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Synthesis

Adaptive Ecosystem Management in the Pacific Northwest: a Case Study from Coastal Oregon

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ABSTRACT

Adaptive ecosystem management has been adopted as a goal for decision making by several of the land management and regulatory agencies of the U.S. government. One of the first attempts to implement ecosystem management was undertaken on the federally managed forests of the Pacific Northwest in 1994. In addition to a network of reserve areas intended to restore habitat for late-successional terrestrial and aquatic species, "adaptive management areas" (AMAs) were established. These AMAs were intended to be focal areas for implementing innovative methods of ecological conservation and restoration and meeting economic and social goals. This paper analyzes the primary ecological, social, and institutional issues of concern to one AMA in the Coast Range in northern Oregon. Based on existing knowledge, several divergent approaches are available that could meet ecological goals, but these approaches differ greatly in their social and economic implications. In particular, approaches that rely on the natural succession of the existing landscape or attempt to recreate historical patterns may not meet ecosystem goals for restoration as readily as an approach based on the active manipulation of existing structure and composition. In addition, institutions are still adjusting to recent changes in management priorities. Although some innovative projects have been developed, adaptive management in its most rigorous sense is still in its infancy. Indeed, functional social networks that support adaptive management may be required before policy and scientific innovations can be realized. The obstacles to adaptive management in this case are similar to those encountered by other efforts of this type, but the solutions will probably have to be local and idiosyncratic to be effective.

KEY WORDS: adaptive management, adaptive management area, ecosystem management, forest ecology, landscape ecology, models, monitoring, old-growth forest, public involvement.

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INTRODUCTION

In the last decade, many federal agencies in the United States have started moving toward ecosystem management as the primary framework for decision making (Grumbine 1994, Stanley 1995). This fundamental change in direction requires agencies to define management in terms of broad spatial scales, long time frames, and communities of multiple species, while continuing to sustain focal species and commodity production in the short term (Christensen et al. 1996). The primary motivations behind this migration toward ecosystem management are to (1) arrest the decline of species and avoid their subsequent listing under the *Endangered Species Act,* (2) plan for the long-term sustainability of ecosystems, and (3) ensure the sustainability of economic and other benefits to people. These goals have also become codified, at least for temperate forests, in international agreements (Santiago Declaration 1995) and national policies (USDA Committee of Scientists 1999).

Given the nascent form of ecosystem theory and the dynamic, unpredictable behavior of ecosystems (Holling 1996), there is substantial uncertainty about the long-term response of ecosystems to management. Some believe that this uncertainty could be addressed by adaptive management, in which management policies and monitoring efforts are designed for the purpose of learning about the responses of ecosystems to different types of management (Holling 1978). However, the application of adaptive management in contentious natural resource settings has met with limited success at best. Recent case studies indicate several barriers to success, including difficulties in modeling ecosystem responses to management, risk avoidance and lack of institutional flexibility, costs of monitoring, and lack of community involvement (Stankey and Shindler 1997, Walters 1997, Gunderson 1999). Because of the lack of cumulative experience with adaptive management, individual cases must be evaluated to build an accumulated understanding of the elements that are important for its successful application.

Ecosystem management, adaptive management, and sustainability are all relatively new imperatives facing land managers around the globe. For some managers, they entail a radical adjustment in policies and practices. At the same time, these terms are imprecise, and their definitions are often subject to debate. How are these new mandates being interpreted and implemented on the ground?

In 1994, U.S. federal land management and regulatory agencies adopted a regional ecosystem management strategy for federally managed forest lands in western Washington and Oregon and northern California. Known as the "Northwest Forest Plan" (NWFP) (U.S. Forest Service and USDI Bureau of Land Management 1994), this strategy was intended to resolve a long-running legal dispute over the fate of the Northern Spotted Owl (*Strix occidentalis caurina*) and other species dependent on old growth, and it dramatically reduced timber harvests in favor of the protection and restoration of late-successional and old-growth forests. The plan was one of several options developed and evaluated by an interdisciplinary team of researchers and specialists (FEMAT 1993). In addition to a regional network of reserves, the plan established 10 "adaptive management areas" (AMAs) to test alternative approaches to achieving ecological, economic, and social objectives for federal forest lands. The NWFP emphasized the need for AMAs to involve the public and practice collaborative management in an effort to avoid future public opposition and legal battles. In addition, one of their primary objectives was to "provide for landscape-level management approaches" (U.S. Forest Service and USDI Bureau of Land Management 1994).

Adaptive management is a structured process designed to improve understanding and management by helping managers and scientists learn from the implementation and consequences of natural resource policies (Holling 1978, Walters 1986, Lee 1993). Learning is necessary because (1) knowledge about species and ecosystem responses to different management approaches is usually incomplete, and (2) changes in the environment, the economy, and social desires are inevitable (Walters 1986). Although some definitions of adaptive management include a wide range of activities that improve learning (Bormann et al. 1994, Westley 1995), others require a more "formal" process of testing hypotheses about management outcomes, in which policies are explicitly treated as experiments (Holling 1978, Lee 1993, Walters 1997). In this approach, a small core team coordinates the efforts of scientists, managers, and policy makers to:

1) define management problems in terms of objectives, constraints, and considerations for analysis;

2) synthesize existing understanding in the form of dynamic models that spell out assumptions and predictions in a way that makes it possible to detect errors and contributes to learning;

3) identify uncertainties related to management effects as well as alternative ideas (models) that might work better; and

4) design policies that produce both resources and better knowledge and that search for untested opportunities (Walters 1986).

This formal approach to adaptive management not only requires intentional learning, but also forces decision makers to define and structure their approach to ecosystem management. This paper examines the progress of adaptive ecosystem management under the NWFP in one AMA five years after the plan was adopted. The formal approach to adaptive management outlined above provides the criteria for evaluating the initial success of the AMA in addressing the key management issues of ecosystem management, forest management, riparian management, and public involvement. Specific objectives include:

1) an examination of the primary questions and alternative philosophical approaches to implementing ecosystem management,

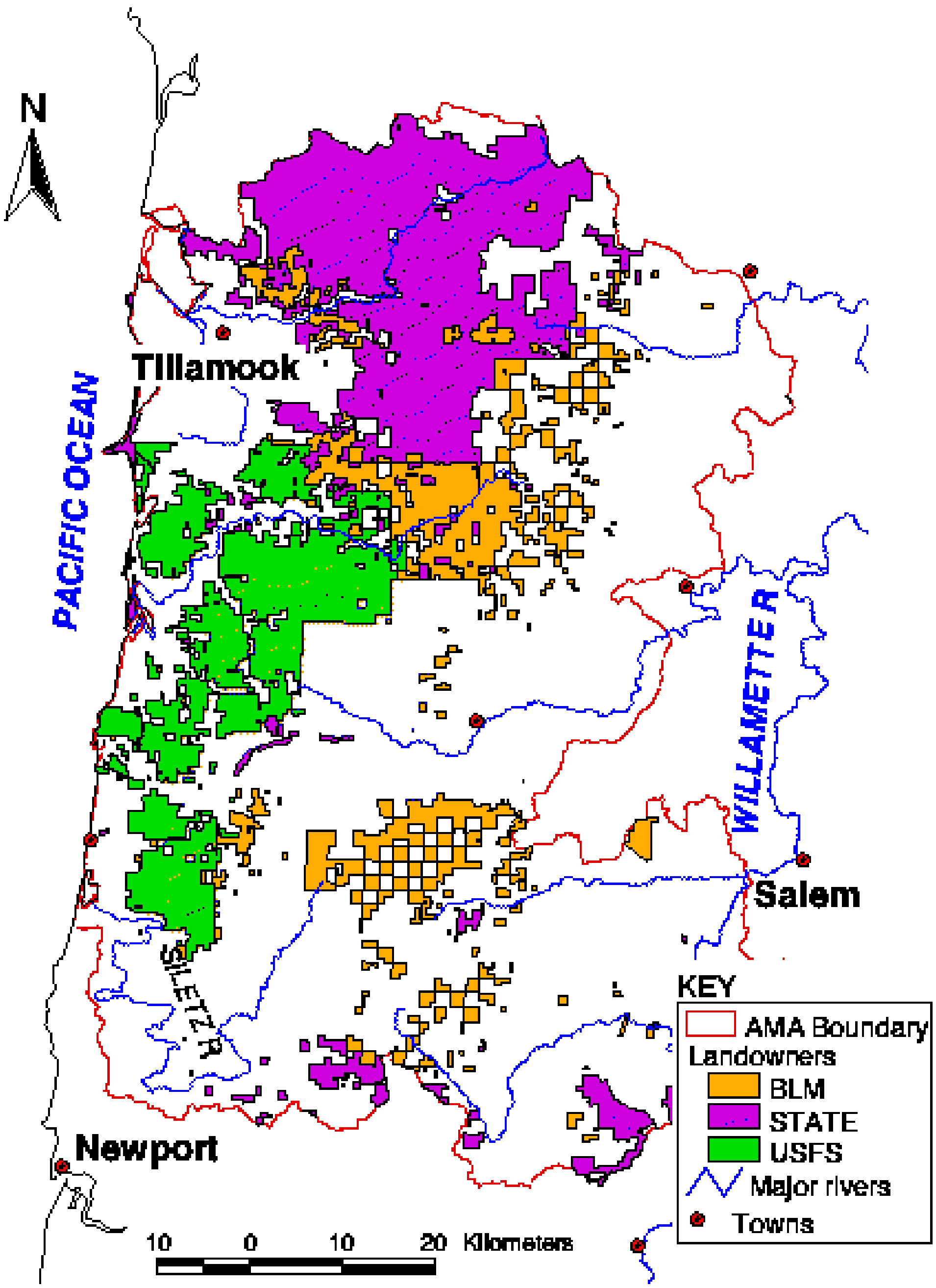
2) an evaluatation of the progress toward implementing adaptive management, and

3) a discussion of potential approaches for future efforts.

CONTEXT OF THE NORTHERN COAST RANGE AMA

The Northern Coast Range Adaptive Management Area (NCAMA) consists of 113,000 ha of federal land between the Pacific Ocean and the Willamette Valley in the Coast Range of Oregon (Fig. 1). These federal forest lands are administered by the U.S. Forest Service (FS) and the Bureau of Land Management (BLM). Most of the surrounding and intermixed lands are owned by industrial forestry companies. Coast Range forests are among the most productive in the world, with aboveground biomass production in mature (~100-yr-old) coastal stands of 10–15 Mg x ha^{-1} x yr^{-1} (Gholz 1982). Compared with the first half of the 20th century, when harvests of large trees and abundant salmon were common, the current landscape is dominated by relatively young forests, and most anadromous fish runs are designated as endangered (U.S. Forest Service and USDI Bureau of Land Management 1997, Gray 1998).

Fig. 1. Map showing the location of public lands in Oregon's Northern Coast Range Adaptive Management Area.



About 60,000 people live in the rural and coastal areas around the NCAMA. The population is growing and aging because of an influx of retirees and second-home buyers. Over the last 35 years, employment in the retail and service industries has increased, while employment in manufacturing and the forest industry has decreased, resulting in a decline in real wages for many residents. At the same time, the cost of rental housing has soared (Leonard 1997).

The NCAMA was singled out for AMA status during the development of NWFP alternatives because its size, its lack of old-growth forest, and the various ways in which federal lands are arranged in the area made it well suited for studying the recovery of the Northern Spotted Owl (*Strix occidentalis caurina*) (T. A. Spies, *personal communication*). The initial emphasis in the plan was on "management for restoration and maintenance of late-successional forest habitat ... [and] ... development of a comprehensive strategy for conservation of the fisheries and other elements of biological diversity in the northern Oregon Coast Ranges" (U.S. Forest Service and USDI Bureau of Land Management 1994). To achieve this, AMAs were instructed to "pursue a variety of approaches" and reduce reliance on "traditional prescriptive approaches" (FEMAT 1993:II-11−12).

Nevertheless, the NCAMA was not entirely free of "prescriptive approaches." Most significant was the designation of the best forest habitat (as identified by Johnson et al. 1991) and any additional sites occupied by the Marbled Murrelet (*Brachyramphus marmoratus*) and the Northern Spotted Owl as "forest reserves." These reserves occupy 66% of the federal lands in the NCAMA and limit management to practices designed to enhance the development of late-successional forest conditions, although only in stands < 60−110 yr old, depending on location. Additional riparian reserves were designated along all intermittent and perennial streams. Reserve boundaries and guidelines can ostensibly be changed following site-specific analysis and planning.

The institutional context for the NCAMA involves a wide range of local and regional players. The FS and BLM land management agencies designated an employee as the "AMA coordinator" responsible for the development, coordination, and communication of adaptive management projects. I served as "lead scientist" (from the U.S. Forest Service Pacific Northwest Research Station) and was responsible for assisting in project development, conducting research, and serving as liaison with the scientific community. Managers worked directly with federal regulatory agencies, primarily the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS), which have considerable influence on management actions because they oversee efforts aimed at promoting the recovery of endangered species. Several regional groups guided implementation, monitoring, and research for the NWFP. The Coast Range Provincial Advisory Committee included members from federal, tribal, state, and community organizations who examined issues and provided management recommendations to federal land managers.

Taking into consideration the overall goals of the NWFP, the resources available to the NCAMA, and expectations regarding adaptive management, the fundamental question for this AMA could be stated as follows: "Which human activities on the landscape are compatible with restoring and maintaining functional late-successional forest and aquatic ecosystems?"

As with most adaptive management questions, the answer to this one will probably depend on more than ecological science. The philosophical and social implications of current knowledge and uncertainty will also be essential ingredients.

LATE-SUCCESSIONAL AND OLD-GROWTH FORESTS

Characteristics and features

"Late-successional forest" refers to a range of forest conditions that develop over time, beginning with stands in which tree crown expansion slows, openings between trees become larger and more stable, and large, standing dead and fallen trees begin to accumulate (see Fig. 2 and Fig. 3). This includes older ("old-growth") stands in which the oldest trees reach their maximum sizes, understory trees form multiple canopy layers, and dead wood accumulates to high levels (U.S. Forest Service and USDI Bureau of Land Management 1994: B-3). Late-successional characteristics typically begin to form in Douglas-fir (*Pseudotsuga menziesii*) forests aged 80–140 yr. Managers of the Northern Coast Range Adaptive Management Area (NCAMA) currently categorize stands > 80 yr old as late-successional (U.S. Forest Service and USDI 1997).

Fig. 2. Photograph of a young forest with a relatively simple structure and composition.

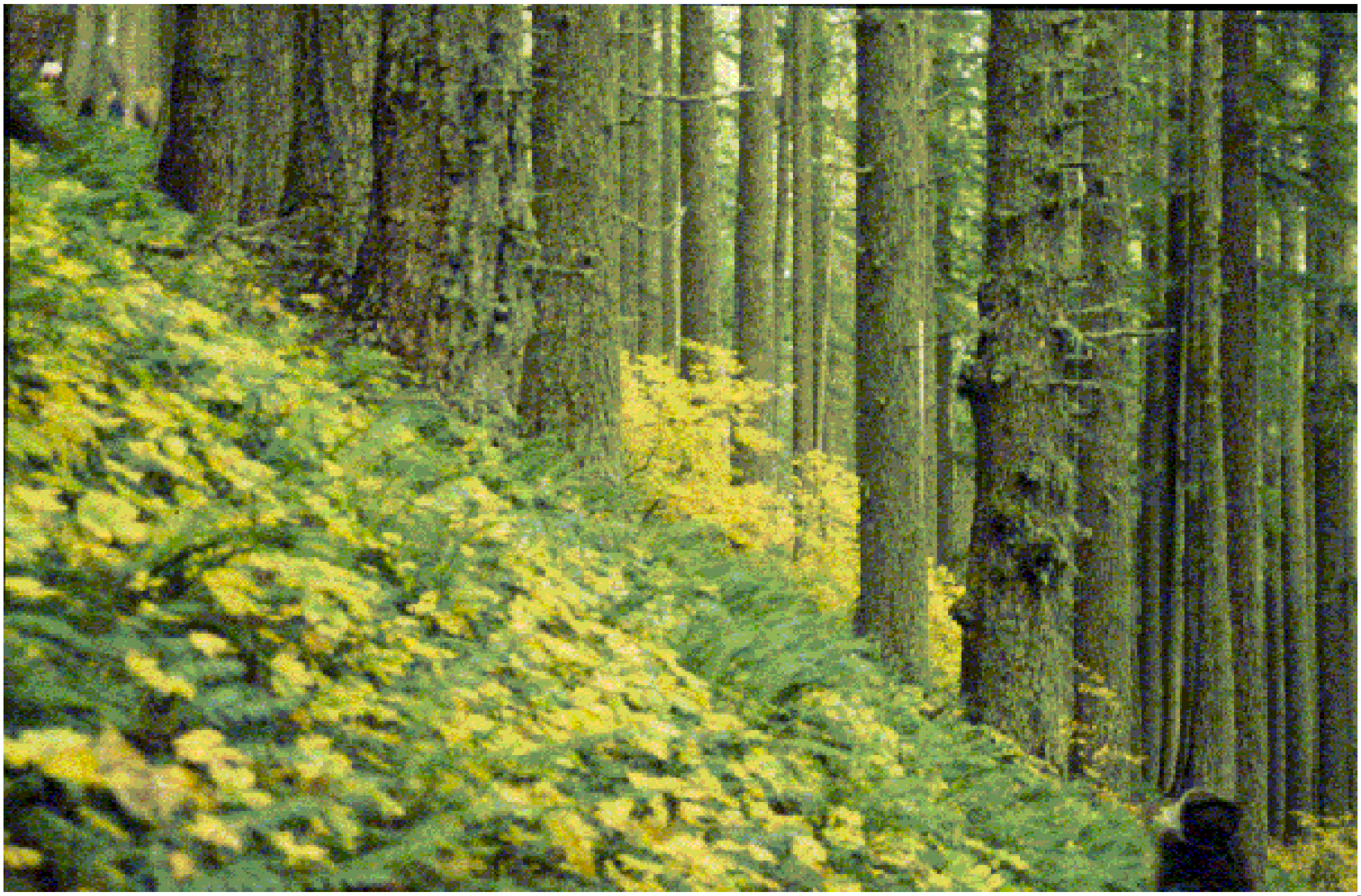


Fig. 3. Photograph of an old-growth forest with a complex structure and composition.

Definitions of "old-growth" for Pacific Northwest conifer forests differ. The most widely used definition applies minimum standards related to the density of large trees, diversity of tree species, range of tree sizes, occurrence of multiple canopy layers, and abundance of snags and logs (Old-Growth Definition Task Group 1986). The minimum criteria for Douglas-fir old-growth forests in the western hemlock (*Tsuga heterophylla*) zone are:

1) two or more tree species with a wide range of tree ages and sizes;

2) 20 Douglas-fir/ha with dbh > 80 cm in diameter or > 200 yr old. The U.S. Forest Service (1992) changed the diameter limits for each Site Class as follows: I, 105 cm; II, 88 cm; III, 78 cm; IV + V, 53 cm;

3) 30 or more shade-tolerant trees/ha > 40 cm dbh, including western hemlock, western redcedar (*Thuja plicata*), grand fir (*Abies grandis*), silver fir (*Abies amabilis*), and big-leaf maple (*Acer macrophyllum*);

4) a deep, multilayered canopy;

5) 10 or more conifer snags/ha > 50 cm dbh and > 4.5 m tall; and

6) 33.6 or more Mg/ha of logs, including at least 10 or more pieces/ha > 60 cm in diameter and > 15 m long.

These characteristics describe important habitat features for a wide range of wildlife and plants as well as a successional stage. Many forests that are considered old growth will meet most, but not all, of these criteria. When information on stand characteristics is not available, a common rule of thumb is to consider any stand > 200 yr old to be old growth. However, old-growth stands are not static, and 200-yr-old stands usually have less structural complexity than 500-yr-old stands (Spies and Franklin 1988). In productive Coast Range forests, old-growth structures (e.g., trees > 150 cm dbh) may develop in as little as 120 yr. Some definitions distinguish between unmanaged, virgin old-growth stands and "fully functional" stands developed through silviculture that might provide most (depending on assumptions) of the same ecosystem properties (FEMAT 1993, Carey et al. 1996).

Issues

The primary purpose of late-successional and old-growth forests under the Northwest Forest Plan (NWFP) is to provide habitat for two species listed under the *Endangered Species Act*: the Northern Spotted Owl (*Strix occidentalis caurina*) and the Marbled Murrelet (*Brachyramphus marmoratus*). In addition, 1098 terrestrial species (excluding arthropods) are believed to be closely associated with late-successional forests in the NWFP area (FEMAT 1993). According to marker trees from land surveys (Teensma et al. 1991), old-growth forest appears to have covered 60% of the Coast Range prior to large fires that occurred in the 1840s (Ripple 1994) and, based on charcoal deposits in lakes, 25–75% over the last 3000 yr (Wimberly et al., *in press*). In contrast, old-growth forest currently covers less than 1% of the federal forest land in the NCAMA, stands 80–140 yr cover 31%, and stands < 50 yr old cover 45% (Gray 1998).

Old-growth forests are commonly believed to be a predictable stage of forest succession (Franklin et al. 1981, Oliver 1981, Spies and Franklin 1996). However, some researchers caution that we know little about how current old-growth stands originated and developed over the last several centuries, and we may not be able to reproduce that development under current climatic conditions, impacts from exotic plants and animals, disturbance regimes, and land ownership patterns (FEMAT 1993: IV-31–32). Many of the younger planted forests (i.e., less than 80 years old) in the region today are relatively dense stands of slow-growing trees that seem to be developing on a different trajectory from many old-growth stands, which probably developed at low densities (Tappeiner et al. 1997). Indeed, many existing old-growth stands developed with significant effects from fire, wind, flood, or disease (Spies and Franklin 1988, Morrison and Swanson 1990; A. N. Gray and V. J. Monleon, *unpublished manuscript*).

Consequently, it has been suggested that, by reducing stand density through logging (i.e., "thinning"), forest managers could induce relatively young stands to more readily develop the size and structure of old-growth forest (Newton and Cole 1987, Oliver 1992, Bailey 1996). Combined with other treatments, such as killing trees to create standing snags or down logs, damaging tree tops to create cavities, introducing wood-rotting fungi, and cutting trees in patches, thinning could provide habitat for many late-successional species at an earlier point in stand development than if the stands were left alone (Hansen et al. 1991, McComb et al. 1993, Carey et al. 1996). Regardless of whether thinning is required to ensure late-successional development, the potential to create economic returns while accelerating forest development attracts support for this approach.

Although overstory tree response to thinning is fairly well known (Drew and Flewelling 1979, Curtis and Marshall 1993, Bailey 1996), the long-term responses of understory vegetation, species habitat, and ecosystem function are not. Limited seed dispersal and the lack of specific microsites required for the establishment of shade-tolerant conifers could inhibit the development of multistoried canopies (Gray and Spies 1997, Schrader 1998). A fundamental, but possibly mistaken, assumption of stand-level manipulation is that species characteristic of late-successional forests will arrive and prosper as stand structure develops.

Implementation

Questions concerning the development of late-successional forests are primarily stand level in scale (e.g., 10−40 ha). A formal adaptive management approach would define a set of alternative stand management approaches and their expected outcomes and implement them systematically across the landscape. This has occurred to some extent. Several replicated research studies, developed in collaborations between researchers and land managers across the region, have been undertaken in the last 10 years; they vary tree and snag density, patchiness, down wood levels, and forest age in stand-level treatments. Many of these studies incorporate long-term measurement of vegetation and wildlife and of economic and social components as well (Gray 1998).

Other stand management activities follow prescriptions and environmental assessment documents that specify objectives and expected outcomes that are often based on basic silvicultural, hydrologic, and wildlife models. However, variations among prescriptions are usually designed for site-specific reasons (e.g., slope, species composition, proximity to streams) rather than for structured testing of alternative approaches. Planning at the stand level is done by interdisciplinary teams. Individual specialists apply their expertise to choose the management strategy that best meets regulatory restrictions and avoids the most undesirable environmental effects. Teams tend to be uncomfortable evaluating trade-offs between short-term environmental impacts and long-term habitat gains. Given the level of management constraint and scrutiny by regulatory agencies (the FWS and NMFS), prescriptions tend to be conservative. Teams also have little experience designing different approaches for the primary goal of developing new information. Although basic monitoring is done, funds are rarely available for the extensive data collection and documentation necessary to address the uncertainties related to many issues.

Nevertheless, the managers in the NCAMA have learned a great deal about the logistics, politics, and economics of implementing treatments under the newer NWFP management objectives.

AQUATIC ECOSYSTEMS, SALMON, AND RIPARIAN AREAS

Characteristics and features

Aquatic ecosystems include the waters of intermittent and perennial streams, rivers, and lakes as well as the organisms living in them. Riparian zones are the interface between terrestrial and aquatic ecosystems and include the land areas affecting and affected by aquatic ecosystems (e.g., forests casting shade on streams, wetlands). Aquatic and riparian ecosystems in forested mountain landscapes are very dynamic. Habitat structure in streams is primarily determined by floods interacting with sediment and by live vegetation and large woody debris from forests on small tributaries, streamsides, and floodplains (Gregory et al. 1991, Sedell and Beschta 1991). Large woody debris is a key structural element that helps retain sediment such as cobbles and gravel. By diverting flood waters and sediment, it creates complex habitat features such as pools and side channels in streams and floodplains; it also provides cover and is itself occupied by organisms (see Fig. 4 and Fig. 5). Logs may fall directly into streams from riparian forests or be transported by landslides from tributaries or hill slopes. Wood from conifers is more important than wood from deciduous trees for providing structure in the Pacific Northwest because it decays more slowly. Much of the sediment and large wood in a given stream may have been deposited by the landslides that occur after large, infrequent catastrophic wildfires, which result in complex habitats and gravel-rich sediments 50−300 yr later (Reeves et al. 1995, Benda and Dunne 1997). Riparian forests and streamside vegetation also affect streams by shading, and influence aquatic food webs and water quality by adding organic litter and regulating the movement of nutrients and fine sediments (Gregory et al. 1991, Sedell and Beschta 1991).

Fig. 4. Photograph of a river with a relatively simple structure, lacking coarse sediment and woody debris.

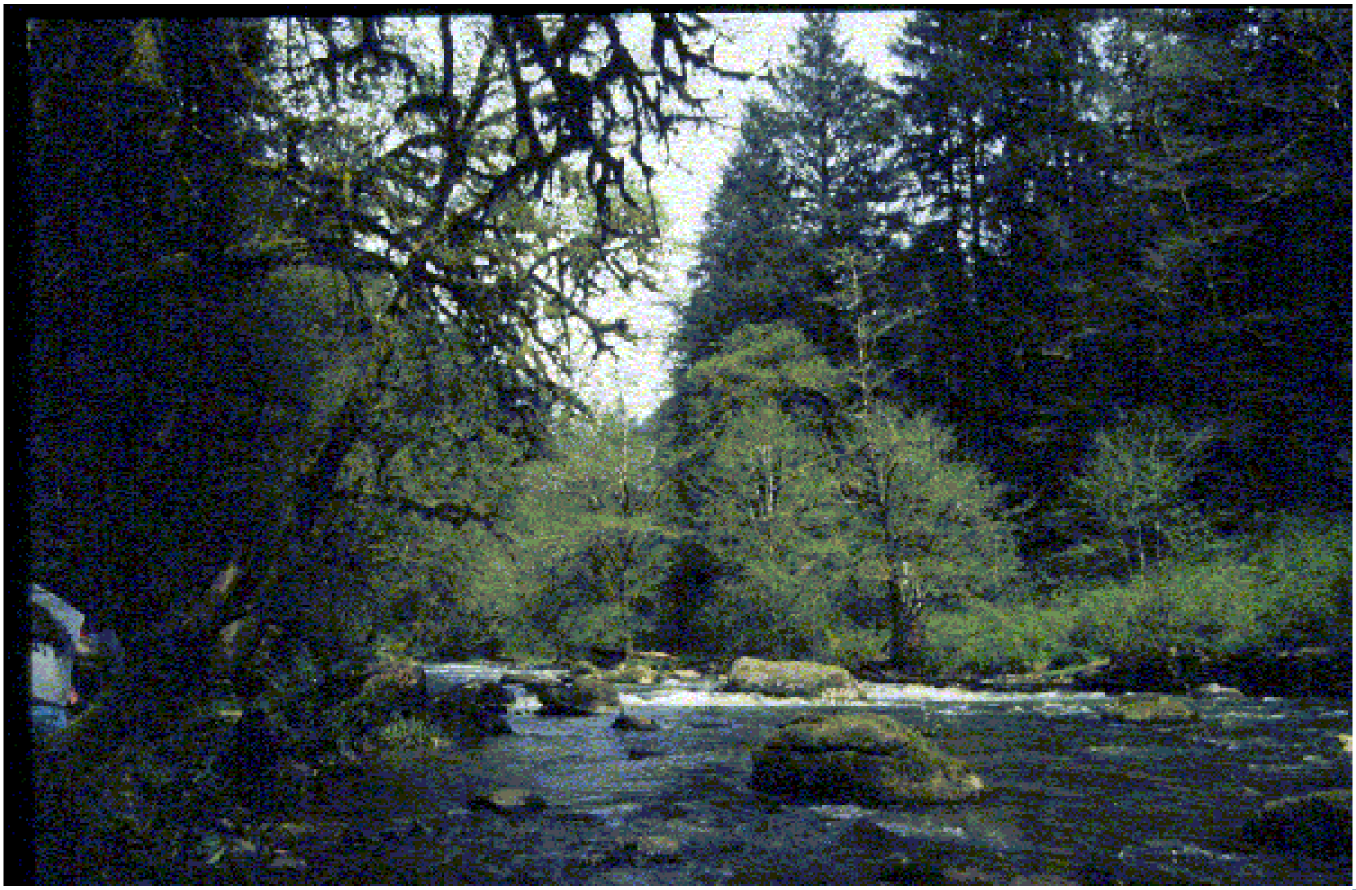


Fig. 5. Photograph of a creek with a complex structure.

Although young salmon (*Oncorhynchus* spp.) feed on organisms in mountain stream foodwebs before heading out to sea, returning adult salmon may represent an important food and nutrient source for riparian and forest ecosystems. Live and dead salmon in healthy runs feed a wide array of animals, including mammals, birds, invertebrates, and even young salmon; nutrients derived from salmon are even found in streamside plants. The amount of ocean-derived nitrogen in different aquatic and riparian organisms in healthy streams where salmon spawn can range from 17% to 100% (Kline et al. 1990, Bilby et al. 1996).

Issues

The primary interest in aquatic and riparian forest ecosystems under the Northwest Forest Plan (NWFP) is the need to restore habitat for fish populations, particularly anadromous salmonids. Aquatic ecosystems in the Northern Coast Range Adaptive Management Area (NCAMA) have become structurally simplified and much less productive over the past century, with most of the native salmon species currently designated as endangered (U. S. Forest Service and USDI Bureau of Land Management 1997). These ecosystems are important habitat for many other terrestrial and aquatic species as well (FEMAT 1993). The causes of the decline in the salmon population include overfishing, migratory impediments such as dams, and a loss of genetic fitness caused by hatchery practices and the introduction of nonlocal stocks. However, the most common cause is thought to be the loss and degradation of freshwater and estuarine habitats (Nehlsen et al. 1991, FEMAT 1993). These habitats have been affected by agriculture, livestock grazing, water withdrawal and diversion, and dams as well as by logging and road construction, which often cause repeated landslides over time (Swanson et al. 1982, 1987). Areas that slid often had no large trees because of logging, and, with streams already low in wood because of past salvage activities (Sedell and Beschta 1991), there were few large logs available to retain coarse sediment and structure fish habitat. Roads and logging are also thought to contribute to higher than optimal water temperatures and amounts of fine sediment in streams.

Several options have been proposed to reduce these negative effects and restore the aquatic and riparian ecosystems on federal lands to the point at which they can sustain fish and other species. Impact reduction has focused on decommissioning or upgrading forest roads and on protecting trees growing near intermittent and perennial streams (Sedell and Beschta 1991, FEMAT 1993: Appendix V-J). Restoration has focused on improving the complexity of instream habitat and the condition of riparian vegetation. Short-term measures include placing large logs in streams to create pools and side channels, although these expensive activities are practical for only a few stream segments. Long-term measures focus on providing shade and future sources of large woody debris by planting conifers in riparian stands where they are scarce and by using thinning to accelerate their growth where they already occur (Sedell and Beschta 1991, FEMAT 1993).

Some of the primary uncertainties about riparian management involve questions about (1) the relative natural abundance of conifers vs. hardwoods along streams (Nierenberg 1996), (2) the short-term effects of silviculture on light and temperature, and (3) the prediction and measurement, both extremely difficult, of the amount of fine sediment introduced into streams by forest management practices (Hall et al. 1987; G. E. Grant, *personal communication*).

Implementation

These questions concerning the management of riparian ecosystems range from stand (or reach) to watershed in scale. As with late-successional forest, several replicated, stand-level research studies are in place across the region to examine alternative riparian management approaches. These studies are assessing the effects of different tree densities, riparian buffer strip widths, planting treatments, and placements of instream structures. Many of them incorporate the long-term measurement of vegetation, microclimate, and fish and amphibian populations (Gray 1998).

One of the first requirements under the NWFP was for managers to conduct assessments of past and current watershed conditions, including vegetation, roads, geomorphology, landslide potential, and habitat potential for threatened and endangered species. These documents focus on priorities for management and often identify the uncertainties and assumptions used in the assessments. NCAMA managers have implemented a range of projects, including road closure, riparian thinning, and tree planting. However, as with forest succession, prescriptions are adapted to fit specific sites based on the professional expertise of interdisciplinary teams, and rarely test alternative approaches. Managers and regulatory agencies are usually unwilling to trade potential short-term effects (e.g., possible increases in fine sediment and water temperature) for long-term gains (e.g., larger trees for future instream woody debris).

SOCIAL AND ECONOMIC INVOLVEMENT

Issues

The primary social and economic direction for adaptive management areas (AMAs) under the Northwest Forest Plan (NWFP) was experimentation with policies and management so that they could become "prototypes of how forest communities might be sustained" (U.S. Forest Service and USDI Bureau of Land Management 1994: D-4). This goal was to be reached collaboratively, with interested parties helping to define issues and goals and evaluate how well they were achieved (FEMAT 1993, Bormann et al. 1994, Stankey and Shindler 1997). The importance of public involvement in adaptive management was repeatedly emphasized, because the lack of it was believed to have been the primary cause for the lawsuits that halted management activities and led to the need for the NWFP.

Agencies pursue public involvement primarily to reach better decisions and to build public support for those decisions (Lawrence and Daniels 1996). Honest, open exchanges of knowledge help promote more democratic decision making by providing detailed information about local conditions for analysis and making technical knowledge available for public scrutiny (Stankey and Shindler 1997). Successful public involvement often requires dedicated efforts to develop leadership, accountability, and the skills needed for participation in this type of activity both within agencies and within communities (Shindler and Cheek 1999).

In terms of economic value and employment, wood products have been the most important forest land commodities in the NCAMA for the last several decades (Leonard 1997). Unlike the large volumes of mature trees cut in the 1980s (~300 x 10^{-6} board feet/yr), timber harvests on federal lands in the NCAMA in the near future are expected to produce less volume (~12 million board feet/yr) of products with a lower value, primarily from the thinning of relatively young stands (USDI Bureau of Land Management and U.S. Forest Service 1997). Many county services, which are funded by proceeds from logging sales on federal lands instead of property taxes, are threatened by this reduced cutting. Contracting for other forest management activities (e.g., road decommissioning) creates some local employment. Hunting, fishing, gathering of edible plants and mushrooms, and collecting of firewood are subsistence activities for many local residents. Tourists generate some income in local communities, but amenities on federal lands are few, and most tourism is focused in a narrow band along the coastline itself.

Implementation

Efforts to involve the general public in discussions about the development of NCAMA objectives and approaches have generally been unsuccessful. Although agency employees often are very active in their local communities and agencies participate in numerous community events (e.g., county fairs and field classes for local schools), organized public involvement in federal management issues has never been strong in the Coast Range. The previously large constituency of forest commodity users generally does not support the policies of the NWFP and has shown little interest in the amount of forest products projected for the NCAMA (A. N. Gray, *personal observation*). Environmental and recreational constituencies usually pay more attention to forests that are closer to major urban areas and to areas where montane parklands or unmanaged landscapes are more abundant. As a result, public meetings at different locations in the NCAMA have rarely attracted more than five nonagency participants.

NCAMA managers had greater success with the AMA committee of the Coast Range Province Advisory Committee (PAC), which was composed of representatives from local governments, regulatory agencies, and conservation groups, as well as interested citizens. With the assistance of researchers, the committee discussed issues and assigned priorities to questions for the NCAMA to address. The group ceased meeting after it became deadlocked over the design of a landscape-level management comparison (see *Ecosystem Management*).

Despite their failure to develop a systematic approach to community involvement, AMA managers have pursued an innovative agreement with the Confederated Tribes of the Grande Ronde. This agreement would allow the tribes to manage their watershed as a cohesive unit while meeting the goals of the NWFP on 4400 ha of federal land in the watershed. This novel "stewardship" approach would involve local communities in the management of historic tribal lands. It could also generate new management ideas that federal managers might not be inclined to try on their own.

The U.S. Forest Service's Pacific Northwest Research Station, which was integral in the development of the 1993 FEMAT assessment and, by extension, the NWFP, made an initial commitment to assist individual AMAs in their efforts. However, the commitment of funds and time to adaptive management has declined recently, apparently because (1) adaptive management involved researchers in many activities (e.g., meetings, presentations, planning) that resulted in few "science" products, (2) there was no strong matching commitment to adaptive management from land managers at the regional level, and (3) the Station was already heavily involved in many applied research studies related to the NWFP. Nevertheless, many researchers pursue NWFP-related studies in AMAs and participate in AMA development as their professional schedules allow.

ECOSYSTEM MANAGEMENT

Issues

A primary objective of ecosystem management is to maintain the characteristics and processes of the whole ecosystem that sustain component species and human uses (Grumbine 1994, Christensen et al. 1996), although definitions of ecosystem management differ with regard to the importance placed on sustaining human use (Grumbine 1994, Stanley 1995). Ecosystem management is usually presented as an alternative to trying to manage for a multitude of species based on their individual habitat requirements. Because any ecosystem can exist in a range of different states and successional conditions, ecosystem management requires some guidance when it comes to determining the desired relative abundance and distribution of ecosystem types and conditions. In the absence of a clear understanding (in this case, of ecosystem dynamics), people are forced to shape decisions based on their beliefs or philosophical outlook (Holling 1995). There are at least three general schools of thought with regard to determining desired ecosystem conditions across landscapes, which I refer to as "species-based reserves," "range of natural variation," and "structure-based management."

Under the species-based reserve approach, ecosystem conditions are determined by meeting the population needs of focal species, usually called "indicator" or "keystone" species. This common approach allocates the best remaining habitat to the reserves that are able to support metapopulations of the species of interest, provides habitat for species dispersal among reserves, and intensively manages the surrounding landscape for other goals (Harris 1984, FEMAT 1993). However, despite efforts to maintain genetic diversity, species with low dispersal rates could become genetically isolated in reserves. Other reserve-based approaches argue that areas large enough to encompass natural disturbance and recovery processes (e.g., large fires) and to support all native biota (e.g., wide-ranging carnivores) are required (Noss 1983, 1993).

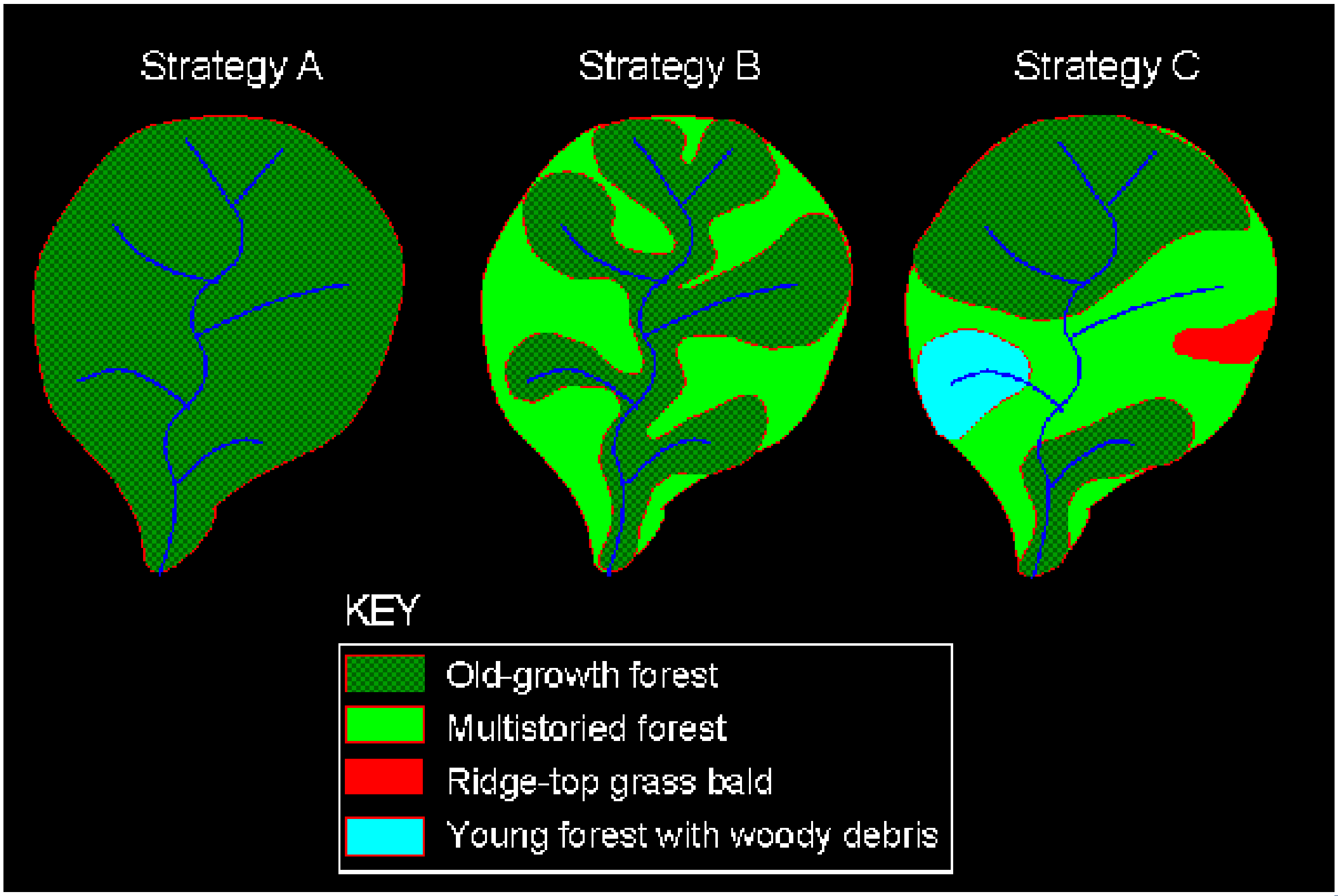
In the approach based on the range of natural variation, desired landscape patterns are based on prehistoric patterns. Because many species and ecological processes are still unknown, maintaining or recreating the range of conditions of the last several thousand years should perpetuate native species and ecosystems into the future (Swanson et al. 1993). The period before settlement by Euro-Americans is usually used as the natural baseline in North America (Wilson et al. 1991); in Oregon, this means landscape patterns predating 1850. The size, severity, and frequency of natural disturbances within the topographic and climatic template are probably the primary determinants of the abundance and condition of ecosystem types. Consequently, management prescriptions in this approach would be tailored to emulate the natural disturbance regime.

In the structure-based management approach, ecosystem patterns are determined by the commodities and processes desired (e.g., wood fiber, habitat, water quality). This approach relies on silvicultural and other treatments to create the desired distribution of ecosystem types and conditions while allowing commodity extraction (Oliver 1992, Carey and Curtis 1996, Emmingham 1998). Management would shift forest successional stages across multiowner landscapes by means of various long-rotation, thinning, and partial-cutting techniques, which would also maintain some old-growth attributes (e.g., old trees, snags, and logs) in most stands. A multidisciplinary modeling effort for a landscape in western Washington (similar to the NCAMA) suggested that such an approach could maintain most vertebrates and produce economic returns comparable to those of short-rotation intensive management (Carey et al. 1996). Indeed, many vertebrates native to the Northwest appear to occupy a wide range of forest successional stages as long as some features of old-growth forests, such as large snags and logs and diverse vegetation, are present (Ruggiero et al. 1991).

Implementation

One of the original intentions behind the creation of AMAs (FEMAT 1993) was to provide areas large enough to examine approaches to landscape-scale ecosystem management that differed from the reserve-based approach adopted for the rest of the region. Researchers initiated a process with NCAMA managers and the members of the Coast Range PAC that was intended to design a comparative landscape management study. Managers agreed to implement an experimental design approach that would compare alternative management "strategies" on replicated landscape units. These strategies would vary the amount of human use and active management of the landscape along the lines of the approaches discussed above. For example, one strategy might rely on natural processes and allow thinning only in plantations less than 30 years old, close most roads and remove those near streams, and allow limited nonmotorized recreation. In contrast, another strategy might allow periodic selective harvesting and treatments to enhance structure in most stands less than 110 years old, improve or realign roads, particularly near streams, and provide a mix of recreational opportunities. Rather than compromise by incorporating alternative values and viewpoints into a single approach (the traditional political solution to conflict), the researchers hoped that these strategies would reflect the diversity of values in society and stimulate interest and involvement in the project. Defining the strategies requires laying out clear visions for alternative future landscape conditions (e.g., Fig. 6), a step that has not yet occurred.

Fig. 6. Example of alternative configurations of forest types in a watershed 100+ years in the future. The intention of all strategies would be to maintain native biodiversity and late-successional species. Strategy A would require little management after initial closing or removal of most roads and thinning of young, dense tree plantations. Strategy B would selectively cut trees and maintain forest structural complexity in upland areas while remaining similar to Strategy A along streams. Strategy C would shift forest successional stages around the landscape on a long (200 years or more) rotation, always maintaining 50% of the watershed as high-quality old-growth forest.



The development of the landscape study has run into several problems. The greatest, perhaps, is the problem of scale. For example, a definitive study of alternative habitat management for Northern Spotted Owls, a pair of which typically uses 730 ha of habitat over a 2600-ha home range in the Coast Range (U.S. Forest Service and USDI Bureau of Land Management 1994), would require landscape units with potential space for several pairs of owls, perhaps 10,000 ha or more. The idea of using a large portion of the NCAMA for the landscape comparison was quickly dismissed by most participants, because some of them felt that the active management approach was too risky to try at that scale, others were reluctant to constrain management discretion on large land areas for long periods, and many felt that current reserve designations in the NCAMA already constrained options for locating strategies and would be very difficult to change. Most participants were more comfortable with using smaller landscape units (1000–2000 ha) and are currently trying to identify reliable indicators of terrestrial and aquatic ecosystem function that can be measured at that scale.

Among other difficulties seen in the landscape design process of this AMA to date are the following:

1) some participants would rather have no study at all (or reduce the unit size to minimize potential impacts) than support the implementation of a strategy with which they do not agree,

2) some specialists have difficulty envisioning alternatives to specific practices (e.g., planting and thinning densities) because of personal experience gained under different management objectives,

3) prescriptive standards developed by regional oversight committees for the management of designated reserves have made it more difficult to locate alternative strategies on similar landscape units,

4) attempts by some managers to preserve discretion by not making strategies too prescriptive have fueled distrust in those who fear that all strategies may become more manipulative over time, and

5) some researchers are skeptical about the ability of large-scale landscape management comparisons to advance knowledge.

The development of the landscape design study had some of the elements of a "formal" adaptive management process, particularly the group of managers, regulators, researchers, and citizens whose purpose was to develop questions for the AMA. However, the process stalled, apparently because not all the participants agreed that a landscape-level study was necessary or desirable, and other management priorities have since surfaced.

DISCUSSION

Adaptive management process

The creation of the Northern Coast Range Adaptive Management Area (NCAMA) has led to several innovations, including applied research studies, the development of landscape-scale strategies for ecosystem management, and increased collaboration with Native American tribes. However, the level of activity is quite modest compared to the ambitious goals set out in the Northwest Forest Plan (NWFP). The NCAMA has met some of the criteria for implementing "formal" adaptive management presented in Walters (1986), but has not implemented this approach in a systematic fashion.

Teams of managers, researchers, and regulators have worked to clarify objectives, identify constraints, and formulate important questions for the NCAMA as a whole. Some of these ideas were contained in the initial AMA plan (USDI Bureau of Land Management and U.S. Forest Service 1997), while others appeared in various watershed, social, or research assessments. However, these plans and assessments made few specific commitments to a continuing process or resulting actions. Individual applied studies tended to be designed and planned by researchers working independently, although collaboration with managers was instrumental in obtaining practical feedback and implementing treatments.

Synthesizing ecosystem understanding and expressing it in the form of dynamic models have not been a priority for the NCAMA. A landscape model is being developed independently to project alternative management policies across the Oregon Coast Range and evaluate the social, economic, physical, and ecological implications (Spies et al., *in press*). This model, which combines several process, statistical, and expert opinion models, should prove useful to anyone hypothesizing the landscape implications of disparate management approaches (e.g., reserves, uneven-age management, and intensive forestry). Nevertheless, it may not be able to evaluate the implications of the relatively small differences among the strategies that NCAMA managers are currently considering (e.g., differences in intensity and timing of thinning and in levels of retention of woody debris).

NCAMA managers have identified uncertainties and questions related to the expected outcomes of management activities. Issues concerning landscape patterns and processes have been discussed, but alternative policies that produce knowledge have yet to be developed. Most biological questions are being addressed through participation in controlled, small-scale research studies. For most management projects, resource specialists and the staff of regulatory agencies tend to apply their experience and education to choosing the best approach for specific situations, rather than identifying uncertainties and potential alternatives to increase learning.

Planning at the larger, landscape level has taken place in other AMAs in the region. The Central Cascades AMA in central Oregon adopted a management plan for a 23,000-ha area that allocated three management approaches to landscape zones based on vegetation community types, topography, and prehistoric disturbance patterns (Cissel et al. 1998). Management prescriptions were designed to emulate the natural disturbance regimes of each landscape zone. Researchers and managers in this area have a long history of collaboration and began developing their ideas on the range of natural variation approach; they began gathering the data they needed to implement these ideas several years before the AMA was designated. The Cispus AMA in southern Washington adopted a landscape design for the entire 58,000-ha AMA that was developed primarily through extensive public meetings. The design presents a general vision for landscape structure, function, and management 200 years into the future and provides for natural areas, late-successional forests, and mixed-seral areas. Although this design calls for some innovative silvicultural approaches, it resembles the reserve approach to planning, with little testing of alternative approaches. Future studies could develop unplanned, case-study comparisons between the approaches in these AMAs and more conventional applications of the NWFP in neighboring landscapes.

Barriers to adaptive management

The Northern Coast Range AMA is by no means immune to the difficulties and frustrations experienced by others who have tried to implement adaptive management (e.g., Holling 1978, Lee 1993, Stankey and Shindler 1997, Walters 1997, Gunderson 1999). This lack of adaptive management activity in the NCAMA may be caused in part by the many recent changes in federal land management practices initiated by the NWFP, including (1) a new primary emphasis for management; (2) new land management designations, often with overlapping guidelines for allowable practices; (3) new requirements for analyses prior to action; (4) the official classification of additional species as rare and endangered, which requires surveys and consultations with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service; and (5) new regional staff units involved in the planning, development, and assessment of NWFP implementation. Meanwhile, agency budgets (which traditionally were tied to production goals for wood products) and personnel have declined significantly over the last 10 years. As a result, managers have been learning and adapting a great deal in their attempts to implement the new management goals and guidelines of the NWFP.

A perceived lack of management flexibility may be another factor limiting adaptive management efforts in the NCAMA. The general impression is that a manager would need an inordinate amount of supporting data, energy, and political support to modify, or obtain an exemption to, existing standards and guidelines through the Regional Ecosystem Office. For example, the designated "interim riparian reserve" boundaries and prescriptions from the NWFP are rarely modified, because managers feel that it is not worth their while to carry out the number of analyses and exert the bureaucratic effort required to change the guidelines for each specific stream (indeed, the "interim" designation is rarely used in discussions or official documents). In addition, many protocols (e.g., for species surveys and monitoring) are being developed at the regional level, so that managers have little interest in devoting their efforts to the same issues at the local level.

It is also possible that, because of the relative calm brought by the NWFP in the wake of such contentious ideological battles, many people simply do not want to revisit the issues and refine or modify approaches. Following current management guidelines insulates management to at least some extent from citizen appeals and regulatory oversight. In addition, constituencies inside and outside the agencies have adopted the relatively protective interim approaches of the NWFP and do not want to see their underlying assumptions tested. Many perceive forest ecosystems to be on the brink of collapse, so no failure is tolerable; some seem to mistrust any project that involves tree cutting. Indeed, lack of trust was identified by AMA managers as perhaps the most insidious barrier to adaptive management. There is a lack of trust with regard to motives, data collection, analyses, and conclusions within agencies, among agencies, and between agencies and citizen groups. Thus it appears that agencies are becoming frozen into the relatively protective interim practices set out in the NWFP. Without at least a few visible attempts at alternative approaches to ecosystem management (and despite the many innovative stand- and stream-level studies in progress), political pressures may increase to do away with the regional strategy entirely.

Some of the difficulties in the NCAMA reflect a lack of ownership. The mandate for adaptive management in the NWFP was intentionally left vague to encourage local inventiveness, but managers have other very specific problems that require their immediate attention. The lack of expertise and models for "how to do" adaptive ecosystem management puts front-line managers in unknown territory and works against the "can-do" spirit common to the land management agencies (Stankey and Shindler 1997). In addition, adaptive management is neither science nor management, but a blending of the two. It therefore does not fit well within existing roles, policies, and regulatory frameworks, which tend to remain static unless there is some strong internal or external pressure to change. A constituency for adaptive management has yet to develop to compete with the many other constituencies influencing federal land management.

The complexity of implementing ecosystem management may be another factor that makes it hard to put adaptive management into effect in the NCAMA. The uncertainties surrounding viability for hundreds of species and interactions among ecosystem processes operating at multiple spatial and temporal scales lead to a bewildering number of questions about management effects. It has been difficult for leaders and participants to assign priorities. As lead scientist for the NCAMA, I felt that my role was to suggest management options and discuss the implications of different designs for learning, but not to advocate any particular course of action. Synthesizing existing ecosystem understanding into dynamic models that can be used as a tool to develop alternatives is probably beyond the abilities of a single AMA. Walters (1997) noted how hard it was to develop models for the functioning of riparian systems; developing dynamic models for whole landscapes and all native ecosystems is even more challenging.

Prospects for adaptive management

Despite the many high-quality, innovative studies carried out under the auspices of the NWFP, relatively little work has been done to develop the landscape-scale alternatives to ecosystem management called for in the plan. It may still be too early to expect great strides in the application of adaptive management, given the preoccupation of managers with implementing the basic requirements of the NWFP. As more projects are implemented and new relationships among agencies develop, it may become clearer which questions and alternative management approaches should be given priority. Similarly, it may be unreasonable to expect high levels of activity at all 10 regional AMAs. It may be more appropriate to focus additional resources and personnel efforts at a subset of AMAs that display promising leadership and ideas. Other AMAs would still retain the flexibility needed to develop future projects.

Collaboration and strong working relationships among different groups may be key ingredients to dispelling mistrust and implementing ambitious ideas. For example, the Central Cascades AMA built upon a strong scientific tradition that was nurtured for decades between researchers at the H. J. Andrews Experimental Forest and managers at the local U.S. Forest Service district. Managers took the lead in designing landscape alternatives with substantial support from researchers. The Cispus AMA developed a very active stakeholder group composed of members of the general public, who dedicated substantial time and effort to its landscape plan. Sustaining this recent involvement may be critical to implementing and refining the plan.

However, the NCAMA as a whole may be too geographically diverse and too nebulous a concept to galvanize public interest and collaboration. One promising approach may be to work with local state-organized "watershed councils." These councils, which consist of policy makers, business people, and concerned citizens, were formed to allocate state funds to restore salmon in specific watersheds. Salmon restoration is also a major concern of the NCAMA, and several watersheds with councils are located within its boundaries. Working with these groups on specific watershed areas could provide a more grounded context for developing ideas on ecosystem management. In fact, it may be a mistake to attempt a landscape-scale ecosystem management project in the NCAMA without first developing social networks and building trust from less contentious projects.

These ideas are much less formal than the structured, core-team-driven, model-building approach to adaptive management advocated by Walters (1986). The focused core-team approach is probably effective at laying the scientific groundwork for management. However, it may not be able to sustain long-term ecosystem management efforts without substantial social groundwork (Shindler and Cheek 1999), which might require years of collaboration and building relationships and trust. The issues facing ecosystem management may be too complicated to be represented in workable, dynamic models. Obtaining results from on-the-ground testing of ecosystem concepts supported by empirical or theoretical models may be more valuable than waiting for more "conclusive" results from the development of sophisticated ecosystem models (Walters 1997).

Greater efforts to institutionalize adaptive management may help in areas where progress is lacking, although it can be difficult to develop the type of interactions and rewards that keep managers, researchers, and citizens involved in long-term efforts. Introducing adaptive management as a component of job descriptions, project design, reporting requirements, and training programs may help. Providing rewards and recognition for the researchers and citizens involved in management planning could also be important. It might also be advisable to formalize interagency commitments to support adaptive management under the NWFP and to accept some local risks, even to endangered species.

The controversies surrounding the management of federal forests in the Pacific Northwest that led to the formulation of the NWFP have not gone away. The role of adaptive management areas is to explore–in fact, to create–a middle ground between forest preservation and the intensive production of forest resources. The growing population in the Pacific Northwest and the relatively high resource consumption rates of U.S. citizens contribute to this dilemma. By trying new approaches to forest management, AMAs can help determine the desired balance between human consumption and the maintenance of healthy ecosystems. Implementing adaptive ecosystem management may require a major shift in management culture to one that admits uncertainty, encourages risk, and accepts that "failures," which can be the most productive form of learning, will occur (Stankey and Shindler 1997). It requires a shift for researchers as well, because, in management situations, control of important variables is often low and noise is high. The challenge remains to institutionalize adaptive management to fit local situations without stifling the flexibility and creativity necessary to make it work.

RESPONSES TO THIS ARTICLE

Responses to this article are invited. If accepted for publication, your response will be hyperlinked to the article. To submit a comment, follow this link. To read comments already accepted, follow this link.

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