Adaptive Management

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Key questions addressed in this chapter

- ❖ **How the many definitions of adaptive management can obscure the core concept of learning and adapting**
- ❖ **How accelerated learning and adapting are required to meet sustainability goals**
- ❖ **How partnerships of managers, scientists, and citizens will speed learning**
- ❖ **Why comparing multiple management pathways at the same time speeds learning and adapting**
- ❖ **How learning can be accelerated by designing management of stands and landscapes**
- ❖ **How organizational barriers limit learning and adapting**

Key words: adaptive management, parallel learning, monitoring, decision space

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KEY FINDINGS

Different definitions of adaptive management lead to confusion. A wide range of views of adaptive management exists--such as simply completing the planning-doing-monitoring-evaluating cycle, adding local public participation, and unstructured and inefficient fiddling. We define **adaptation** as responding positively to change. We define **adaptive management** as an approach to managing complex natural systems that builds on learning—based on common sense, experience, experimenting, and monitoring—by adjusting practices based on what was learned. We argue that adaptive management should focus on accelerating learning and adapting through partnerships based on finding common ground where managers, scientists, and citizens can try to learn together to create and maintain sustainable ecosystems that can support human needs indefinitely.

Don't wait for a cookbook for adaptive management. People learn and adapt in many ways, and the process of learning and adapting must also evolve over time. We define a range of learning and adapting strategies that can be combined into effective solutions for the great diversity of ecosystems and possible manager-scientist-citizen partnerships. We are advocating that adaptive management become an expanded focus on learning about—and adapting to—changes in society's needs and wants and in ecological capacity. This philosophy recognizes these assumptions and principles:

- Managers, scientists, and citizens need faster and more effective approaches to learning that can easily be incorporated into their everyday lives.
- Citizens and managers have as much or more at stake in learning as scientists do, and scientists and citizens can help managers adapt to changing values and information.
- Knowledge, the product of learning, must be considered as a resource of equal or greater value than the physical resources that traditionally have been the focus of management.
- The managed landscape itself contains important information—including opportunities for retrospective studies of past management and natural events—that can be given value and managed to produce knowledge for future decisions.
- We need to go beyond technology transfer (unidirectional transfer from scientists) to cross-translation of new information and knowledge between citizens, scientists, and managers.

Learning to Care for the Land and Serve People

Fig. 1. Proposed change in the Forest Service mission.

New citizen-manager-scientist partnerships are essential to learn to achieve sustainable ecosystems. Society no longer accepts expert-based learning and decision-making, or segregating learning by scientists from doing by managers. We are optimistic that creative solutions will arise from interactions of diverse groups, whose individual roles will have to change. New roles for citizens (described in other chapters) are needed to relate management to societal values, bring in fresh ideas, and challenge existing institutions. New roles for scientists and managers are also needed.

Effective learning and adapting must be central to the mission of managers, researchers, regulators, and society as a whole. Agencies must fully institutionalize concepts of adaptive management. To begin this process, we propose a change to the Forest Service mission (fig. 1). Additional steps include adding learning objectives to both decision and NEPA documents.

We can no longer afford reactive learning. Learning should be accelerated by designing management projects to produce knowledge along with meeting other resource objectives. Because parallel approaches can compare different policies simultaneously, learning is more rapid than with a less-structured approach that compares different policies sequentially. Agencies have mostly been using a reactive approach, where external influences dominate decisions. The sequential model completes an internal learning cycle in the management agency. The parallel model additionally compares a range of actions simultaneously, with the goal of creating, over time, a wider range of approaches through faster, more efficient learning and adapting. Sequential and parallel models need learning partnerships that in effect are internal to the management system.

We must assume that a variety of pathways can meet a given objective. People must design and test a wide range of pathways to achieve the objectives set by the current generation and to provide future generations with more choices. For example, side-by-side prescriptions established today will be especially valuable to future generations.

Making management more experimental is not an attempt to convert managers into researchers. We propose using scientific learning tools to answer questions that are balanced across critical manager, scientist, and citizen issues. Experimental management compares alternative strategies, each of which can reasonably be expected to achieve the **same** objective for the area being managed; permits a complex of management practices; and uses statistical tools where possible (replication, random allocation of treatments, and long-term monitoring).

Many small-scale management experiments have been started, but some important questions can only be addressed at large scales. Because many environmental, social, and organizational dynamics cannot be measured at small scales, these dynamics can overwhelm small-scale studies. And because few examples of management experiments exist at large scales, developing them is challenging. Assessments and Forest Plan revisions and amendments must include learning objectives and approaches to begin effective learning at this scale.

Rapid learning among citizens, managers, and scientists is essential to expand the range of alternatives available to managers and society. Management alternatives (often called decision space) can be expanded by finding new and creative solutions, such as increasing compatibility between resource uses and developing management disturbances to mimic natural disturbances. This expansion increases the likelihood that management to meet societal values does not exceed ecological capacity.

1 INTRODUCTION

The goal of adaptive management on federal forest and range lands is to create and maintain sustainable ecosystems that can support human needs indefinitely. To do this requires that both human and ecological processes (particularly agents of social and ecological change) and their interactions be understood. **Ecosystem sustainability** is defined as the condition where both what people want for themselves and for future generations, and what is ecologically possible in the long run, are achieved (fig. 2). Increasing knowledge of societal values, ecological capacity, and their interactions through learning increases the chances that ecosystems can be sustained.

1.1 Partnerships for Learning

Environmental and social changes are happening faster as the rapidly burgeoning world population produces air and water pollution and increases its expectations of high standards of living and demands for raw materials. Little time may be left for society to learn the limits of the world ecosystem and how to live at a sustainable pace within those limits.

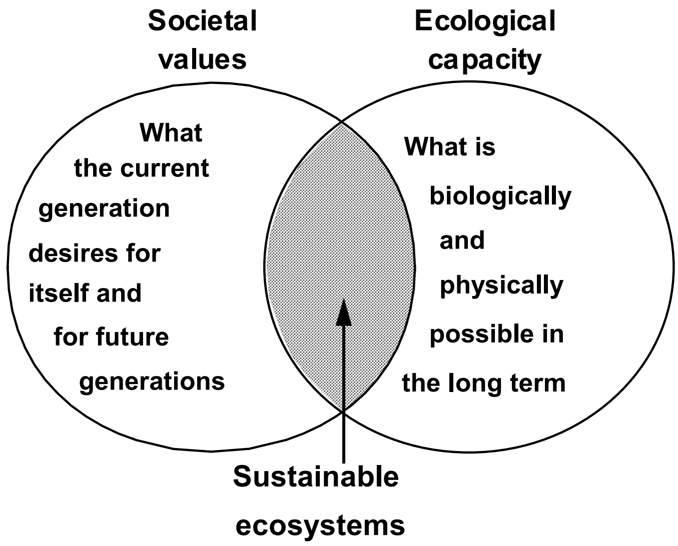


Fig. 2. Defining ecosystem sustainability as the condition where societal values and ecological capacity are simultaneously met, after Bormann et al. (1994a). Adaptive management can increase the overlap (set intersection) between social values and ecological capacity when managers produce information for future decisions at the same time they produce other resources and amenities, and when managers, scientists, and citizens see learning as common ground.

These forces make natural-resource management today much more complex than it was only a few decades ago. Worldwide, natural forests have usually been harvested before much was known about them. In simpler times, few people questioned the concept that liquidating old forests was a necessary step in improving forest productivity. Today, however, forest managers are responsible for the care and use of a mix of human-influenced “natural” forests and forest plantations in a world concerned about global trends in climate, the need for biodiversity, maintaining site productivity—with management efforts under the scrutiny of an increasingly critical citizenry. Important information can be obtained from these forests in the process of managing and through retrospective studies, but without cross-translation between managers, scientists, and the citizen-owners of federal lands, newly developed knowledge will not be readily adopted.

Traditionally, creating new formal knowledge about ecosystems has been the domain of the scientist. But scientists and their organizations do not have the resources necessary to develop the amount and kinds of information required by today's greatly expanded scales of geography, time, and complexity (NRC 1990). Nor have scientists been very good at discerning the needs of managers and policy makers (Byerly and Pielke 1995). As a result, **learning to achieve sustainable ecosystems requires a diversity of learning strategies and requires managers**

and citizens working directly with scientists in close partnership to provide a holistic view of desired conditions and positive, creative responses to change (fig. 3).

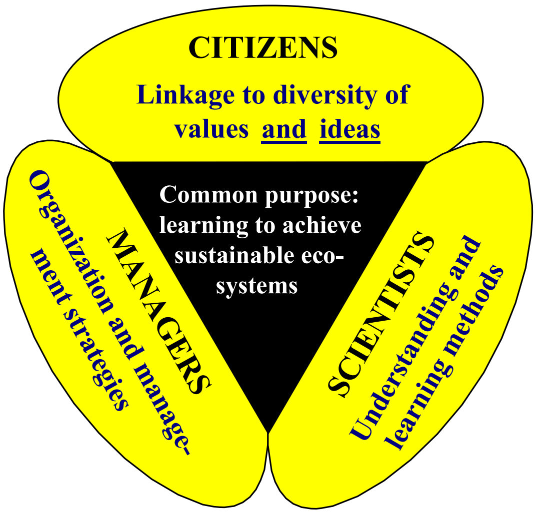


Fig. 3. Learning as common ground for building new, mutually beneficial relations between citizens, managers, and scientists to achieve sustainable

In this chapter, we explore possibilities for a new citizen-manager-scientist partnership—focused on learning—to achieve sustainable ecosystems. We believe an expanded focus on learning will result in better management policies for federal lands. The need for and value of citizen partners in the learning partnership is amply demonstrated by the thoughts of an unofficial citizen reviewer (box 1).

1.2 Accountability to Future Generations

The relation between learning and sustainable ecosystems may be best understood by imagining what managers, scientists, and citizens, 30 years from now, would wish today's managers, scientists, and citizens had done or not done to help them be successful. We know that societal desires and ecological capacity change a lot in 30 years, that ecosystems cannot return to a previous state because of ecological dynamics, and that people looking back tend to think they have perfect vision. **Future generations will be looking at a different set of alternatives determined by the extent that alternatives have been precluded by our actions, and the extent that we can begin to produce knowledge about ecosystem dynamics and new alternatives, not well known today.** When a single approach to forestry is almost universally applied—as in the staggered-setting clearcut and slashburn approach in the Pacific Northwest over the last 40 years—little biophysical, economic, or social knowledge is provided about alternative approaches to management or about the ecosystem itself. The scarcity of knowledge from innovative trials like Black Rock (box 2) has limited today's options because of the lack of adequate understanding of how alternative approaches would work across the varied Pacific Northwest landscapes.

BOX 1.
CITIZEN'S UNSOLICITED COMMENT ON A DRAFT OF THIS CHAPTER

During a discussion of plans to cut some timber I was asked by what right did I, or any other person, assume the privilege to cut down a tree growing in a natural setting? My first inclination was to answer that I needed the money from the sale, which hardly seemed like a moral defense. So, I mumbled on about responsible forest practices and managing for sustainability. It later occurred to me that our individual perceptions of "natural setting" are very different, and based to varying degree upon knowledge of the history of land-use practices in North America. I don't face a dilemma over the decision to alter the forest landscape on my family's small parcel because I have learned that a wide variety of past human activities have largely shaped that same landscape and thereby forced me to act. My land planning decisions will be based on today's version of aesthetics, knowledge of local ecosystems, and awareness of past human manipulation, tempered by local regulations. My task is to learn as much as possible about these things before making my decisions.

Similarly, you as planners and managers of public lands don't face a dilemma over the decision to manipulate earth's environment. Someone millennia ago made a choice for all of us living today and by doing so committed us to awesome responsibility. The humans who first used fire, and their descendants who invented 50,000 years of human technology, have challenged our continuing ability to accomplish adaptation to, and manipulation of, our environment. Ethical and moral considerations about how we "manage" our natural environment must accept the reality of an earth that has evolved with alteration by humans.

Public land managers in the United States are charged by mandate with perpetuating successful multiple use of those lands. We know that perpetuation faces a threat from the degradation or unwise use of today's ecosystems. "Morality" is the definition of right and wrong, and wise versus unwise, and in your context as land managers, that defining is the hard part. If it is also right to perpetuate sustainable ecosystems and thereby meet the public mandate, then it is also right to do all within your power to gain the knowledge necessary to successfully manipulate our ecosystems. That knowledge must be learned, and the use of any method by which learning is truly accelerated is your moral and legal obligation.

Phil Sanders, Humbolt County rancher

1.3 New Roles and Responsibilities for Managers and Scientists

Achieving the complex goal of ecosystem sustainability through faster learning and adapting requires continuously redefining roles and responsibilities for managers, scientists, and citizens to find common ground and building incentives to achieve both collective and individual objectives. Finding common ground between citizens, managers, and scientists is discussed in other chapters. We explore here potential common ground between managers and scientists, along with several ideas for manager-scientist-citizen collaboration, not covered in the other chapters (table 1).

Research and management have traditional objectives that are fundamentally different but contribute individually to the goal of ecosystem sustainability (Rensselaerville 1995). Research usually limits its emphasis to general understanding, often with a narrow disciplinary focus, with the goal of applying that understanding to broad geographic and long time scales. Management is more typically responsible for specific pieces of ground (at project, District, Forest, state, regional, or national scales). For scientists, a focus on a specific piece of ground can only be justified as a test of general theory; for managers, developing broad understanding can be justified only if the broad understanding is secondary to understanding the managed landbase. **Common ground is found when scientists accept management as a dominant ecosystem process and managers recognize that increased information and analysis are necessary to manage large landbases.**

Managers in the Departments of Agriculture and Interior are not currently allowed to do "research" because research and management funding comes in separate line items in the federal budget. Research is commonly, but not officially, defined as “activity producing new knowledge." If this definition were to be legally accepted, then much of the activity proposed for managers in this chapter would not be allowed. A refined definition of research may help to alleviate this problem. The following guidelines are proposed. An activity ought to be regarded as **research** when the focus of the work is on **developing general theory or understanding specific causes and effects, usually by limiting the scale or number of factors being manipulated.** An activity should be regarded as **adaptive management** when the focus is on **the landbase being managed and when complex interactions and responses are permitted, making the connections between specific causes and effects more difficult to understand.** Managers and scientists need this administrative flexibility to contribute resources to joint adaptive-management activities as well as to continue their traditional roles and responsibilities.

BOX 2.
PUSHING THE ENVELOPE OF ACCEPTABLE PRACTICE

Alan Berg, professor in the Forest Science Department, Oregon State University, describes treatments he created in the early 1950s at the Black Rock Forest. Going against a strong tide of opinion of the day, Berg thinned a 48-yr-old Douglas-fir stand in ways that had not been tried in the Pacific Northwest before. The treatments included no-thin controls, light (standard for the day), and medium thinning, as well as underplanting hemlock after a heavy thinning. Criticisms at the time included: “Why try wide spacings in Douglas-fir when we know that it does not respond to thinning?” and “Why plant a weed species like hemlock?” By pushing the envelope of acceptable practice and putting creative ideas on the ground, Berg and others responsible for maintaining the study have contributed much to the current debate about how to manage forests. Thinning Douglas-fir and managing hemlock are common practices today.

Photo by Allan Doerksen

Table 1. Historical roles of research and management and possible common ground between them; the common ground defines shared roles that promote learning and adaptation to build overlap between society's needs and wants and ecological capacity

Research		Management	
Traditional roles	Common ground: shared roles to promote learning and adapting		Traditional roles
Listen to managers, directly answer their questions, or ignore them; avoid public input	Seek to understand and answer manager, citizen, and science questions simultaneously	Apply a full partnership model with citizens and scientists, where allowed by existing law	Apply a public relations approach where required by law
Focus on finding general understanding that applies to wide areas over a long time	Test general understanding at a specific time and place	Invest more in broader landscapes and over longer time frames	Focus in the short-term on the land-base being managed to the exclusion of adjacent lands
Show a historical bias in ecology toward "natural" ecosystems	Recognize that management is a dominant ecosystem process	Increase value of other resources, including information	Show a historical bias toward managing stands of trees, not whole forests
Study factors in isolation of other factors, usually at small scales and with extreme treatments	Integrate across disciplines, accept more complexity, and study whole ecosystem responses	Compare multiple approaches to achieving the same objective to increase learning	Track effects of a complex of practices across the managed landbase
Model processes and species independently	Focus on modeling ecosystem responses	Recognize model outputs as hypotheses not certain outcomes	Rely on economic, resource, and allocation models
Maximize independence and credibility	Help design and interpret management experiments and monitoring for decisionmakers	Support independent monitoring and analyses of management experiments	Work as a coordinated management team

2 ADAPTIVE MANAGEMENT REVIEW

2.1 History of the Adaptive Management Concept

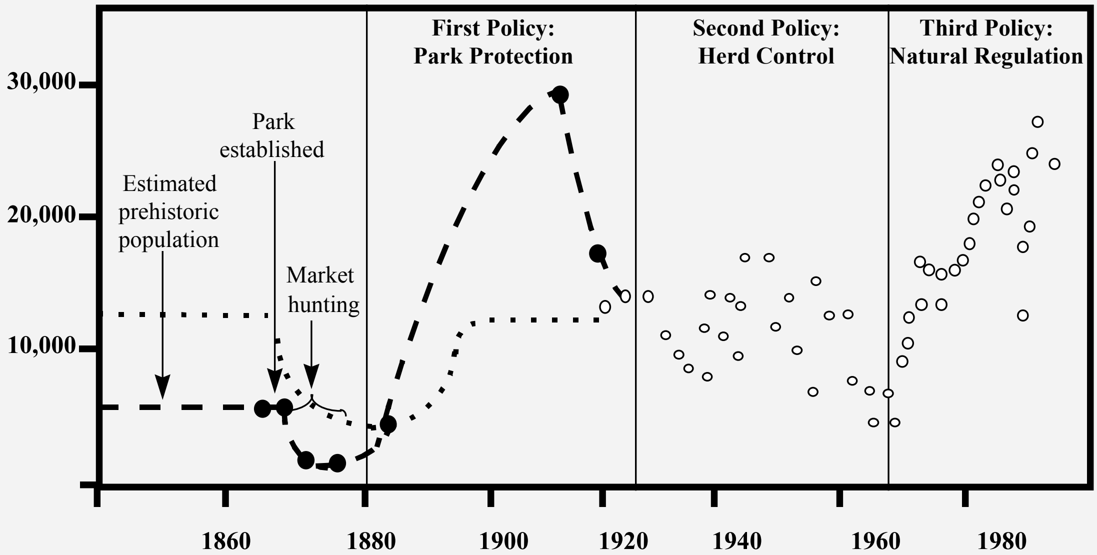
> *The great obstacle to discovering the shape of the earth, the continents, and the ocean was not ignorance but the illusion of knowledge.*---Daniel J. Boorstin (1983)

The concept of adaptive management is being widely debated and is taking on different forms and definitions. The origin of the concept can be traced back to ideas of scientific management pioneered by Frederick Taylor in the early 1900s (Haber 1964). Various modern perspectives on adaptive management are rooted in parallel concepts in business (total quality management and learning organizations, Senge 1990), experimental science (hypothesis testing, Kuhn 1970), systems theory (feedback control, Ashworth 1982), industrial ecology (Allenby and Richards 1994), and multicriterion decision-making, to mention a few.

The term "adaptive management" evolved in natural resources from workshops with decisionmakers, managers, and scientists focused on building simulation models to uncover key assumptions and uncertainties (Holling 1978). Walters (1986) distinguished between passive and active adaptive management: passive adaptive management is monitoring a single "best" practice, and active adaptive management compares alternative practices. Hilborn (1992a) describes three learning models for federal land managers—reactive, passive, and active—around which adaptive management approaches can be developed.

In the reactive approach, change is driven by stimuli external to the management system, including Congress, lawsuits, public reactions, and research findings. Certainly, this approach is a type of adaptive management because feedback does occur and adjustments are made. Problems arise when different stimuli conflict, and the rate of change outstrips the rate of learning. Crisis management tends to emerge, and creating and maintaining a long-term strategy becomes extremely difficult. Scientists and citizens supply criticisms that may or may not be constructive and may or may not be strongly considered by managers. Thus, the latitude for decisions may be restricted unduly, and decisions may be delayed until options are severely restricted or lost. Management of the Yellowstone elk herd is one of many possible examples of this approach (box 3).

BOX 3. REACTIVE MANAGEMENT: THE YELLOWSTONE ELK HERD



Changes in Yellowstone's northern elk herd in response to policy shifts: adaptive management deflected. Population estimates before 1920 vary. The dashed lines are based on historical reports and early superintendents' and biologists' reports; dotted lines are inferred by Houston (1982). Open circles are based on direct census, corrected for sightability and removal (Houston 1982, Mack and Singer 1992, Coughenour and Singer 1996, Lemke et al. 1996).

Management of the elk herd is an example of a reactive approach to management, typical of the more traditional approaches to many of the big issues in federal land management. Although the intentions are always good, managers typically seek a "best" solution, which often leads to a crisis later. These solutions usually reflect the science, societal, and political knowledge for the time and place, but often fail to recognize the complexities of the ecological basis of the problems (Gunderson et al. 1996).

The management of the northern elk herd has gone through three policies: no hunting, 1867-1920; control by Park rangers (trapping, removal, and shooting), 1920-1967; and natural regulation, 1967-present. Each policy was based on values of some societal interests that dominated Park policy at the time. The first two policies were based on managers' best judgment; the third is claimed to have been set by external political pressure. The Park was established by act of Congress in 1872 to preserve its natural wonders, including wildlife. Little wildlife science was available at the time, except for rules of thumb; for example, that protection from hunters, artificial feeding, and predator control were desirable. Freed of historical constraints, the herd increased to 20,000 to 30,000 animals by the early 1900s (Smith et al. 1915). In terms of population increase, the policy was effective and the embryonic science of the day gave valid guidance. Increasing herd size and hunting that forced the herd to winter inside the Park, however, led to profound effects on the Park's ecosystem. Research, from 1915 through the 1960s, reported the elimination of aspen woodlands, riparian vegetation, and deciduous shrub understories (Skinner 1927; Grim 1939; Kittams, 1948, 1959; Barmore 1981); white-tailed deer (Bailey 1930); and beavers (Jonas 1955, Kay 1990). By the 1920s, a new policy was in place: elk were controlled by Park rangers to reduce these undesirable effects. A target herd size of 5,000 elk was attained by 1962 (Houston 1982), and some recovery was observed in aspen (Kay 1990), willows (Barmore 1981), and bighorn sheep (Oldemeyer et al. 1971). By 1967, however, people who had hunted successfully outside the Park were falling on hard times. After they appealed to their Congressional delegation, Wyoming Senator Gale McGee threatened to cut off Park funding if herd control was not stopped (U.S. Senate 1967). In fall of that year, the Park announced its third policy, natural control (Anonymous 1967), later renamed "natural regulation" in 1971 (Houston 1976). This policy, still in effect, essentially eliminates human intervention. The policy assumes that the herd will limit its own numbers without significantly affecting the Yellowstone ecosystem. Initial estimates of the equilibrium were 6,000 to 9,000 (Houston 1971), but when the herd surpassed 9,000 in the mid 1970s, a new equilibrium was predicted at 12,000 to 15,000 (Houston 1976). Increased research accompanied the third policy. Early publications reviewed the previous 60-year documentation and research and concluded that the peak size in the herd did not reach 20,000 to 30,000 after the turn of the century and that the prehistoric populations were higher as well (Houston 1982). When the herd was freed of population constraints again in 1968, the herd responded as before, increasing from 20,000 to 22,000 in the 1980s (Mack and Singer 1992). Park research initially sought to minimize elk effects and to attribute the changes to various combinations of climate change, fire suppression, and natural succession (Houston 1982, Despain et al. 1986). But as investigations not supported by the Park increasingly publicized the extent of changes—including near elimination of aspen woodlands and riparian zones again (Kay 1990, Kay and Wagner 1994, in press)—elk effects could not be denied. *continued…*

BOX 3 (continuation)

The third policy has failed to achieve its objectives of an equilibrium elk population, uninfluenced by people and without significant alteration of the Yellowstone ecosystem. And Park science, with its objectivity constrained by conformance with policy, has ill-served Park management by failing to accurately account for the condition of the range. In sum, policy and management of the northern herd first went through two policy shifts based on the science of the times. The second policy was adapted from the first when the newer science indicated a change was needed to meet Park objectives. The third policy shift cannot be considered an adaptation of the second, but rather driven by political intercession. It was contrary to the then current science, has not been effectively served by agency science subsequently, and is taking the Park away from its objectives.

Steps are needed to apply a more effective adaptive policy to managing the Park's northern range. First, all available scientific knowledge must be openly discussed by the science, manager, and citizen communities. Second, the Park should reassess management goals for the Park, again through an open process with major public involvement, in keeping with the emerging paradigm for resource management on public lands (Wagner 1994). Finally, effective monitoring and feedback are needed. Because of the political nature of the Park's policies, collaborative approaches to monitoring and adjustment are essential to meet Park goals.

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The passive approach, which we are henceforth calling **sequential learning** (fig. 4), recognizes that more can be learned from a management action if attention is paid to what actually happened relative to what happened in the past. Learning is advanced when the questions and anticipated outcomes are clearly defined and monitoring plans are written before management actions are taken. When a commitment to monitoring wanes, the strategy reverts to a reactive one. The sequential approach requires patience to allow sufficient time for learning. Scientists and citizens continue to offer criticism from outside; they may also help to frame questions, anticipate outcomes, and help design and implement a monitoring plan.

Our third category is similar to Walter's (1986) and Hilborn's (1992) "active," which we refer to as **parallel learning**. A parallel approach seeks to learn more rapidly than under sequential approaches by designing suites of policies that can be directly compared in "management experiments," which then become the focus of monitoring and evaluation. Because parallel approaches can compare

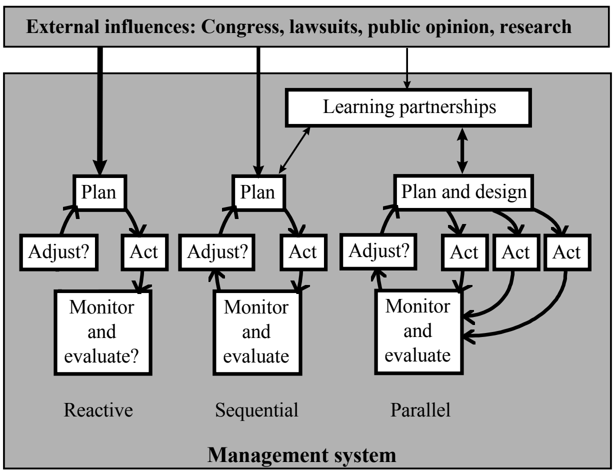

Fig. 4. Conceptual models of adaptive management.

different policies **simultaneously**, learning is more rapid than with a less structured approach that compares different policies **sequentially** through time.

Adaptive management based on parallel learning has evolved in fisheries into experimental management, where some elements of the scientific method are applied to management decisions (Walters and Collie 1989, McAllister and Peterman 1992, Sainsbury et al. 1994). Making management more experimental is not an attempt to convert management into research, however. Rather, it seeks to use some of the learning tools from science to address managers' critical questions. Experimental management compares alternative strategies, each of which can reasonably be expected to achieve the same objective for the area being managed; permits a complex of management practices; and uses statistical tools where possible (replication, random allocation of treatments, long-term monitoring). Alternatively, if management were driven solely by research interests—a concern expressed by some managers, but not what we advocate—the focus would be to develop general theory to be applied beyond the area being managed, to include some strategies thought likely to fail, and to reduce complexity by exploring single factors. Research is essential, but on smaller scales, to complement, help understand, and interpret interactions in complex experimental management at larger scales. **Regardless of the learning model used, all management needs to be thought of as experimental in that we only think we know what the outcomes will be, and that we don't know what all of the effects of any management will actually be.**

2.2 Application to Regional-Scale Forestry

The first major use of the adaptive management concept in a large regional forestry application is in the Northwest Forest Plan for Oregon, Washington, and California National Forests and BLM Districts in the range of the northern spotted owl (box 4). The simplest description of the Northwest Forest Plan is that it attempts to protect a wide range of species under existing federal laws, including the Endangered Species Act of 1973, while producing some timber and other commodities. The Record of Decision for the Northwest Forest Plan (ROD 1994) sets forth a strategy to achieve this goal that includes specific land designations as late-successional and riparian reserves, matrix lands, and adaptive management areas. Activities on these designated lands will be regulated with specific standards and guides that, for the most part, constrain and focus management to achieve land-allocation-specific objectives.

Adaptive management was required in the record of decision to "learn to manage by managing to learn," with the objective of improving the Plan through time. Ten adaptive management areas were designated to provide an environment where new management techniques could be tested. Although the term adaptive management is shared by the adaptive-management-area land designation and the management philosophy, **federal agencies were directed to apply adaptive management on all federal lands in the Pacific Northwest by the Record of Decision for the Northwest Forest Plan (ROD 1994), not just on adaptive management areas**.

2.3 Organizational Adaptability

Adaptive management areas were also established to "encourage the development and testing of technical and social approaches to achieving desired ecological, economic, and other social objectives" (FEMAT 1993). With these ideas and those of Lee (1993), public participation has become synonymous with adaptive management in many people's minds. Many models for enhanced public participation have been suggested and some tried, both at local (box 5) and at national scales—for example, in the recent 7th North American Forest Congress.

BOX 4.
SEQUENTIAL MANAGEMENT IN THE PACIFIC NORTHWEST

The Northwest Forest Plan for parts of California, Oregon, and Washington offers an example of sequential management. Some parallel learning is sought in the 10 adaptive management areas, created by the Plan as centers for the "development and testing of new approaches to management" (ROD 1994). A premise of the adaptive-management-area concept is that new approaches and learning should not be developed and tested everywhere because of the risks associated with failing to achieve desired objectives at the expense of new knowledge. By designating these few areas, the effects of possible failures might be reduced. Strong links with research, communities of interest, communities of place, local knowledge, and scientific and expert knowledge were recognized as keys to the success of the concept. Each adaptive management area has its own set of biological, social, economic, and political characteristics. Although this idea appears to be taking hold in some of the areas, it has not catalyzed the interested stakeholders in others; the success of this approach may take a decade or more to evaluate (Stankey and Shindler, 1997.).

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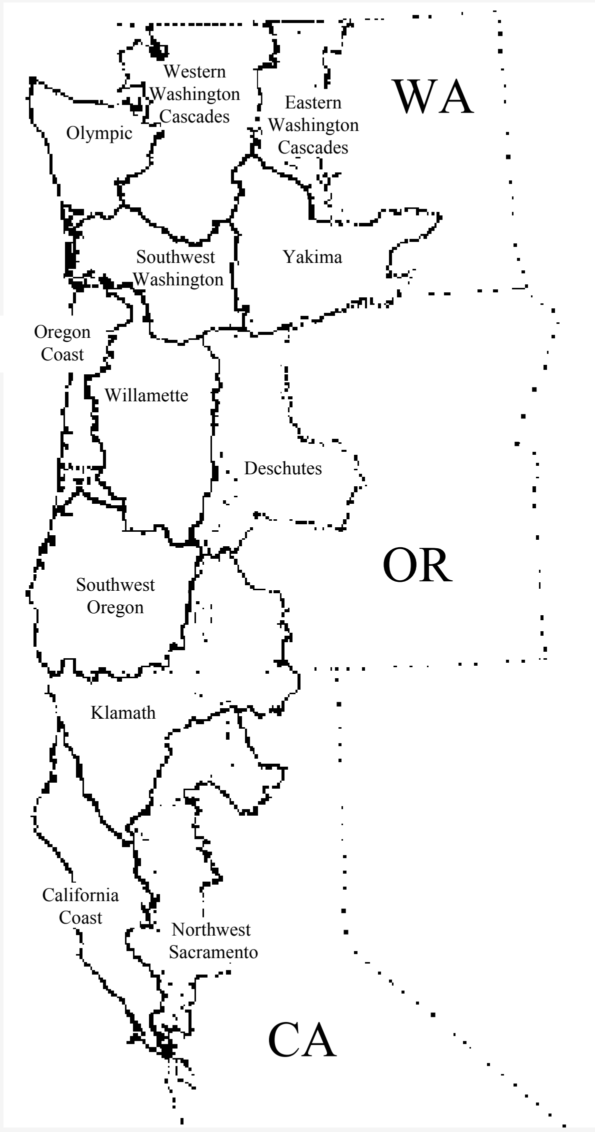


BOX 5.
PUBLIC PARTICIPATION: THE APPLEGATE PARTNERSHIP

As their slogan suggests, the Applegate Partnership is an example of improved public participation in making federal decisions. People from federal agencies responsible for the Applegate watershed were joined by local citizens, in creating a partnership to explore public problem-solving across organizational, administrative, and jurisdictional boundaries. The strength and early successes of the initial partnership helped convince policymakers to create the network of adaptive management areas in the Northwest Forest Plan, to which the partnership was joined. About 70 percent of the 492,000 acres of the Applegate watershed is managed by the Rogue River and Siskiyou National Forests and the Medford District of the Bureau of Land Management; the remaining 30 percent is state and privately owned. Much of the problem-solving has focused on bridging institutional boundaries, developing a common geographic information system, completing community and watershed assessments, restoring key watersheds, and getting citizens to participate in research and monitoring (Spinos and Rolle 1995). The partnership is wrestling with some of the most perplexing problems facing federal managers, including how to reconcile local and national interests, how agencies can work together, how to spark local interest, and how to initiate change in long-held bureaucratic traditions (Shannon et al. 1996).

Contact: Su Rolle, Medford BLM District Office, Medford, OR.

Holling (1996) describes a "pathology" of traditional resource management, where key variables influencing resource production are successfully identified and then controlled, establishing predictable outputs and societal dependencies. Over time, the control leads to an undetected change in the key control variables and subsequent difficulty in maintaining outputs and meeting societal expectations. Holling goes further to postulate that organizations tend to obey general ecological theory and that recent turmoil in resource management and research organizations may reflect a dynamic, "successional" change underway. Organizations may "evolve" slowly from a focus on exploitation to conservation (birth and growth) and then, through dynamic and unpredictable disturbance (death), be released to allow rapid reorganization (renewal), and cycling back to new exploitive-conservative stages. The more that organizations can accept and work with these "natural" changes the more adaptable they become.

Most people in these organizations are concerned with the uncertainties and perceived threats associated with the reorganization stage; some people recognize that only during reorganization are new ideas likely to be seriously considered. Five "disciplines" are recognized as the foundation for learning organizations: systems thinking, personal mastery, mental models, building shared vision, and team learning (Senge 1990).

2.4 Using a Diversity of Ideas To Speed Learning

People's views on most natural-resource issues cover a wide range. Parallel learning can tap into this diversity by comparing multiple means to a desired

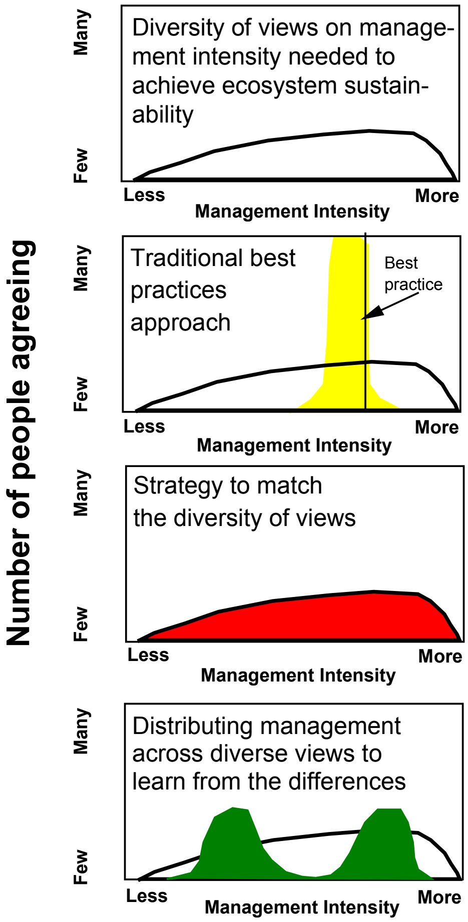


Fig. 5. Redistributing management intensity (shaded areas) to meet a diversity of views (lines) and to learn from them.

common end. Viewpoints can be presented as a frequency distribution, for example on the question of whether more or less intensive interventions in the forest (such as thinning or putting logs in streams) best lead to desired management goals (fig. 5).

Historically, the best-practices approach has led to a narrow averaging of viewpoints to find a single approach, regardless of how well the approach represents the diversity of views. To better reflect the diversity, managers could manage for the distribution, rather than manage for the mean. Even better, the views can be coalesced to form discrete, equally viable approaches that can be compared in parallel management experiments. Two benefits, in addition to faster learning, arise from these latter approaches: a greater likelihood that more people can relate to at least some actions on the ground (especially when people have widely differing views), and increased variability or heterogeneity across the landscape, which some biologists believe will maintain or increase biological diversity (chapters 11 and 15).

2.5 Core Concepts

Many definitions, activities, and procedures have been associated with the term adaptive management. Common to all and at the root of all these associations are two processes, **learning** and **adapting**. Because many, diverse activities and procedures can increase learning and adapting, identifying a single definition or approach is not appropriate. Presenting a wide array of approaches **to accelerate** learning and adapting to achieve goals across diverse landscapes and potential partnerships and ownerships is more useful. Faster learning and adapting are needed because rates of change are increasing, land management is becoming much more complex, research is difficult at the scale of management, incentives are needed to continue monitoring, and learning needs to extend beyond federal landsFederal lands, the focus of this chapter, are but a small fraction of the United States. The actions of private and industrial landowners, including the extent that they initiate, support, and participate in learning and adapting, will determine in large part whether sustainability can be reached. Having direct comparisons of different policies that people can observe for themselves is more likely to change policy than are arguments over existing scientific knowledge and best practices. Comparisons need to be structured to build confidence in our ability to interpret them correctly.

3 WHAT'S DIFFERENT ANYWAY?

Many managers respond to descriptions of adaptive management concepts with the question, “What will be different from current and past practice?” Many research scientists also see little need to change their priorities and approaches. To us, the differences are large and numerous for both managers and scientists, including:

Anticipate surprises; don’t just wait for them. Once our society accepts that future conditions cannot be predicted and controlled with great certainty, and that a single best practice cannot be determined in advance, then we can accept that we need to learn as part of management, and especially with managers, scientists, and citizens learning together. Research should address durable problems to provide knowledge to support future decisions and solve problems before they become contentious issues.

Expand decision space over time. Rapid learning among citizens, managers, and scientists, and successful adaptation are perhaps the only methods available to expand the range of alternatives available to managers and society to increase overlap in societal values and ecological capacity. Decision space is increased by finding new, creative solutions, such as increasing compatibility between resource uses and developing management disturbances to mimic natural disturbances.

Learn and adapt actively. Simple first steps to accelerate learning and adapting include better documenting activities, stating anticipated outcomes in advance, comparing two or more approaches simultaneously, and identifying triggerpoints to facilitate adaptation.

Include learning objectives in decision documents and NEPA purpose and needs statements. Learning becomes instantly institutionalized if learning objectives, learning clients, and learning methods are required in NEPA documents (perhaps excluding some NEPA documents where no learning can be justified). Learning at multiple geographic scales is facilitated when nested NEPA documents are coordinated.

Manage stands and landscapes. Many of the most important policy questions are more relevant as scale increases, which fundamentally changes information requirements for management and approaches to research. Managers need to recognize the importance of information coordination and accessibility, sampling to represent broad areas, and the need for large-scale management experiments. Scientists should study the influences of broad policies and link study of natural processes and management practices across multiple spatial and temporal scales.

Synthesize and integrate. Reductionistic basic and applied sciences associated with individual resources are not sufficient to provide the knowledge to achieve ecosystem sustainability. Science to underpin predictions of ecosystem responses and to achieve compatible (joint) production of a wide array of ecosystem goods and services is needed more than science to support a land-allocation-based approach to land management.

4 STRATEGIES TO APPLY ADAPTIVE MANAGEMENT

4.1 Planning

Learning and adapting are essential, integral parts of the activities of federal land managers, from stream restoration to recreational trail design. A wide array of learning and adapting strategies is possible (table 2). Some strategies are identified for further development in this chapter; others are developed in other chapters. In addition to suggesting an array of strategies for consideration by decisionmakers, other managers, scientists, and citizens, ideas on how to combine strategies to effectively achieve learning and adapting objectives are offered (section 5). Because learning to achieve sustainable ecosystems requires a diversity of learning strategies, effective adaptive management must also focus on redefining the relations between managers, scientists, and citizens (fig. 3, table 1) as well as peoples' relation to the ecosystems on which they depend.

4.1.1 Information as a Primary Resource

A principal difference under an adaptive-management framework is to add learning and adapting as management goals. Learning to provide new choices to future generations and to speed adaptation are identified as major new goals for managers as well as for scientists and citizens; such goals should be considered just as important as producing and preserving other forest resources.

Any learning strategy must begin with assessing who needs and wants to learn. **Citizens—the owners of federal lands and ultimate decisionmakers—must be considered the primary target for learning.** Although citizens often have difficulty coming to agreement about land-management issues, they may be more willing to support learning to find the answers needed to make decisions more easily. Learning is, and will continue to be, the role of scientists. Forestry research organizations—historically focused on narrowly defined disciplines—have not allocated the resources to take on many of the large-scale, long-term , and highly complex issues associated with managing ecosystems (NRC 1990). In the past, managers were directed to be the doers, and have relied on research to recommend major changes in practices. The transfer of research ideas and technology has not been able to keep up with the increasing information requirements to manage complex ecosystems in response to changing societal needs and wants. **Managers, therefore, must be responsible for producing new knowledge too**, not only because of their need for information, but also for the experience-based knowledge they can share with scientists and for more efficient transfer of ideas and technology to practice. **Scientists have a new role in listening to managers and citizens more closely and identifying design options for managers and citizens to consider.**

Table 2. Short- and long-term learning and adaptation strategies that could be used as criteria to evaluate the effectiveness of adaptive-management proposals[1]

Short-term learning strategies	• Exchange concerns, knowledge, and constructive ideas among citizens, scientists, and managers. • Construct common and accessible databases, GIS, and decision-support systems. • Synthesize and translate existing knowledge for decisionmakers. • Record predictions from science-based models on effects of proposed management decisions. • DEFINE LEARNING OBJECTIVES IN NEPA ACTIONS. • CREATE A DATABASE OF RESEARCH OPPORTUNITIES. • INITIATE RETROSPECTIVE RESEARCH.
Long-term learning strategies	• APPLY SEQUENTIAL LEARNING MODELS: ◊ LEARN-FROM-EXPERIENCE MANAGEMENT. ◊ INTERVENTION MANAGEMENT. • APPLY PARALLEL LEARNING MODELS: ◊ COMPARATIVE MANAGEMENT. ◊ EXPERIMENTAL MANAGEMENT. • LINK RESEARCH TO MANAGEMENT. • LINK MONITORING TO LEARNING.
Adaptation strategies	• APPLY TRIGGERPOINTS. • IMPROVE COMMUNICATION AND LEARNING WITHIN AND BETWEEN INSTITUTIONS. • PUBLISH AN ADAPTIVE MANAGEMENT JOURNAL. • CREATE A SABBATICAL PROGRAM. • REWARD PEOPLE WHO HELP TO LEARN AND ADAPT. • Recognize the need for thoughtful consideration and judgment when making inherently complex decisions. • Select for leaders who can overcome barriers to innovative solutions.

[1] Capitalized strategies have been chosen as the focus of this chapter and are described in the following pages; other chapters address most of the remaining strategies.

Citizens, scientists, and managers will have their own priorities for what needs to be learned and how learning takes place. Balancing and coordinating the investments in learning across citizen, scientist, and manager groups will help to increase the diversity of questions asked and ensure that everyone has an opportunity to learn.

4.1.2 Learning Objectives in Decision Documents and NEPA Actions

Planning—a foundation for decisions—assesses existing information; defines issues, purposes, and needs; and then schedules and distributes management actions to implement the decision. Adaptive management, by focusing on learning and adapting, alters the planning objectives, increases the emphasis on planning for monitoring and evaluating to support adaptation, and requires different actions to focus on learning.

A key strategy to achieve balanced learning among citizens, scientists, and managers would be to require that NEPA documents at regional, state, Forest (box 6), District, and project scales include, as part of their purpose and needs statements:

- What is expected to be learned by implementing the action (learning objectives);
- How the learning objectives from citizen, scientist, and manager groups are balanced; and
- What strategies, methods, and monitoring variables will be used to achieve the learning objectives?

Communication among and between citizens, scientists, and managers is then needed to identify the key issues, assumptions, questions, and learning objectives and methods. **Facilitating communication on these topics may be a more meaningful public participation activity than many that have been tried up to this point** (see also chapter 3).

4.2 Managing

The scientific method is applied to scientific questions to accelerate learning and to reduce the risk of biased or incorrect interpretations. As information from and about the land being managed is more widely accepted as a resource, and learning and adapting are recognized as important activities for managers, methods to accelerate learning and improve interpretations will become increasingly valued by managers.

4.2.1 Scientific Methods in Everyday Management Actions

Elements of the scientific method can be applied in many everyday management actions through scheduling and distributing management activities across the landscape and through time, with the goal of increasing the efficiency of learning and the quality of interpretations useful to managers and decisionmakers. Total objectivity can never be assured, but scientists have highly developed mechanisms to reduce the natural bias that often hinders people's interpretation of their own, or of widely accepted, ideas (Shrader-Frechette and McCoy 1993). These elements could be applied to assist managers to quickly recognize when their ideas have shortcomings, rather than falling into a confirmation trap or not hearing about shortcomings in a bureaucratic system with a strong tendency to hinder flow of negative information, such as in the Challenger and Chernobyl disasters (Bella 1987).

BOX 6.
LEARNING OBJECTIVES IN NEPA DOCUMENTS: THE SIUSLAW NATIONAL FOREST

The Forest Leadership Team of the Siuslaw National Forest formally decided to include learning-objective statements in the purpose and needs section of most NEPA documents produced for projects. By including learning objectives, line officers will balance knowledge production with other resource production and protection needs. An early prototype of this concept is an environmental assessment produced for the Pollard-Cedar project area in the Coast Range Province Adaptive Management Area. Because careful attention was given to learning designs, and because learning objectives were described in the purpose and needs section of the NEPA document, the project has enjoyed broad support. Timber from this project has been sold without appeals, and the project is progressing toward its goal of learning how to manage for the development of late-successional habitat characteristics (see also box 10).

Contact: Jose Linares, Siuslaw National Forest, Corvallis, OR.

Elements include a written record of the anticipated outcome from a proposed action to help identify the thinking and key assumptions behind a decision. Having managers, scientists, and citizens identify anticipated outcomes helps to focus limited monitoring resources. When results of actions turn out differently from what was anticipated, people are forced to review and often adjust their thinking. Another element of the scientific method useful to management is to increase the diversity of approaches to make differences easier and cheaper to detect. Simultaneously comparing multiple approaches to achieving the same policy objective (as in parallel learning) is the fastest way to speed learning. The wider the contrast between approaches, the easier the differences in results can be detected through monitoring. All approaches to be compared, however, need to be valid approaches to achieving defined, common goals. Several approaches may turn out to be nearly equally acceptable, increasing the choices available to managers. Some approaches may work better in certain situations and others elsewhere.

Interpretation of management effects can be applied with greater confidence to the broader managed landscape when sets of management approaches can be repeated (replicated) across the landscape. Replication helps to avoid concluding that observed differences are due to approaches when they are really due simply to chance; the more replication, the less likely this mistake will be made. An organized set of replications also helps to avoid a search for the “right” answer and to broaden the applicability of new knowledge in the larger managed landbase.

A second method to improve confidence in interpretation of management effects is to randomly allocate management approaches (treatments) among initially similar areas (experimental units). This method overcomes any subconscious tendency to place a favored approach in an area that will make it look better than alternative approaches. Random allocation does not work well when variability between treatments is smaller than the variability between areas. People often think that variability increases with geographic scale, but the opposite may often be the case, thus, landscape similarity--using variables related to the questions being asked--should be evaluated. Where variability is high, combining areas into more homogenous groups (blocks) can help to take advantage of the benefits of random allocation. Organized, independent review by other managers, perhaps including blind reviews, is another application of the scientific method that may help managers to overcome people's natural tendency to avoid change.

These elements can be combined into strategies for incorporating the scientific method into everyday management to produce information for future decisions about the particular landbase being managed (table 3). How the elements are combined is important; four of the more powerful of many possible learning strategies for adaptive management—learn-from-experience, intervention, comparative, and experimental management—are described below. The appropriate strategy should combine elements to fit specific situations. As a rule, the speed of learning increases in the order the strategies are presented. Be reminded, however, that learning and adapting require that these long-term learning activities fit within a broader strategy (table 1).

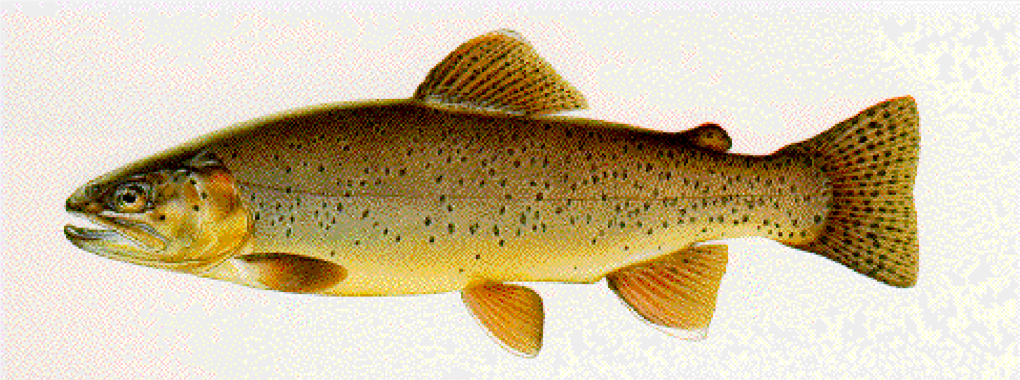
4.2.2 Learn-From-Experience Management

The first type of sequential learning model we describe is what we define as learn-from-experience management. This type of management is similar to what Walters (1986) calls passive adaptive management, where a single approach is adopted about which anticipated outcomes are recorded and a monitoring plan is developed, preferably beforehand (box 7). Learning with this sequential strategy tends to be slow because comparisons can only be made with what happened in the past and only when learning is the business of the management organization rather than the individual manager. Intensive monitoring is required to detect trends, and interpretations are limited mostly to analyses of trends with little understanding of factors that caused them. Where immediate action is called for and where the managed area is thought to be unique, learn-from-experience management may be the only adaptive-management option available. This type of management action most closely mimics past, mostly reactive management because no specific distribution or scheduling of management actions is designed to enhance learning opportunities, other than to schedule and distribute monitoring and research.

Table 3. Elements of the scientific method in traditional management and research and in adaptive management strategies

Learning strategy	Anticipated outcomes stated in advance?	Anticipated outcomes monitored?	Alternate approaches compared?	Treatments replicated in other areas?	Treatments replicated through time?	Treatments allocated randomly?	Comparisons simplified?	Results independently peer reviewed?	Focus of learning?
				Traditional management					
Reactive	few	few	no	no	no	no	no	no	none
				Adaptive management					
Sequential learning models:									
Learn-from-experience management	yes	yes	no	no	yes, but only qualitative	no	no	optional	managed area
Intervention management	yes	yes	yes	optional	yes, via pre-treatment data	optional	no	optional	managed area
Parallel learning models:									
Comparative management	yes	yes	yes	no	optional	yes	no	optional	managed areas
Experimental management	yes	yes	yes	yes	optional	yes	no	optional	similar managed areas
				Traditional research					
Sequential learning models:									
Observational studies	yes	yes	yes	no	optional	no	yes	yes	general theory
Quasi-experiments	yes	yes	yes	no	yes, via pre-treatment data	no	yes	yes	general theory
Parallel learning models:									
Formal experiments	yes	yes	yes	yes	optional	yes	yes	yes	general theory

BOX 7.
MANAGEMENT BY EXPERIENCE: THE THREATENED APACHE TROUT



An excellent example of management by experience is found on the Apache-Sitgreaves National Forest, where management plans for grazing allotments with important fish habitats were revised to provide for conservation of the threatened Apache trout (Oncorhynchus apache) and other threatened plant and animal species. Formal consultation with the U.S. Fish and Wildlife Service on the Apache trout yielded a Biological Opinion that identified protective measures to avoid further endangerment of the trout. A team of scientists and managers (a riparian ecologist, a fish biologist, a hydrologist, a soil scientist, and the range management staff) worked together to develop a scientifically based Apache Trout Habitat Improvement Plan and a research and monitoring strategy for selected Apache trout streams of the West Fork Allotment to follow habitat changes and improvements. The interdisciplinary team—working with other professionals, the interest groups, and the public—identified the following problems: use, primarily by cattle and elk, of riparian habitats classified as Apache trout habitat; disagreement over the use of habitat capability methodologies to evaluate trout habitat; lack of knowledge of the functions and processes of these montane riparian areas, as well as effects of ungulates on these processes; and the restoration of trout habitat in areas where grazing-allotment management plans are being revised. The plan identifies roles and responsibilities for researchers as evaluating existing data and methods, identifying habitat factors controlling long-term trout sustainability, developing and administering a monitoring plan, writing a research plan, and assisting managers with the design of the Apache Trout Habitat Conservation Plan. Management roles and responsibilities included revising the allotment management plans, designing and installing pasture and enclosure fences, managing livestock on the allotment, facilitating data collection, ensuring the integrity of monitoring and research sites, coordinating activities with other agencies, and coordinating and purchasing structural improvements. The plan helped to avoid litigation under the Endangered Species Act, and the availability of new information helped to diminish conflicts among affected parties. Managers gained easy access to a new, continually updated information database on ungulate use, important to managing grazing and quality of trout habitat. Relations with the interest groups and the general public were enhanced through open meetings and other communications. The ability to comply more fully with the Endangered Species Act was expanded. The potential for de-listing of the Apache trout in the near future is strong. Short-term learning objectives are met through effective collaboration of managers, scientists, and citizens, and the application of credible science. Long-term learning will depend heavily on research findings because the sequential learning model used here (applying a single management approach) will provide new knowledge slowly.

Contact: Michael Rising, Apache-Sitgreaves NF, Springerville, AZ.

4.2.3 Intervention Management

A second type of sequential learning is known as intervention management. If predicted outcomes are recorded and a baseline of useful variables is monitored that captures most of the year-to-year variability—before a management action takes place—and monitoring is continued after the action, then conditions for intervention management are met (table 3, box 8). This approach is preferred where the geographic scale of the management issue is large and not much land is available to find initially similar areas for parallel learning models (see below). A drawback to using this approach in natural-resources problems—unlike many social policy issues—is the lack of long-term databases to establish pretreatment conditions. Thus, intervention management often will require several to many years of monitoring before any intervention is made. Lead-time may not be needed in a few areas where long-term inventory or monitoring has been done, such as existing study areas and on inventory plots, or where data can be obtained through retrospective research.

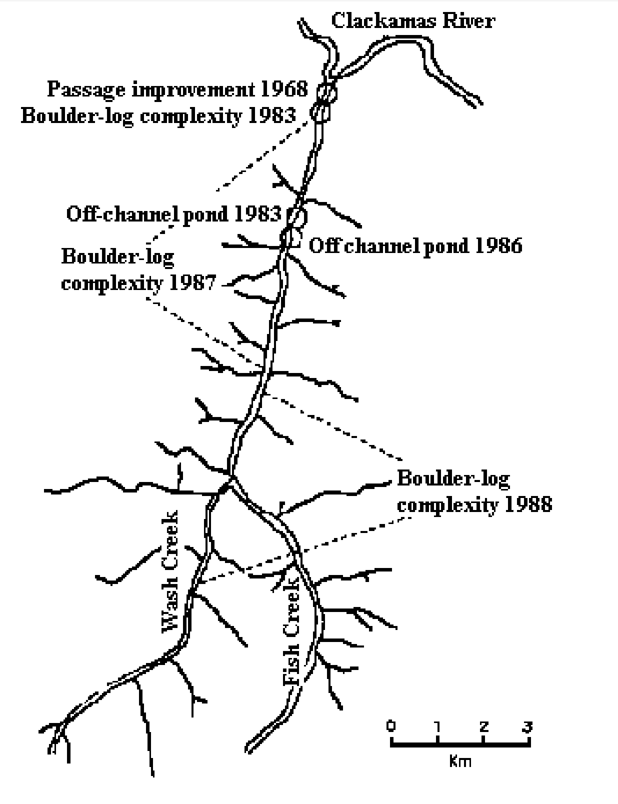
4.2.4 Comparative Management

Two types of parallel learning models are identified that build on sequential experience by comparing two or more different management approaches that seek the same goal at the same time (in parallel). This additional learning structure meets the base definition of what Walters (1986) calls active adaptive management. The first parallel learning model is comparative management, where simple comparisons are made, usually on side-by-side areas known to have roughly similar initial conditions, and where management approaches are assigned to the similar areas randomly (box 9). The greater the certainty about similarity of initial conditions, the higher the quality of the interpretations from this kind of management. Monitoring can be less intensive than in learn-from-experience management when differences between approaches are large. Because replication is not included, interpretations must be limited to the immediate area being managed (table 2). This problem is less important when a large portion of the managed area is included in the approach.

BOX 8.
INTERVENTION MANAGEMENT: MOUNT HOOD NATIONAL FOREST

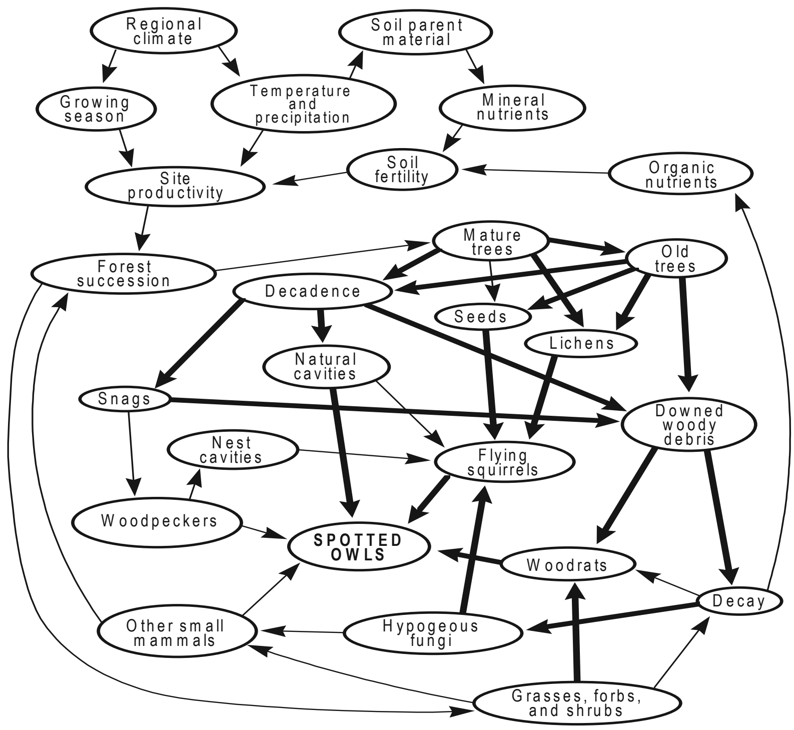
Long-term monitoring of pools and woody debris thought to influence salmon and trout habitat began in 1959 along Fish Creek, Mount Hood National Forest, Oregon. The creek was resurveyed after a major flood in 1964. A reduction in pools, from 45 to 25 as a percentage of the stream sections used by fish, was attributed to loss of large wood from the stream. Stream "restoration" removed more wood from streams from 1965 to 1980, following the thinking that wood hindered passage to fish. Further reduction in pools (from 25 to 11 percent) was attributed to wood removal, although other effects were possible, from clearcut harvesting of 41 percent of the watershed beginning in 1944 and peaking in the 1980s.

New research findings began to suggest that pools and spawning habitat were crucial to fish survival, and new restoration plans were developed. This plan began with three years of evaluating prototype restoration practices, after creating boulder berms and off-channel areas, planting trees along the stream, and knocking large trees into streams with explosives. Results only from off-channel areas were positive, and 500 structures were deployed in the middle and lower portions of the stream in 1986 to 1988. Monitoring of late-summer habitat, numbers of juvenile fish in late summer, and smolts leaving in the spring began in 1982, four years before off-channel areas were created. Additional monitoring of habitat types, pools, riffles, glides, and side channels began in 1985. This approach contrasts with most other stream restoration efforts in the Pacific Northwest that do not have long-term monitoring. Although interpretation of Fish Creek data is still complex, for example because of simultaneous logging and stream wood manipulations, interpretations are easier than in other restoration projects where variable responses after placement of structures may be driven by long-term trends that have gone unmeasured. Another reason for variable responses may be with stream-to-stream variability. This source of variation can only be quantified when treatments are replicated in other streams (see experimental management).



Contact: Gordon Reeves, USDA Forest Service, Pacific Northwest Research Station, Corvallis, OR.

BOX 9.
COMPARATIVE MANAGEMENT: SPOTTED OWLS IN CALIFORNIA



This partial spotted-owl envirogram was used in designing parallel, comparative management on the Kings River Ranger District, Sierra National Forest, CA. In an officially designated administrative study, the Forest Service is comparing two landscape prescriptions on two side-by-side, 30,000-acre watersheds. Both approaches seek to achieve "sustainable forest ecosystems." One mimics the effects of natural fire before the 1850s with a group-selection system to manipulate vegetation; the other applies substrategies to streamside, mid-slope, and upper-slope zones (low-, intermediate-, and high-intensity management, respectively). Research underway on these watersheds to support the management experiment includes studies on spotted-owl demography, abundance and reproductive success of forest birds and small mammals, species and genetic diversity of plants, validity of habitat models, harvest-practice effects on soils, and survey techniques for fishers, martens, and Sierra Nevada red fox. Assumptions, key questions, and knowledge gaps were identified in landscape-analysis plans written for each watershed.

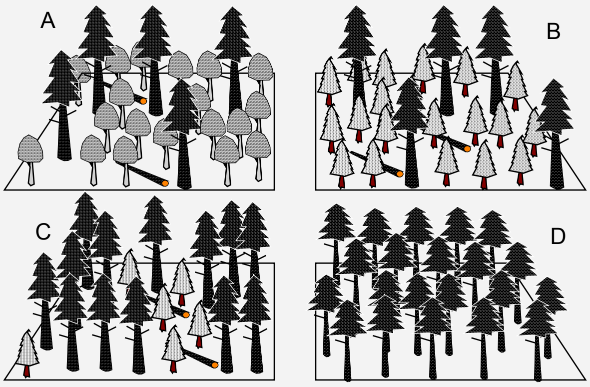
Contact: Jared Verner, Pacific Southwest Research Station, Fresno, CA.

4.2.4 Experimental Management at Stand Scales

A second parallel-learning model is identified as experimental management which is comparative management with replications. It is the most efficient way to improve the quality and interpretability of the information produced to support future decisions, where the approach can be implemented (Box 10). The process of designing management experiments will likely clarify and document the initial thinking and assumptions, usually left unsaid or unrecorded. When this approach is applied at the scale of a timber sale or small watershed project, usually for 10 or more years, it can be called a "**prescription experiment**."

Experimental management at stand scales may look to some people a lot like research plots, but major differences exist between them. Management experiments compare alternative, complex prescriptions to achieve the same goal; research experiments usually focus on single factors and are intensively monitored over only a few years. Only certain aspects of the scientific method are shared (table 2). Management experiments that receive little or no monitoring, whether by design or lack of funding, can provide valuable information through future retrospective analysis if they can be relocated and if descriptions of what was done are sufficiently documented (see 4.3.2).

BOX 10.
PRESCRIPTION EXPERIMENT: GROWING OLD GROWTH



The Mt. Hebo restoration project, an example prescription experiment being implemented by the Hebo Ranger District with assistance from the PNW Station in the Coast Range Adaptive Management Area, as part of the Pollard-Cedar timber sale (see box 6). Four management strategies are being compared to see how well they can create old-growth conditions while producing commodities for local communities starting with an 80-yr-old Douglas-fir plantation. In prescription A, the plantation is thinned to a very wide spacing, and continuous 30-yr rotations of red alder produce timber and improve the soil. Prescription B is the same as A, except that continuous conifer rotations are grown as a second story. Prescription C is a series of lighter thinnings, allowing a second story of conifers to develop slowly. Prescription D allows old growth to develop without harvesting. Prescriptions were randomly assigned to twelve 15-acre tracts (three replicates).

Contact: John Johansen, Hebo Ranger District, Hebo, OR.

4.2.6 Experimental Management at Large Scales

Parallel, replicated comparisons of different approaches to achieving the same management objective can also be applied to address broader policies, regulations, and issues at larger scales (box 11). This "**policy experiment**" approach is especially important and powerful when knowledge from intervention, comparative, and stand-scale experimental management cannot be extrapolated to large scales. Many issues and policies–for example, surrounding viability of wide-ranging animals, watershed cumulative effects, and local community development–may require working at larger scales. Whether truly large-scale experimental management is possible remains uncertain and untested, but the need for learning at this scale is clear and possibilities for important advances are perhaps the greatest with this approach. An even more powerful approach would be to combine intervention and experimental management. Such an approach has never been attempted to our knowledge.

4.3 Monitoring and Evaluation

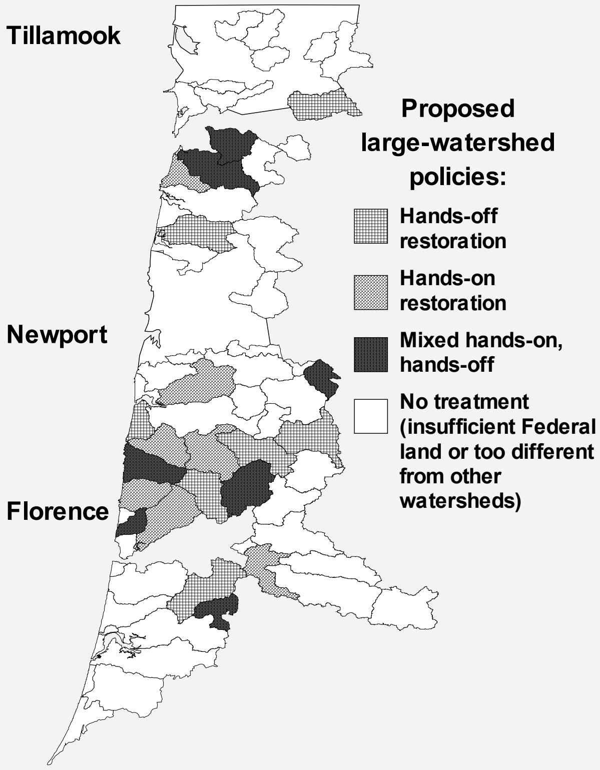
The real purpose of monitoring, we argue, is to learn something, although it is often thought of as a legal or bureaucratic requirement, disconnected from specific learning objectives. Adaptive management, by focusing on learning and adapting, helps to bring purpose and direction to monitoring activities. A monitoring philosophy is needed that fits with the broad learning goals we propose for adaptive management. Key elements to this philosophy link to other learning and adaptation strategies:

Define learning clients and learning objectives. Because citizens, scientists, and managers are all learning clients, objectives for learning will likely be broad and diverse, and related to the questions asked. Monitoring needs to be balanced and distributed across these groups to ensure that all groups have opportunities to learn. Overlap in issues and questions is likely, and many monitoring variables will be useful to address other groups' concerns. Only after analysis of the questions and discussion of the possible variables can an efficient set of monitoring variables be determined. Leaving the decision of what to monitor to a single group of managers or scientists is not likely to achieve broad learning objectives.

Incorporate scientific methods. A key element of the scientific method that applies to monitoring is stating anticipated outcomes, assumptions, and thinking in advance of all management actions. Clarity in these statements is required to be able to test them against the reality of what happens. Scientific methods might best be incorporated in monitoring by requiring that proposals for land management actions and subsequent NEPA documents state learning objectives. In addition, scientists have considerable experience in designing efficient sampling procedures to maximize the opportunity to detect differences and trends efficiently, and to minimize biases.

Compare anticipated outcomes with actual outcomes. The pre-existing record of anticipated outcomes (from citizens, scientists, and managers) should be accessible to anyone who is interested in evaluating the differences in anticipated and actual outcomes. In addition to providing computerized data, trail or road access to experimental sites will be very important to allow people to see for themselves differences in alternate treatments and anticipated and actual outcomes. Interpretive signs and documents will be needed to establish background information for those people not involved in designing the treatments. Threshold trigger-mechanisms are a special type of compared outcome, where specific thresholds are identified in advance that, if achieved, trigger changes (adaptations). These mechanisms are discussed under additional strategies below.

BOX 11. EXPERIMENTAL MANAGEMENT: THE OREGON COAST PROVINCE



A large-watershed policy experiment for the Oregon Coast Province (Bormann et al. 1996) is being proposed in a joint manager-researcher-citizen project exploring adaptive management strategies to implement the Northwest Forest Plan. The feasibility of applying multiple approaches to 21 of the 27 large (20,000 to 150,000 acres) watersheds that have more than 50% federal land in the Province is being evaluated. Watersheds along major river systems and with less than 50% federal land were excluded under the assumption that interpreting responses from these watersheds would be too difficult. Three approaches, based on different philosophies for restoring old-growth and riparian ecosystems and producing some commodities for local communities, were proposed for randomly assigned watersheds dominated by federal land. The Northwest Forest Plan focuses on restoring old-growth and riparian conditions and at the same time producing commodities to support local communities. In essence, the Plan seeks to blend "hands-on" and "hands-off" philosophies by allocating some land for hands-on restoration (more intensive; see box 10) and others for hands-off (less intensive) restoration. The Province-wide policy experiment does not violate the Plan or substantially change resource production goals, but rather, seeks to redistribute management across the landscape to learn more efficiently from management. Treatments might be exaggerated in the adaptive management area in the northern third of the Province to maximize their differences to speed learning. Proposed treatments are:

Hands-off restoration. In seven of the large watersheds selected at random, apply the standards and guides from the ROD without local modification. This treatment is not entirely hands off because it includes harvesting on the ridgetops where the "matrix" land designations are. Some areas outside the pre-watershed-analysis riparian buffers will have light commercial thinnings.

Hands-on restoration. In another seven of the large watersheds selected at random, the ROD would be applied by distributing management throughout the landscape as much as possible by using local knowledge and judgment gained through watershed analysis, Provincial assessments, and experience. Active restoration, including wide spacings in intermittent riparian buffers, will begin after watershed analysis.

Mixed hands-off and hands-on policies on small watersheds. Although the comparison of hands-on and hands-off policies will be interesting and provide valuable information, a wider range of policies, though certainly possible, will not fit on the limited number of large watersheds. For this reason, other policies were proposed for the smaller watersheds within the remaining seven large watersheds, selected at random. This approach would broaden the range of policy alternatives implemented and studied.

Contact: Pat Cunningham, Pacific Northwest Research Station, Corvallis, OR.

4.3.2 Delayed Monitoring for Comparative and Experimental Management

In this time of declining federal support, increased funding for monitoring will likely come as painful reductions in other important management activities. Monitoring—and adaptive management because of its seeming requirement for increased monitoring—is thought by some managers and line officers to be too expensive to really be feasible in all but a few places. Although monitoring can be made more efficient through better coordination of existing monitoring (chapter 29), gains in efficiency will not necessarily allow for a major increase in monitoring. An alternative approach might be tried in situations where resources are not available for intensive monitoring. In what might be called "delayed monitoring," parallel learning models (comparative or experimental management) could be applied with little or no initial monitoring. With sufficient documentation of the location and different prescriptions or policies, a management comparison or experiment could be left for later monitoring, or only be considered for retrospective research analysis much later. If this approach had been taken many years ago, we would have a wealth of retrospective-research opportunities today that could be prioritized to yield the most-needed information (see Black Rock, box 2).

4.3.3 Trigger Points

Learning can be faster and more effective when specified thresholds or trigger points for specific monitoring variables can be established. These points or conditions are thresholds that no group thinks is acceptable to go beyond, and where groups agree to legal consequences for crossing these thresholds (box 12). The trigger-point concept has two interrelated parts, documenting adverse changes in the resources, and examining possible linkages between changes and the presence or absence of specific management practices. Linkages are best examined as anticipatory research to create management options that can be implemented at the time when a change in management appears warranted; research after an adverse change is documented will be less useful. Common thresholds and legally binding agreements have special importance in large, mixed ownerships, where a natural diversity of approaches is likely. Mixed ownerships represent an expanded opportunity to learn, especially when all owners can agree on some broad, common goals and then explore their own ways to achieve those goals. When goals are not compatible, learning is still needed to find ways to increase compatibility.

4.4 Research

Change in approaches to research are needed for scientists to better contribute to manager-scientist-citizen partnerships for learning and adapting. Traditionally, research has contributed to learning and adapting by using scientific methods to produce rigorous interpretations and understanding of uncertainties for questions arising in science or from managers' immediate problems. Without reducing emphasis on quality of understanding, research changes should include more emphasis on:

- Linking explicitly to manager and citizen questions, even in science-driven studies;
- Analyzing past management effects retrospectively;
- Integrating disciplines to understand multiscale ecosystem responses;
- Anticipating and preparing for future questions from managers and citizens;
- Considering models as hypotheses that can be tested with adaptive management;
- Advising managers and citizens on learning techniques; and
- Studying the process of learning and adapting, itself.

BOX 12.
TRIGGER POINTS: THE KARNER BLUE BUTTERFLY

About 3 million acres in central and northwestern Wisconsin are home to the endangered Karner blue butterfly. The habitat conservation plan for the butterfly is being written to apply adaptive management and to develop specific responsibilities among the varied landowners (intensive recovery on public and volunteered private lands; minimizing incidental take [loss of individuals] and enhancing habitat on large corporate lands; minimizing and mitigating incidental take that is proportional to actual take among large, more than 1000-acre, noncommercial private ownerships; and no requirements for small noncommercial owners). Legally binding agreements are being developed to support surveys and research to invoke practice changes in the advent of a decline in the distribution and abundance below a to-be-specified trigger point that can be scientifically linked to management practices. Studies are underway to identify trigger points that can be reasonably measured, given the large inherent variability in butterfly populations.

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4.4.1 Models

Models—abstract representations of a part of the real world that is of particular interest—can range from verbal descriptions or graphic or schematic representations to detailed mathematical models. Models are a means to force scientists and managers to think as thoroughly and precisely as possible about the structure of the systems with which they work. Modeling often turns into a learning experience when people from different perspectives systematically describe what they know (and think they know) about resource systems. A valuable additional role for models is to record predicted outcomes that can be compared to future actual outcomes. Articulating the thinking and functional basis for predictions more clearly provides more chances to learn. Models can also help to identify critical monitoring variables from among the many that people express interest in. Qualitative models with schematic, box-and-arrow representations of causes and effects that can be understood by citizens, managers, and scientists who want to learn will likely play a much more important role in adaptive management than so-called blackbox, highly reductionistic and mechanistic mathematical models.

4.4.3 Retrospective Research

A key area for observational studies and quasi-experiments (table 3) is reconstructing the effects of past management actions and natural cycles and events in "retrospective research." Because long-term experimental management will take many years to provide knowledge, retrospective studies are especially important in understanding long-term and cumulative effects of management quickly. Recognizing the limitations of retrospective approaches is also important because only rarely will initial conditions be known or a sufficiently long-term data set be available to do quasi-experiments. Most of these approaches will be qualitative. Also, because management strategies are changing rapidly, past actions may not help to understand current or future strategies well.

Much can be gained from creating a database of retrospective study opportunities. Any landscape contains information resources, such as old research studies, inventory plots, administrative studies, and fence-line comparisons. The quality of information and relevance to current questions will differ among these places. For locations with substantial information resources, recognition of this value is vital to weighing the relative importance of information related to other resources—for example, trying not to inadvertently destroy or diminish an opportunity not known to exist. A database could also help in setting priorities among opportunities for study to achieve broad learning objectives.

4.4.4 Formal Experiments

Another way research can be linked to experimental management is to help tease apart the complexities that will undoubtedly result from policy and prescription experiments. Because prescriptions are complex sets of practices distributed through time and space, interpreting differences between different treatments and attributing causes will be challenging, especially where differences end up being small. Traditional research on smaller scales can address the effects of individual practices, practice interactions, and interactions between practices and natural events and cycles. This research would focus on testing assumptions about what are thought to be the principal factors and would go beyond simply addressing effects, to looking for causes as well.

4.4.5 Anticipatory Research

Anticipating future problems by thinking about long-term trends (for example, in population and natural cycles) is especially important for increasing the speed with which managers can react. Advance warning can lead to changes that even offset the problem before it becomes a contentious issue. Developing measures of ecological capacity (fig. 2) should be the focus of "basic" research to support adaptive management. Probably the best hope for making broad, long-term predictions about ecosystem behavior is an improved understanding of environmental and genetic (population) causes and ecosystem effects (Gordon et al. 1992). The more that anticipatory research can influence the design of experimental management and retrospective studies, the more management can be designed to reduce uncertainty about issues before they reach crisis proportions.

4.5 Institutional Changes

We propose four institutional changes that can promote a culture of learning and adapting, including: increasing institutional memory, publishing an adaptive management journal, creating a sabbatical program, and rewarding people and organizations who learn and adapt.

4.5.1 Increasing Institutional Memory

Because of the long-term learning cycle for many forest ecosystem issues, memory must transcend from the individual to the institutions to make adaptive management possible. Many learning opportunities are lost because of nonexistent or ineffective institutional memory of successes and failures (Hilborn 1992). Institutional memory goes beyond monitoring management actions to include the knowledge that accumulates in files, reports, databases, and--perhaps most important--in people's minds. Strategies to increase institutional memory include

- Recording the **thinking** that goes into decisions, in the form of statements of anticipated outcomes, assumptions, and logic paths in assessments; NEPA, ESA, and air- and water-quality consultations; and decision rationale.
- Creating and maintaining long-term records, libraries, and computerized knowledge bases;
- Using existing long-term inventory data sets to extract new information;
- Writing and distributing historical accounts of issues and approaches to solutions; and
- Reconstructing historical failures in institutions unable to communicate possible failures when they occur.

4.5.2 Publishing an Adaptive-Management Journal

We propose developing an electronic journal composed of three parts: a peer-reviewed section to publish adaptive management designs, analysis techniques, and results; a resource-management section to provide practical information on what worked and what did not; and a public information section to describe results and their implications for people's values and wants. All sections would be open to comments from anyone—not just the people in that section's category—who wants to address her or his views toward the likely readers of that section. Knowledge about failures is as important to future experiments and decisions as knowledge about successes. The continual communication among all participants through the journal's pages would contribute to the collaborative learning by which management actions would be adjusted through time.

4.5.3 Creating a Sabbatical Program for Scientists and Managers

Scientists are sometimes granted sabbatical leave; one purpose is to expose them to new ideas and give them time to write. Most scientists spend time thinking about generalities and have few opportunities to try their ideas on the ground. A sabbatical program run by managers might be a way to learn from scientists about possible applications of the scientific method to their specific landscape-based problems and to teach scientists about real problems and innovations from managers and local citizens. A sabbatical program would be an especially important mechanism to lure scientists, temporarily, away from research centers.

Managers occasionally go back to school to get more training and advanced degrees. A sabbatical program run by scientists, where managers participate in research projects, perhaps without a formal degree program, might be a way to learn from managers about their innovations, experiences, and specific landscape-based problems, and a way to teach managers about applying aspects of the scientific method and how research institutions work.

Many benefits derive from having managers and scientists remain in an area long enough to understand the historical, biophysical, and social dynamics of the area. Many other benefits also derive from managers experiencing other bio-social regions. A sabbatical program for managers and scientists where they temporarily exchange positions with others might help to achieve both sets of benefits.

4.5.4 Rewarding People and Organizations Who Help To Learn and Adapt

The current reward systems for managers and scientists reflect traditional roles. New roles and responsibilities require that new rewards and incentives be established to help individuals overcome barriers to contributing toward ecosystem-sustainability goals. Rewards for citizen learners are all but nonexistent. Learning is usually difficult, often requiring painful admission that the initial expectations were incorrect. Rewards and incentives will play a special role in getting managers to "embrace error" to speed learning and adapting. Offering various economic incentives for private landowners is an important mechanism to influence management on nonfederal lands.

5 A MODEL OF ADAPTIVE-MANAGEMENT EFFECTIVENESS

The effectiveness of learning and adapting are ultimately evaluated by their contribution to the goal of increasing the overlap in what people want for themselves and for future generations, and what is ecologically possible in the long run (fig. 1). Because many learning efforts will take a long time to evaluate, no immediate direct measure of effectiveness is possible. In lieu of direct measures, we propose several initial processes that are likely to be closely related to long-term effectiveness:

5.1 Balance Learning and Adapting Strategies

Sharing and organizing ideas and knowledge from diverse groups can lead to rapid short-term learning. Testing ideas, even with parallel management strategies, will take much longer. Balanced investments in short- and long-term learning ensure that the best ideas are evaluated over time. Combining strategies (table 2) into an adaptive management system will require coordinating research and management organizations in ways not yet achieved.

The combination of various strategies (table 1) chosen should be well balanced, requiring coordination of institutions with historically segregated goals. One of the best balanced examples we found was developed by the Ouachita National Forest (box 13). Excellence in learning and failure in adaptation would not be as effective as some mixture of learning and adaptation. Some strategies can replace the needs of other strategies; for example, accelerated research on small plots, together with extremely careful and independent monitoring of a single management policy, might work nearly as well as a management-experiment strategy combined with modest research activity. Some strategies, however, should not be considered as optional—for example, defining learning objectives in planning and decision documents, maintaining long-term records that describe what was done and where, and leadership to overcome barriers to innovative solutions.

5.2 Fit Combinations of Strategies to Their Environment

Every place has unique combinations of social, ecological, management, and research history. Combinations of adaptive-management strategies should be designed to work with the limits and opportunities provided by the history of each place. The more rapid are the perceived changes in societal values and ecological capacity, the more need for emphasizing parallel learning models and adaptation strategies like defining trigger points.

BOX 13.
A BALANCED APPROACH: THE OUACHITA NATIONAL FOREST

We consider the Ouachita National Forest to be one of the best examples where learning to manage and managing to learn have become a priority for a large land area and organization—a National Forest. They have demonstrated their commitment to learning and adapting by openly acknowledging their lack of knowledge for managing whole systems sustainably, building adapting and learning into everything they do, emphasizing a collaborative approach in all of their management, establishing demonstrations of alternative vegetation management approaches throughout the forest and conducting many field tours to these sites, developing landscape-scale management experiments, initiating new research projects to improve future management, building strong partnerships with the science community, and recognizing that learning and adapting are essential to achieving sustainable ecosystem management.

Policy for the Ouachita shifted in 1990 when Arkansas Senator David Pryor and Forest Service Chief Dale Robertson went for the famous “walk in the woods.” After this walk, the Ouachita ceased to prescribe clearcutting as the standard harvest method. Before this policy shift, clearcutting was the dominant vegetation management technique. The policy shift sparked a whole series of fundamental changes in the Ouachita’s relations with the public and the scientific community and the Forest’s work and culture (Voth et al. 1994, Voth 1995). The changes centered around redefining learning to restore old growth, learning to recover red-cockaded woodpecker populations, and learning to renew shortleaf pine-bluestem grass ecosystems (Henderson and Hedrick 1991, Baker 1994).

A three-phased approach was taken to change and learn from on-the-ground practices. Phase I installed numerous demonstration sites throughout the Forest. More than 2,000 people have toured these sites since 1991. Phase II is a replicated, multidisciplinary study of 52 native shortleaf pine stands that examines forest responses to a full range of innovative even-aged and uneven-aged partial cuttings (Kuzmic et al. 1994). Phase III is directed at ecosystem responses to alternative management strategies at watershed and landscape scales (Guldin 1994). An ecosystem management advisory committee was formed in 1991 and continues to function today in providing advice and recommendations about projects and research needs and priorities (Frentz 1996). This committee consists of professionals from a variety of institutions and fields.

The efforts of the Forest and partners toward improving knowledge, interactions, and decision-making is illustrated in more than 40 publications and reports since 1990. Although many of the adaptive management concepts we have described are being used on the Ouachita, an adaptive management strategy was not explicitly addressed in the above references. We suggest that the Ouachita and others would greatly benefit from a description of their adaptive management strategy. This strategy would articulate how and when policies will be tested, evaluated, and adjusted based on learning activities.

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5.3 Emphasizing the Quality of Comparisons

Effective learning depends on comparing different approaches. Without any comparison, nothing is learned about "what might have been". Sequential learning models compare current with past approaches; parallel models compare different approaches at the same time. Several managers have questioned whether having several sequential comparisons is the same as having a parallel comparison; after all, two different practices can be compared. Also, people have questioned whether sequential approaches on federal land could be compared to adjacent private lands. These comparisons can be useful, but--because they are comparing places that were not likely to be initially similar--confidence that the responses observed can be attributed to the different approaches, rather than initial condition, will be very low. Rather than arguing for strict "research" designs, we are simply arguing for a focus on increasing confidence that we are interpreting comparisons to avoid coming to incorrect conclusions. False confidence is perhaps the greatest impediment to achieving management goals.

5.4 Learn About Learning

Where possible, multiple approaches to learning should be tried simultaneously. As with land-management policies, the single best way to learn is not known in advance. Thus, multiple approaches to learning should be tried, which might also be called experiential, parallel, intervention, and experimental. Learning to learn efficiently will require scheduling and distributing learning activities to set up meaningful comparisons that take advantage of local attributes, including accessibility to scientists and citizen interest.

5.5 Focus on Societal Learning

The ultimate objective of an informed citizenry and electorate must be kept in mind for adaptive management to be effective, and adaptive management strategies should therefore increase public participation. Four propositions to evaluate societal learning proposed by Stankey and Shindler (1997) are that boundaries are meaningful to stakeholders, partnerships will highlight limitations in knowledge, partnerships will highlight differences in world views, and partnerships will challenge current institutions.

6 REMOVING BARRIERS

6.1 Skills in Existing Organizations

The principal attributes for managers and citizens implementing adaptive management are inquisitive minds and a willingness to learn about new approaches to management. Principal attributes for scientists implementing adaptive management are inquisitive minds and willingness to learn beyond their traditional disciplinary confines. Broad new goals for management, like ecosystem sustainability, require tapping into the brightest minds in a wide range of disciplines, including social sciences, land-use planning, public affairs, and marketing research, as well as the natural sciences. Whether people in existing organizations can acquire state-of-the-art knowledge on learning techniques should be addressed. A special role, at least in the interim, exists for people who can move freely between science and management communities, including science-trained communicators.

6.2 Funding Forest Management and Research

Forestry research is a small portion of total federal funding for forest management (6% of the total 1996 Forest Service appropriations, and a smaller percentage of total revenues), and support has declined steadily—for example, 16 percent from 1978 to 1988 in 1982 dollars (NRC 1990). With information requirements increasing rapidly, the need for having other groups participate in learning has become clear. A recent proposal for managing the proposed Coquille Forest, near Coos Bay, Oregon, allocated 17 percent of total revenues to research and monitoring (Gordon et al. 1995).

6.3 Knutson-Vandenberg Act of 1930

The Knutson-Vandenberg Act allows managers to "require any purchaser of National Forest timber to make deposits of money in addition to the payments for timber to cover the cost of [reestablishing trees, forest improvement, and] protecting and improving the future productivity of the renewable resources of the forest land on such sale area,...". If timber is harvested as part of a management action, and receipts are sufficient, Knutson-Vandenberg funding for monitoring and other adaptive management actions (see table 3) should be encouraged. Because of the need for monitoring variables proposed by citizens, scientists, and managers, and in lieu of increasing appropriations for forest management and research, Knutson-Vandenberg funding may become a major means to fund adaptive management activities. Current Forest Service Manual direction permits funding of monitoring, but only for 5 years after harvest. A longer monitoring period, at least 50 years, and permitting pretreatment monitoring for intervention management, may be essential to meet the intent of the law, and certainly would allow for a much more complete analysis of management effects.

6.4 Nonfederal Lands Antitrust Concerns

About 10 percent of continental United States forest and range land is managed by federal agencies (28%, including Alaska). Achieving sustainable conditions across broad landscapes, therefore, would seem to require some coordination and cooperation among many landowners. When forest-industry managers talk to other companies or the federal government about timber harvest strategies, antitrust issues emerge. The most important aspect of this concern is whether an opportunity exists, or might be created, to control price by controlling availability of harvestable timber. Georgia-Pacific Corporation, as part of the Karner butterfly project in Wisconsin (box 12), asked a law firm in for an opinion about the possibility of an antitrust violation from participating in the habitat conservation plan. Georgia-Pacific was advised that an antitrust violation could occur even though unintended, no matter “how noble the cause.” Laws could be violated or appear to be violated when companies negotiate among themselves about the land areas involved or the volume of timber to be cut under the plan. Further, the law firm thought that having a government agency orchestrate these negotiations may not avoid the antitrust issue, so long as the changes are likely to affect the market. The law firm also thought, however, that revealing ownership acreages and timber types by age class would not be a significant antitrust issue because substantial data related to ownership and timber types is already available to citizens directly and indirectly from state and federal agencies through the Freedom of Information Act. As currently written and interpreted, antitrust laws appear to constrain but do not prevent industry participation.

7 INITIAL STEPS FOR MANAGERS

Look for learning opportunities in current projects to demonstrate concepts. Learning is possible in every project, and modifying projects already underway is a good way to start. As an example, if a single prescription has been developed for a project, find a comparable area that can be used as a no-management comparison and extend baseline and post-implemetation monitoring to that area. Creating new prescriptions to compare side by side is often easy and does not require extensive monitoring if the goal is to create long-term comparisons for possible retrospective analysis. Sufficient information about what was done, however, must be collected and preserved.

Share the concepts of adaptive management with possible partners; look for enthusiasm. From our experience, what and how to learn in the normal course of management is a topic of considerable interest to managers, scientists, and citizens. Managers should look for leadership from local groups (like the Applegate partnership, box 5), or, if unavailable, initiate these discussions themselves. Who initiates the discussion is less important than whether the discussion begins. Try to take advantage of enthusiasm and creativity wherever you are lucky enough to find them.

Build your partnership for learning by creating an inclusive, safe, learning environment. Facilitation skills are important. Promote courteous disagreement as a means to identify alternative pathways. Be tolerant of ideas that initially seem unacceptable. Prescriptions that incorporate these ideas will help everyone to see their advantages and disadvantages.

Disagree: disagreement is a source of information on alternative pathways. Use the power of the collective human mind. Disagreements are based on different world views, experiences, and knowledge. Disagreement is fuel for developing alternative pathways to achieve the same goals. Consensus, especially averaging or power-based decisions that choose a single answer, ignores the knowledge of those whose answers were not chosen. Rather that insisting on a single path, learn to tolerate the views of others, at least long enough to start to see the positive and negative aspects of their (and your) approaches.

Value information through both retrospective and small-scale research. The land also has information resources that can be used to better manage the land. Information can be thought of as equal to other environmental and commodity resources, to be managed in like ways (planning, harvesting, monitoring, evaluating). When managers include and balance learning objectives with other traditional resource objectives, information becomes more valued. Extracting knowledge through retrospective research on ecological history (for example, natural and management disturbances) and on social history (for example, attempts at public involvement), may be an inexpensive way to increase knowledge, and a way to expand scientist participation in local management. Also, research may be possible in more narrowly defined small plots within your managed stands to better interpret complex management experiments and test some of the underlying assumptions prescriptions are based on.

Explore failures and successes to better learn from them. Do you remember a project that, especially after some years of reflection, had a negative outcome in terms of environmental or social damage? You can explore what happened and what went wrong to help avoid repeating the mistake, and by doing so, turn a negative into something positive. Ultimately, how knowledge, once obtained, is recorded, organized, and communicated will demonstrate the value placed on it.

Try a community-based experiment to compare different pathways. The energy and creativity of communities of place or interest can be harnessed to help pose questions that could be answered in management experiments. They can also help develop sets of prescriptions to create different pathways to achieve broad-enough goals they all can agree to. The quality of the comparison, in terms of how well people will attribute results of the different pathways, will be determined largely by the structure of the management experiment. Finding areas that are initially similar in variables that relate to the question being asked is essential; otherwise, people will tend to attribute different results to the differences in location.

8 SUMMARY AND CONCLUSIONS

Can scientists and managers work together better? Yes, the exercise of writing this chapter demonstrates that managers and scientists can better understand each other's perspectives and find common ground where they can work together to achieve important societal goals. Case studies also suggest that management and research objectives can be effectively combined in management experiments and linked research.

Can citizens play a more meaningful and personally rewarding role in natural resource decisions? Yes, we think so, especially if citizens are allowed to identify priority questions that can be answered in the course of management. Although the need for expanded citizen involvement is obvious, it remains mostly a theoretical advantage. Broader experience with citizen involvement, especially seeking creative ideas from citizens with widely different backgrounds and at the scales of states and regions, is needed to answer this question.

Can the range of alternatives for managers expand through time? Yes, by taking advantage of creative ideas, wherever they come from; evaluating on the ground a wider range of options; and planning for future information needs are ways to find new alternatives that otherwise seem so difficult to come by.

Do bureaucracies create barriers to learning and adapting? Yes, it seems that people who gain the most from a bureaucracy try hardest to maintain the status quo. Managers should try to include and consider learning objectives any time they make decisions about commodity production and resource protection. For federal managers, learning objectives can be added to project initiation letters, NEPA purpose and needs statements, proposals and alternatives, and monitoring and evaluation plans.

Are research resources sufficient to address the questions raised by ecosystem sustainability goals? No, but adaptive management can be a way to supplement and extend research by sharing the responsibilities for learning with managers and citizens, to extend learning directly to the larger scales of management, and to look at new questions more directly related to societal problems.

Does monitoring seem disconnected from learning? Yes, but monitoring can be more focused and help to make future decisions easier when it is done in the context of learning and adapting plans. Agency monitoring often fails to ask questions like, Who needs to learn? and What needs to be learned? Monitoring groups tend to focus on measurement techniques, without much effort to understand the nature of the questions, and how to extend learning beyond their group.

Can managers get in front of issues before they become contentious? No, not until they implement strategies to explore future management options before they become the centers of contentious debate.

Adaptive management, as described here, is an evolving way for managers, scientists, and citizens to work together to achieve sustainable ecosystems. Superficial changes to current practices will not likely accelerate learning and adapting. We present our latest ideas on an expanded set of alternative approaches to implement adaptive management. These ideas will evolve and grow as experience is gained by trying them in the real world. We encourage you to try these strategies, and evaluate and change them as your experience dictates.

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Jack Ward Thomas responded to an earlier effort to put our ideas on paper, by saying something like, "I can agree with most of what you have written, but it won't mean anything until it's on the ground." His words—and his own successes in bringing managers and researchers together in eastern Oregon—pushed the science authors of this chapter to collaborate with the managers of the Siuslaw National Forest to do what he suggests: to work together to put our collective

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