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New Perspectives in Forest Management: Background, Science Issues, and Research Agenda

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Abstract

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Scientific, management, and social factors that have contributed to changes in United States forest management are examined. Principles underlying new approaches are developed and implications are considered at various spatial and temporal scales. A general framework for a research program is outlined.

Keywords: Landscape management, National Forests.

Summary

The decade of the 1980s was a turbulent time for forest managers and forest scientists; if anything, challenges increased in the 1990s. One result of this turmoil was the development of "new perspectives" in forestry. But whether these new perspectives represent genuinely new thinking about forest management or are merely a reshuffling of existing concepts is not clear. This paper emphasizes scientific, management, and social factors that have contributed to changes in approaches to forest management.

Preliminary hypotheses of the scientific content of new perspectives include the scale at which questions are raised; the degree to which objectives and assumptions are being questioned; and a view of the forest as a system, rather than reducing it to components. In giving attention to issues at spatial scales larger than the forest stand, and in explicitly recognizing of the need for interdisciplinary approaches, these new perspectives in forestry differ most from previous forest management science.

Introduction

Forestry seems to be in the midst of a revolution. The literature describing the changing perceptions of forest scientists and changing practices of forest managers is burgeoning, and only a little of it is in traditional, peer-reviewed journals. Some of the interesting literature is not in journals at all. Meetings with "new" in their title abound, areas demonstrating "new forestry" have been established by managers of Federal, state, and private land, and the USDA Forest Service has begun a national program, "New Perspectives for Management of the National Forest System." The flurry of activity around issues of forest management suggests that something is happening in the normally somnolent world of forestry.

But whether these new approaches represent genuinely new thinking about forest management is not clear. What is new about "new perspectives"? What is new about "new forestry"? And are the two terms, often used interchangeably, different? No clear consensus exists as yet among scientists or among natural resource managers about what these terms mean or what exactly is new. For such a consensus to evolve requires clear definition of the issues faced by forest management in the 1990s.

A note on terminology is in order. The term "new perspectives" has been applied to an amorphous set of ideas, a proposed USDA Forest Service priority research program, and generically, to an ad hoc movement to change some of the traditional practices of forest management. Here, we use *new perspectives* to indicate the changing management precepts and guiding philosophies, including reconsideration of the public's role in forest planning. More recently, the term "new perspectives" has been used less and the effort to achieve broad biological objectives has been termed "ecosystem management." *New forestry* is a collection of specific silvicultural and landscape management practices designed, according to its advocates, to achieve the objectives of new perspectives (or ecosystem management).

Background

The Social and Political Context

The emergence of new perspectives in forestry can be traced to converging developments in forest science and management, and to trends in technology, sociology, and politics. We begin with a brief discussion of these trends and developments because they bear on what is demonstrably "new."

In many ways, the essential components of new perspectives in forestry are neither unique nor new. Similar concerns are reflected in debates over agricultural policy, agricultural practices and science, and viewed more broadly, energy, industrial, and environmental policy. Concern over human impact on ecosystems at the local, national, and global scale is not restricted to forestry.[1] Neither are these concerns new; intensified debates over forest management on public land in the Western United States coincide with the 20th anniversary of Earth Day—an expression of popular awareness of the impact of humans on the environment. The first Earth Day (in 1970) was itself a manifestation of social, political, and economic changes that developed over decades. Public perceptions, public debate, and public policy have been shaped since the early 20th century by observations of unintended and irreversible human impacts on the global environment and the need for controls on the type and scale of human activity (Koppes 1988). The lessons of both ecology and economics demonstrate that the systems we depend on are complex, with connections between apparently independent parts, and actions have consequences that may spread throughout the system and endure or even accumulate through time.

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[1] See, for example, Battie (1989), Brundtland (1989), Ehrlich (1989), and Leopold (1990).

Two factors dominate the social changes giving rise to new perspectives. First is the increased recognition that growth in both population and resource use are reaching—or already exceed—rates that can be maintained without degrading natural systems. This recognition now influences the thinking of even those who see natural systems as no more than sources for raw materials or sinks for wastes. Awareness of the human transformation of ecosystems is now broad-based. Although no consensus has been reached about specific limits to human exploitation of natural systems, few deny these limits exist.[2]

At the same time, though, the list of commodities and services people want or expect from natural systems, perhaps especially from forests, gets longer. In addition to traditional forest-based commodities, such as timber, water, wildlife, and forage, society increasingly values forests for such things as age, absence of human disturbance, biological diversity, and their role in regulating or mitigating climate change. Many of these newly recognized, or newly emphasized, values depend on conditions of intact forests rather than on products, such as timber, removed from them. These views of forests are, at their core, utilitarian in the sense that they originate in the objective of satisfying human needs or desires.[3] In this sense, they are in keeping with the tradition of forest management in which the owner's, in this case society's, objectives establish the goals of management. This use of the term "utility" should not be confused, however, with the need to produce commodities. Forest managers are understandably frustrated: many are ill-equipped to understand, let alone balance and satisfy, these diverse, often mutually exclusive, ill-defined expectations.

The Forestry Context for New Perspectives

The science of forest management science always has relied on an understanding of forest ecosystems. But the nature and depth of this traditional understanding of ecological processes, and the uses to which it is applied, now are being critically examined.

From the start of the 20th century through the late 1960s, forestry in the United States was directed mainly towards relatively simple utilitarian goals—primarily the production of wood fiber. From the time of Gifford Pinchot (the first Chief of the Forest Service, 1898-1910) to the present, most state, Federal, and private timber managers have practiced some form of "scientific forestry." They have applied the tools of modern crop science (such as genetics, fertilizers, pesticides, pruning, thinning, prescribed fire, and replanting) with the primary purpose of rapidly growing healthy stands of commercially valuable trees, often as monocultures. The significant analytical problems for managers were to determine desirable amounts of growing stock and the best time for harvesting, and whether to control forest stand and tree characteristics or to capture mortality before final harvest. The central problem of

[2] Some suggest very different interpretations of data from the past few decades; for example, Simon (1981) does not deny the existence of limits, but argues that the data demonstrate that resources are not scarce in an economic sense.

[3] For example, viewing forests as a place for spiritual renewal, as an essential component in global systems, or as a reservoir of diverse flora and fauna (on whose existence the future quality of life depends) all can be termed utilitarian.

forest science and management was to determine the response of single trees and groups of trees to various management actions. Some forests—mostly public—were managed for purposes other than timber production, such as wildlife, recreation, and watershed protection, but often only to the degree to which these goals did not conflict with the primary goal of timber production.

The rise of the environmental movement in the late 1960s and early 1970s and the dramatic increase in recreational use of forests presaged a growing concern with managing forests for purposes other than timber production. The National Forest Management Act of 1976 (NFMA) reinforced this view by mandating that managers of National Forests analyze the impacts of forest planning decisions on all forest resources, not just timber. The response of land managers has been to develop a lexicon of "outputs" and to define the value of nontimber forest resources in relation to foregone commodity outputs. In National Forest plans, for example, alternatives generally are described in terms of tradeoffs among outputs such as board feet, user-days of recreation, pairs of pileated woodpeckers (*Dryocopus pileatus*), and tons of sediment. Not coincidentally, measures of previously unquantified forest "products" correspond with the use of linear programming models such as FORPLAN (Johnson and others 1986).

Predictably, applying these approaches and tools divides the forest into areas reserved for special uses, such as wilderness, wildlife habitat, and riparian buffers, that exist in a framework of land managed for timber production. With few exceptions, Forest plans deal with the total area of forest in each use; the actual pattern or distribution of stands, set-asides, or harvest units is addressed in only a minor way. Pattern is controlled primarily by timber management considerations.[4]

Effect of pattern—Perhaps the first major impetus toward a reexamination of some of the basic tenets of forestry, and also perhaps the origins of the perspectives we now label "new," occurred in the mid-1980s. It began with the recognition that certain types of problems were not being addressed by segmented, pattern-insensitive approaches to forest management. Specifically, a set of issues emerged that was strongly influenced by the actual pattern of managed forest stands.[5] These include the viability of some wildlife species with habitat requirements that include interior forest conditions and dependence on large areas; a perceived loss of general ecosystem diversity, expressed in terms of species and in terms of physical or ecological characteristics; cumulative effects of management on watersheds, with connectivity through pathways for movement of water, sediment, wood, and energy emphasized; susceptibility and response of forests to pathogens, insects, and disturbances, such as fire and wind; and potential forest decline or change in the face of pervasive, slowly developing, and enduring factors, such as atmospheric pollution and climate change.

[4] This pattern-independent management has begun to change, and pattern-sensitive analytical techniques are being developed; broadly, however, pattern effects are examined only after management decisions have been implemented.

[5] See, for example, Forman and Godron (1981), Harris (1984), Franklin and Forman (1987), Hanson and others (1990), Swanson and others (1990), and Turner (1990).

Many of these problems became apparent only as forests were increasingly fragmented by the practice of dispersing logging and associated activities over as wide an area as possible (most common in Federal forests). The policy of dispersed harvesting was itself a response to negative impacts on forest ecosystems associated with extensive, contiguous harvest blocks. Recently identified problems (such as maintaining habitat for species requiring large areas and contiguous blocks of forest) reflect advances in understanding of forest ecosystems, and they are a direct consequence of effects cumulating over decades. The scope and pace of timber harvesting in the Pacific Northwest—the focus, if not the origin of many of these issues—is probably no more extensive or rapid than that in other regions or in other eras.[6] What is different in the Pacific Northwest is that harvesting effects have coincided with public and scientific recognition of forests as sources of things other than timber. These issues can be addressed only by explicitly recognizing the importance of forest pattern at a spatial scale larger than is typical of forest management.

Ecosystem complexity—A second impetus for new perspectives comes from increased recognition by forest ecologists of the complex web of interactions in forests and the importance of biological and physical diversity in maintaining healthy forest ecosystems. This view is reflected in recent studies documenting the importance of key attributes of natural forests.[7] Among these are the identification of the multiple functions of woody debris (in all forms) in forests and streams; "legacies" from previous stands of structures, organisms, and soil chemical properties that maintain site productivity and regenerative capabilities; the complex interactions among organisms (such as rodents and spiders) whose roles previously were unrecognized; and interactions among tree species, which maintain site productivity and resilience to infestation or disease. This new information has contributed to a shift in support away from traditional forest practices in the Pacific Northwest, such as clearcutting, burning of all residual material, removing woody debris from streams, and planting of single species. More important, these results of forest science share a recognition of the importance of thinking about forest productivity and health through multiple rotations and have fostered a sense of humility about current understanding of forest ecosystem dynamics.

New technology—A third inducement to develop new perspectives has been recent developments in computer-based technologies suitable for handling multiple-resource problems over large areas and long time scales. Advances in Geographic Information Systems (GIS), for example, have dramatically increased the capacity of resource managers and researchers to manipulate, model, and monitor representations of forest landscapes with microcomputers or minicomputers. Forests now can be inventoried by remote sensing (with greater frequency and coverage than with land-based methods) and resulting data organized in GIS. This ability to locate, classify, and monitor the spatial distribution of multiple forest resources and attributes over an entire landscape has changed the scope of questions that can be asked. We now can monitor, for example, changes in the abundance and distribution of large areas

[6] Although logging in the Pacific Northwest began in the middle of the 19th century, roughly two-thirds of all timber removed (for industrial products) has been harvested since 1950.

[7] See, for example, Maser and others (1988), Franklin (1989), Franklin and others (1990), and Swanson and Sparks (1990).

of forest with various characteristics and examine associated wildlife populations. Questions about forest pattern are now not just relevant; they also are approachable. The proliferation of computer-based analytical methods has led to increased use of and reliance on mathematical models and simulations for extrapolating trends and predicting outcomes.

Social and political influences—Social and political factors have contributed a fourth motivation for changes in forest management and science. Prolonged and acrimonious public debate among forest users—the public, organized interest groups, forest resource managers, and forest scientists—underscores conflicting values and changing expectations for forest resources.[8] These conflicts are revealed in questions on harvesting old-growth forests, preserving species of plants and animals, and the importance of forests in regulating or mitigating changes in the global climate. These debates also suggest that, in general, interested parties no longer are willing to let a narrowly trained group of experts (that is, forest managers, planners, and scientists) prescribe forest practices in isolation. A larger and more diverse cross-section of the population is seeking an active role in the process of planning the management of forests. Legislation, most notably the NFMA and the Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA), have encouraged and promoted this involvement.

By most accounts, the increasingly polarized prescriptions promoted by special interest groups ("lock it up" or "cut it down") have resulted in an impasse and paralysis of the political process. Stopgap, temporary arrangements may buy some additional bargaining time but do not represent long-term solutions. In this polarized environment, the concepts of new perspectives are appealing alternatives because they seem to embrace ecological values without rejecting commodity production. Whether this provides a basis for resolution of conflicts will depend on the existence of a scientifically legitimate middle ground and the ability of scientists, managers, and others to compromise and build a consensus based on it.

Agency climate—Changes in Federal land-management agencies, most notably the USDA Forest Service, also promote a new agenda. Widespread dissension over appropriate objectives and priorities within the Agency parallels the contentious debate occurring outside the Forest Service. Low morale in the Agency, in large part resulting from employees' sense of being caught in the middle of a no-win debate, contributes to a willingness among individuals to seek solutions other than a continuation of current policies and practices. Although some individuals question whether attitudes of managers in the Forest Service have changed (see, for example, Twight and Lyden 1988), the creation and growth of organizations such as the Association of Forest Service Employees for Environmental Ethics (AFSEEE) suggest both discontent among managers and a willingness on their part to act.[9]

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[8] Some of these issues are discussed further in Shepard (1990). See also discussions in Overton and Hunt (1974), Daniels (1987), and Behan (1990).

[9] For elaboration of this point see Niemi and others (1991). AFSEEE is described in the periodical, *Inner Voice*; AFSEEE, P.O. Box 11615, Eugene, OR 97440.

The role of science—Along with changes in the objectives, philosophy, and process of management, a fundamental change also is taking place in the role of forest scientists. These changes are consistent with those being experienced by scientists in other fields. Forest scientists traditionally have offered managers certainty and tools for controlling systems; the practice of this science depended on thorough, controlled experiments and effective transfer of proven techniques to forest managers. The emerging role of scientists is primarily in identifying uncertainties and in pointing out the complexities of systems to managers. This science must be conducted without the luxury of unlimited time, with an explicit recognition of limits to certainty, and in the presence of contentious debate.

Changes in the burden of proof and standards of evidence for decisionmaking may be more significant than the change in focus (away from an emphasis on timber production). Current management policies and practices have ecological, economic, and social consequences that benefit some and harm others. Increasingly, advocates of intensive forestry must prove these practices benign, whereas in the past, critics had to prove them harmful (to wildlife, for example). A critical set of questions—affecting the content, methods, and role of science—focuses on the standards established for making or changing decisions. Confusion among members of the public and conflict within the scientific community frequently arise from the use of different standards for gathering, evaluating, and drawing conclusions from data. Determining who sets the standards and who must meet these standards are as important to the outcome as is the nature of scientific hypotheses. A further complication, beyond differences in values and management objectives, is differing opinions on the type and distribution of risks that are seen as acceptable.[10]

Policy decisions and management decisions always are made in a climate of uncertainty. Those who make decisions require analytical tools developed with a recognition of the imperfect nature of information. To provide these tools is the role of new perspectives research: the tools must include the best information available and focus attention on critical elements. Even if these tools are no more than rough guides for evaluating the effects of alternative choices, they can provide a systematic framework that identifies what we know and what we do not know.

Principles and Implications of New Perspectives

Some Management Precepts

Seen broadly, the development of new perspectives reflects changes in the philosophy of forest management; as a result, a particular set of prescriptions does not accurately or adequately characterize new perspectives. The new approach to management has grown from a set of hypotheses about how natural systems operate and about strategies appropriate for human use of forested ecosystems. Although some of these hypotheses have been tested, many have not. Indeed, testing some of them,

[10] Risks inherent in new forestry are discussed in: DeBell, D.S. Silvicultural practices and new forestry. Paper presented at the April 19, 1990, workshop, New forestry in the 90s, Coos Chapter, Society of American Foresters; and Atkinson, W.A. Another view of new forestry. Paper presented at the May 4, 1990, meeting, Oregon Society of American Foresters, Eugene, OR. Manuscripts. On file with: Pacific Northwest Research Station, Social and Economic Values Research Program, Forestry Sciences Laboratory, 3200 S.W. Jefferson Way, Corvallis, OR 97331.

in the strict scientific sense, may be difficult or impossible because they may properly be viewed as premises, assumptions, or statements of value. Distinguishing those assumptions that can be tested and determining how to test them are major challenges to the science community.

As with any evolving set of ideas, consensus does not exist. In fact, most discussions of emerging issues in forest management have been distinguished by the diversity of opinions represented. Several significant tenets or guiding principles that underlie most of these issues nevertheless can be identified:

- **Forest management decisions must be based on an ecosystem perspective.** An ecosystem perspective views forests as composed of organisms hierarchically organized into functional groups and linked through complex processes to their physical environment and to each other. An ecosystem perspective for management recognizes the need to design practices sensitive to the balance among various components of the forest. An ecosystem perspective is not a matter of managing ecosystems for their own sake, but a recognition of the context within which any management objective can be pursued. Management decisions also must take into account uncertainty about our understanding of the system and uncertainty about future conditions.
- **The effects of forest management need to be evaluated over a range of spatial scales.** Emergent properties at each of several spatial scales (microsites, forest stands, watersheds, landscapes, and regions) influence ecosystem response; these properties must be considered when the effects of human activities or natural disturbances are examined and interpreted. The threat to the spotted owl population (*Strix occidentalis*) is an example of what happens when spatial scale is not considered; landscape fragmentation occurring over a large area, and cumulating over time, conflicts directly with the habitat requirements of this species.
- **The effects of forest management decisions must be evaluated in light of ecologically relevant time scales.** As with spatial scale, extending the time scales for considering effects of forest management causes new perspectives and new issues to emerge. Questions about long-term site productivity, resilience of forest ecosystems in the face of changing climates or other disturbances, and the long-term viability of populations necessitates thinking across a range of ecosystem time scales. These time frames include the period over which vegetative succession takes place, cycles of major and minor disturbances, and the period defined by the life cycle of dominant ecosystem components and organisms. The cumulative effects of policies and practices must be assessed at a scale of space and time consistent with a fully developed forest ecosystem. This period extends well beyond typical planning horizons, even those of public agencies.
- **One of the premises of forest management must be maintaining future options.** Unresolved societal debates about the role of the forest, uncertainty about future climates, and lack of understanding of basic ecosystem processes force the conclusion that the wisest approach to forest management is to avoid foreclosing on future opportunities by hasty and irreversible decisions. Instead, forest planning and management decisions must be made with an eye to maintaining as wide a range of choices as possible for the future. Making sound choices requires consideration of how present actions will affect future forest patterns, species composition, susceptibility to a wide range of disturbances, and present and future economic opportunities.

- **The full range of forest users must be encouraged to participate actively as equal partners in forest planning decisions.** The current polarized climate clearly hinders reaching workable compromises and clear direction for forest management. Full participation of all those affected by forest management decisions requires developing creative and sincere partnerships with all groups of forest users, including commercial interests, environmentalists, recreationists, and scientists. Such participation is essential in reaching agreement on management objectives, in evaluating the consequences of specific practices, and in making difficult choices when values conflict or resources cannot satisfy all users.

A Framework for Research

The Need for a Framework

Given the range of issues and concerns encompassed by new perspectives, a conceptual framework must be developed to identify the scope of necessary research effort, to lay out key research objectives and approaches, and to assign priorities to research tasks. A framework is needed to provide a common language, to frame and test hypotheses, and to communicate results with other scientists, resource managers, and policy makers.

An interdisciplinary effort of this complexity and breadth might be organized in several ways. We have taken a systems approach in defining the research agenda because we believe it helps clarify the issues addressed by new perspectives and couches them in terms accessible to a broad scientific community. The systems approach has a long and rich tradition in ecology, as well as economics, as a method to deal with complex problems.[11] It is especially appropriate when the contributions of many disciplines must be integrated and focused on common or compatible hypotheses (Shugart and O'Neill 1979).

Some relevant research questions undoubtedly will fall outside this framework, but we have tried to encompass as many of the concerns as possible without making the structure unwieldy. The basic terms we use are defined in the next section; how research in new perspectives can fit within this framework is shown in the section, "A Research Agenda."

States, Stocks, and Flows

We begin with the premise that a forest ecosystem can be described by its states, stocks, and flows. A *state* is a description of the condition of a system by certain observable attributes measured at a given moment. Key attributes include, but are not limited to, the age, structure, and composition of vegetation; the type, abundance, and distribution of wildlife; and the type, magnitude, and distribution of human benefits from forested ecosystems. Old growth might be an example of a state description: it is a forest condition defined by an age-class of vegetation, structure of forest canopy, volume of dead and downed woody debris, and other attributes; old growth is trees, other vegetation (including decaying material), birds, mammals, and other

[11] See Boyce (1985), Shugart and O'Neill (1979), Smith (1970), and Watt (1966) for examples of systems analysis in ecology. Our approach draws heavily on that of these authors and others.

organisms and the manner in which they associate and interact in communities. No single or simple measure, such as age, is sufficient to describe the conditions recognized as old growth (Franklin and others 1981). Other states can be identified similarly by measures of condition and consequent processes.

Old growth is a state with tremendous popular appeal; however, other states are equally important to forest ecosystem processes and forest-dependent organisms. The limited nomenclature of states reflects the fact that little attention has been paid to describing or defining them. State descriptions depend on spatial scale; particular states may not be meaningful at all spatial scales, but all states have a scale-dependence. The definition of an old-growth stand, for example, is likely to have a different collection of attributes associated with it than an old-growth landscape will. Although some state definitions are distinctive and somewhat intuitive in their meaning (such as old-growth), others are less clear and may be defined for convenience as discrete conditions along a continuum. By definition, each state is a distinct and unique collection of attributes; however, one or more attributes may have equivalent values in one or more states.

Ecosystems change states over time in response to both successional (autogenic) and disturbance (allogenic) processes; disturbance includes human activity (management) as well as natural events such as fire, disease, and insects. Factors that develop slowly, such as atmospheric pollution and climate change, are less obviously disturbances in the same sense, but are likely to affect both successional and disturbance processes.

One obvious model for this discussion is the successional stages through which plant communities progress; in fact, our notion is to propose the development of a terminology and topology of states within the current understanding of forest succession. The resulting detail can provide the basis for examining interactions among conditions, processes, spatial and temporal scales, and disciplines. The essential difference between this and traditional forest succession modeling (see, for example, Shugart and West 1980) is that we include humans as an integral part of the system.

A given state supports various stocks and flows. *Stocks* are quantities of resources per unit area; these stocks might include the number or volume of standing trees, density of spotted owls or pine martens *(Martes martes)*, or miles of trail. Measures of stocks are likely to be among the attributes useful in defining the state of a system. *Flows* are the periodic yields from the stock of the system; these yields include water or sediment discharge, annual production of fiber, annual smolt escapement, or forest-dependent jobs. Stocks can be viewed as the capital of the system; flows are the equivalent of the income produced by this capital.[12]

[12] The concept of capital in the sense we use it here is developed in greater detail by Costanza and Daly (1991) and El Serafy (1991).

Forest science has historically emphasized developing tools, knowledge, and methods for manipulating stocks and flows without much attention to states. This emphasis reflects society's general perception that forests are primarily sources of commodities for human consumption. Commodities, in this sense, are tangible flows, separable from the system, and often are characterized in economic terms. Some of the most visible (and volatile) political issues in the forestry arena relate to reductions in stocks or disruptions in flows; for example, loss of individual species or economic dislocations resulting from reduced timber harvests. But many major forest issues—underlying debates in the social, political, and scientific arenas, such as forest fragmentation, biological diversity, and long-term sustainability—are more properly focused on the state of the forest ecosystem. This transition from a science concerned only with stocks and flows to one concerned with states and associated stocks and flows is a significant shift in perspective and may be a "scientific revolution" (Kuhn 1970).

A look at forest practices by their effects on states, stocks, and flows provides a common reference point for analyzing past, present, and future practices. As an example, consider how new forestry techniques might affect the risks of undesirable but uncertain outcomes inherent in management. Many current silvicultural practices were developed to increase the certainty of future wood fiber production (a flow) by reducing risk of regeneration failure or mortality from interspecific competition. In developing such practices, we may have accepted a certain measure of risk to the forest state of reduced biological, structural, or functional diversity. Proposed new forestry techniques, such as green-tree retention, may accept some increased risks to certain flows, such as wood fiber production, or produce states with higher susceptibility to catastrophic loss (for example, from fire, insects, or disease), while reducing the risk of reduction in long-term site productivity, system complexity (state characteristics), or loss of spotted owls (a stock).

The terminology of states, stocks, and flows helps communicate the nature of the tradeoffs associated with various actions; scenario analysis provides a method of organizing this information and examining possible future conditions. A *scenario* is a description of hypothetical changes in states over time; scenarios are characterized by sets of exogenous assumptions and rules specifying endogenous processes. To be most useful in both scientific and political discussions of possible future conditions, the rules and assumptions used to generate changes in either assumptions or processes must be stated. Fully depicting a scenario requires analysts to specify the basis for changes in exogenous drivers such as climate, land-use, and management practices and how the system responds to those changes. A consistent analytical framework (ideally, a formal model) provides the basis for interpreting the effects of assumed changes in these factors. Progressive changes in forest landscape structure over several decades that have resulted from dispersed harvesting (one assumption) or aggregated harvesting (an alternate assumption) are examples of scenarios driven by assumptions about the pattern of future harvests. Scenarios illustrate transitions between two states or transitions between a state and several successive states.

A Research Agenda

Research Objectives

The scientific approach outlined in the framework requires the definition of states, stocks, and flows and the development of scenarios describing the essential features of possible future conditions. Stated generally, six objectives of this science program must be:

- Define, characterize, and measure different forest ecosystem states.
- Develop methods to analyze quantities and qualities of stocks and flows of commodities associated with different ecosystem states.
- Evaluate social benefits, values, costs, and preferences associated with different states, stocks, and flows.
- Determine factors that influence transitions between states.
- Develop scenarios and analyze associated changes in states, stocks, flows, and benefits.
- Propose methods of public participation in defining objectives and in designing and implementing forest demonstration and research areas.

These objectives are defined broadly to provide a context for a broad spectrum of work to be conducted in the new perspectives program. Research in these areas must be conducted at several spatial scales. Examples of how spatial scales might be defined are shown in table 1.

Table 1—Definitions and examples of spatial scales

Physical processes	Spatial scale	Management
	Hectares	
Microsite	0.1-1	—
Stand	1-50	Cutting unit[a]
Watershed	50-5,000	Watershed
Landscape	500-20,000	District[b]
Multi-landscape	10-500 thousand	Timbershed[c]
Subregion	500-1,000 thousand	Forest[d]
Region	1,000-10,000 thousand	Oregon and Washington west side[e]

[a] Timber harvest for stand replacement is generally smaller than this on public lands, and larger on private lands.
[b] For example, a National Forest Ranger District. This also is equivalent to the smaller end of the spectrum where community issues (effects on towns and groups of towns) can be usefully examined.
[c] This classification is based on timber production and processing; a timbershed contains at least one major timber-processing center, and the majority of the timber processed originates in that timbershed. See Sessions and others (1990) and Beuter and others (1976) for timbershed definitions for Oregon. These range from single counties (such as Douglas or Lane County) to multiple counties.
[d] National Forests in Oregon and Washington range from 100 to 500 thousand hectares.
[e] All timberland in western Oregon (public and private) is about 5,000 thousand hectares.

Characterize states——Producing scientifically credible and workable definitions of possible states is the first and fundamental step; developing ways to define, characterize, and measure different forest ecosystem states is one of the principal challenges facing the research community. Research must provide both quantitative and qualitative descriptions of alternative forest states, either designed or unintentional, at all relevant spatial scales. The sets of attributes characterizing the states must encompass a broad range of biological, physical, and social (including economic) features.

Designed forest states are those developed for one or more specific management objectives, such as diversity, productivity, resiliency, complexity, or old growth.[13] Unintentional states may result from natural disturbance processes, such as wind and fire, interacting with either a natural or designed landscape. Producing scientifically credible and workable definitions of possible states is the first and fundamental step. Given descriptions of possible future states, social and political processes can be designed to determine which of them society prefers. The design and evaluation of social and political processes also can be approached with more deliberation and experimentation than has been used in the past.

New definitions of forest and ecosystem conditions will be required to expand our vocabulary of states behind simple terms such as "old growth" or "clearcut." These descriptions will be based on measures of forest or ecosystem condition, geometry, context, functions, capabilities, or capacities. Some state variables, such as the degree of forest fragmentation or the distribution of particular stands or landscapes of interest, can be measured and analyzed relatively easily with such tools as remote sensing and inventories. A profitable approach might combine layers of forest attributes (such as vegetational structure, topography, and wildlife distributions) in a GIS environment to produce maps and quantitative indices of state variables.

One goal of research conducted under this heading will be to identify the full range of states possible for specific ecosystems and landscapes. For example, Can all sites support old growth? Do disturbances, such as fires of different intensities, produce distinct states or a continuum of possible states? What characteristics distinguish plantation forests from natural forests? The result of this work will be an increase in our understanding of, and appreciation for the types and conditions of forests across the landscape.

Stocks and flows—Continued societal interest in the flow of products from forest ecosystems requires knowledge about the quantities and qualities of stocks and flows associated with different ecosystem states. With this knowledge, the effects of alternative forest states on key flows, including timber, water, sediment, target or indicator wildlife species, user-days, and carbon dioxide, can be assessed. Both quantity (total flux of products) and quality (of wood fiber or water, for example) must be addressed, and research must include an understanding of basic ecological processes.

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[13] One example of a designed forest state might be the "desired future conditions" identified in Forest plans.

Scientists need accurate methods to evaluate and measure flows of ecologically significant products. Possible approaches include retrospective studies, process studies, field experiments, computer modeling, and large-scale landscape experiments. Developing simulation models to analyze various flows and designing large-scale landscape experiments to test hypotheses and assumptions will be particularly important parts of this effort.

Social science—What social benefits, values, and costs are associated with different states, stocks, and flows? This is among the most critical elements of the research agenda. Research must be broadly directed toward identifying the range of societal benefits represented by different states, their derived stocks and flows, and specific scenarios. One obvious component of this research will be analysis of the direct economic benefits associated with specific states or scenarios (for example, forests managed primarily for timber, biodiversity, spotted owl production, or old-growth conditions). But economics research must go beyond simple measures of the number of jobs and the value of wages and instead produce a comprehensive view of the role of forest resources in economies and communities. We also must improve our ability to assess the economic and social benefits of forest attributes other than timber.

In a more general sense, research will be needed to identify the values assigned by the public to different forest states and scenarios. For example, What are the values attached to old growth? To plantation forests? To a forest managed primarily for diversity? To a fragmented forest? Methods such as computer simulations, videos, and public opinion sampling may be needed to identify how the public perceives different forest states. An important result from this line of inquiry may be effective methods of communicating visions of the future forest among different groups of forest users and, as a result, clear expressions of preferences.

Transitions between states—A major direction for work at the stand and landscape scales must be improving understanding of factors influencing transitions between states. Studies must focus on how natural and anthropogenic processes change the forest attributes that define states, such as vegetation age, structure, composition, and pattern. Changes in state may be due to succession, competition, and other autogenic processes or in response to changes in environmental conditions, such as fire, wind, and climate change. Linked retrospective, process, and modeling studies can improve understanding of how forest ecosystems respond to these types of disturbances. The goal of this research will be to evaluate probabilities and paths for transitions between states for given scenarios and to clarify mechanisms of ecosystem change. This work can be viewed as defining the topology of states: the shape of the domain of possible states for particular forest ecosystems.

Scenarios—An integrated and interdisciplinary analysis of forest stand and landscape change is a fifth area for research. Scientists must describe ecosystem change through time, and analyze changes in states, stocks, and flows and benefits associated with these changes. The objective of these studies must be to assess the effects of alternative mechanisms, patterns, or rates of vegetative change over time and at various of spatial scales. Effects must be described by ecosystem properties of interest, such as wildlife habitat, economic returns, and stream flow. This effort likely will improve communication among researchers, strengthen research planning, and provide a basis for formulating alternative but consistent visions and hypotheses of future forest conditions.

Scenarios can be developed by interdisciplinary groups and by using several different approaches, including computer models and field experiences. The intent in defining scenarios is to develop plausible but contrasting views of alternative future states of the system: for example, to compare even- and uneven-age management at the stand scale, and aggregated and dispersed cutting patterns at the landscape scale. After scenarios are defined, individual disciplines must analyze effects of the alternative scenarios on stocks and flows of interest (such as marketable commodities, stream flow, recreation, or specific wildlife species).[14] These analyses will use tools ranging from sophisticated computer models to intuition. This process is iterative in the sense that the results from the first round of scenario development and analysis logically will lead to development of additional scenarios.

Public participation—Researchers must participate in developing new ways to involve the public in defining objectives for forest management and in designing and implementing efforts to demonstrate and examine the consequences of these objectives. The public plays a critical role in evaluating and choosing among alternative future states; new approaches to expand public involvement should include experiments in both forest management (effects on forest ecosystems) and public participation (the effectiveness and outcome of public involvement). This approach, which represents a new opportunity, may play a key role in producing a publicly acceptable and technically feasible vision of future forests.

Demonstration areas can be part of traditional, controlled experiments and part of a broadened experimental design (in which strict controls are not possible) to evaluate new forestry practices. Adjustments in future management strategies (that is, adaptive management as described by Walters [1986]) can be made based on these experiences with ecosystems and human expectations. Demonstration areas offer a vital meeting ground for researchers, managers, and the public and a medium for transfer of research results into practice.

Timeline

The research agenda to address new issues in forest management will require many years; process, retrospective, modeling, and field studies must occur simultaneously. Scientists must demonstrate quickly, however, an ability to contribute to near-term management and policy decisions, and this participation by scientists is risky. Scientists are increasingly drawn into conflicts over resource use that are based on conflicts in values; in the absence of certainty, diverse opinions proliferate and dominate. Under these conditions, evaluating information and making decisions become increasingly difficult for policy makers and the public; scientists must take responsibility for contributing productively while maintaining scientific credibility.

Early efforts will be concentrated on retrospective studies, including analysis of changes in forest pattern through time, identification of ecological and wildlife responses at the stand scale to alternative silvicultural treatments, analysis of historical stream flow data with respect to rates and spatial patterns of harvest, and compilation and analysis of economic and social benefits at various spatial scales. Modeling, for both processes and systems, also must begin immediately, to benefit from and contribute to development and design of expanded data collection.

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[14] For an example of this see Brunson and Shelby (1992).

Conclusions

We reject the idea that the challenges and troubles faced by forest managers have emerged only recently and are the product of an unappreciative public stimulated by "radical" environmentalists. Although these new perspectives incorporate some genuinely new approaches to forest management and forest research, they are the cumulative result of the past 50 years of forest science. Shifting social values, new scientific understanding of forest ecosystem dynamics, emerging technologies, and a ripe political and social climate allow rethinking of many basic assumptions about the role of forests in society. The science underlying new perspectives reflects growing recognition of the need to view forests as integrated ecosystems operating within a range of tolerance rather than as limitless producers of commodities for human consumption. Research in new perspectives cannot define social objectives for forests, but it can help evaluate the ecological and economic tradeoffs between alternative visions.

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Scientific, management, and social factors that have contributed to changes in United States forest management are examined. Principles underlying new approaches are developed and implications are considered at various spatial and temporal scales. A general framework for a research program is outlined.

Keywords: Landscape management, National Forests.

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