaic of different

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stand ages, structures, and levels of management that satisfy the range of demands placed on the landscape by society. Satisfying these demands requires maintaining, over the landscape, many native species and all the ecosystem processes that ultimately provide resources and habitat for their survival.

Real forest health problems exist in some areas in the western United States where conditions have been altered over the past several decades by intensively harvesting early successional species or excluding fire in fire-adapted ecosystems (Wickman 1992, O'Laughlin et al. 1993, Covington and Moore 1994). However, present concerns over forest health also reflect a failure to define management objectives that are acceptable to society.

In the absence of well-defined and widely publicized management objectives that reflect the diversity of values held by society, forest health will continue to be a concern—even with dramatic breakthroughs in scientific understanding of forest ecosystem processes. On the other hand, public expectations must be tempered with the understanding that, in many cases, the range of potential values from forests is limited by biological constraints.

Forest scientists can provide information on types and rates of ecological processes that lead to and maintain certain forest conditions, and design management strategies to produce these conditions. However, the specific forest conditions that satisfy public objectives are ultimately a socioeconomic decision. JOF

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