Adaptive Management of Forest Ecosystems: Did Some Rubber Hit the Road?

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Although many scientists recommend adaptive management for large forest tracts, there is little evidence that its use has been effective at this scale. One exception is the 10-million-hectare Northwest Forest Plan, which explicitly included adaptive management in its design. Evidence from 10 years' implementation of the plan suggests that formalizing adaptive steps and committing to monitoring worked better than allocating land to adaptive management areas. Clearly, some of the problems in implementing any new strategy should have been expected and probably would have been avoided if the plan had called for even more focused feedback. But decisions made after monitoring results were analyzed have led to new management priorities, including new approaches to adaptive management. These decisions suggest that one adaptive management loop has been completed. A continued commitment to learning about and adapting practices and institutions will most likely be needed to improve performance in the future.

Keywords: adaptive management, forest assessment, regional monitoring, interpretive steps, synthesis

We explore the concepts of adaptive management as they were developed in a regional-scale scientific assessment (FEMAT 1993) and applied on federal lands through the Northwest Forest Plan (USDA and USDI 1994). By the early 1990s, federal land managers, who are responsible for managing roughly a third of the forests in the Pacific Northwest, were confronted with difficult issues concerning the harvesting of old-growth forests; the decline of northern spotted owl, marbled murrelet, and salmon populations; and the social well-being of forest-dependent rural communities. The controversy over those issues—and a 1991 court-mandated injunction on timber harvesting, issued in response to threats to the northern spotted owl—led to a presidential summit in 1993 in Portland, Oregon. President Clinton issued a mandate for a plan to resolve the conflict between timber and other resources by using the following five principles (FEMAT 1993):

- Never forget the human and economic dimensions of the problem.
- Protect the long-term health of forests, wildlife, and waterways.
- Be scientifically sound, ecologically credible, and legally responsible.
- Produce a predictable and sustainable level of timber sales and nontimber resources.
- Make the federal government work together and work for its citizens.

The process used to write the plan had never been tried before, but it has become a model for many other planning efforts nationally and internationally. A team of federal scientists, the Forest Ecosystem Management Assessment Team (FEMAT), was commissioned to write a science-based assessment (FEMAT 1993) that developed and analyzed a range of alternatives to be applied to all 10 million hectares of federal land in the region. Planning hitherto had been confined to smaller forest, district, and project scales. The assessment fed directly into a traditional planning process and ultimately into a record of decision (USDA and USDI 1994). Scientists had never before wielded so much influence over policy. The resulting plan was a watershed in the management of federal forest lands: Giving ecological concerns priority led to placing 80 percent of the land in late-successional and riparian reserves and reduced federal harvest projections by four-fifths. The FEMAT focus on developing an approach based on conservation biology was to be expected, given the injunction over the owl. What was more surprising, and less widely appreciated, was the addition of a regional adaptive management program. In effect, the plan chose adaptive

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management as its cornerstone (Pipkin 1998, Stankey et al. 2003) because of the explicitly acknowledged uncertainties in the conservation biology approach and in the likely ecological and social outcomes (FEMAT 1993).

The origin of adaptive management can be traced back to the ideas of scientific management pioneered by Frederick Taylor in the early 1900s (Haber 1964, Bormann et al. 1999). Various perspectives on adaptive management are rooted in parallel concepts found in business (total quality management and learning organizations; Senge 1990), experimental science (hypothesis testing; Popper 1968), systems theory (feedback control; Ashworth 1982), and industrial ecology (Allenby and Richards 1994). The concept has gained attention as a means of linking learning with policy and implementation (Stankey et al. 2005). Although the idea of learning from experience and modifying subsequent behavior in light of that experience has long been reported in the literature, the specific idea of adaptive management as a strategy for natural resource management can be traced to the seminal work of Holling (1978), Walters (1986), and Lee (1993).

In this article, we define adaptive management as a systematic and iterative approach for improving resource management by emphasizing learning from management outcomes. Adaptive management is not simply changing management direction in the face of failed policies; rather, it is a planned approach to reliably learning how to improve policies or management practices over time in the face of uncertainty. Adaptive management requires exploring alternative ways to meet management objectives, predicting the outcomes of alternatives based on what is known, implementing one—or if possible, more than one—of these alternatives, monitoring to learn which alternative best meets the management objectives, and then using results to update knowledge and adjust management actions. Adaptive management is not an end in itself, but a means to more effective decisions and enhanced benefits; thus, its true measure is in how well it helps meet environmental, social, and economic goals, adds to scientific knowledge, and reduces tensions among stakeholders.

Before the Northwest Forest Plan, federal forest managers had not institutionalized adaptive management at any scale. Although managers have a long history of trying innovative treatments, typically these were applied on small scales, with inadequate experimental design, without broad coordination, and, more often than not, without monitoring. More important, learning was rarely considered a legitimate task for managers; learning was the task of researchers, who transferred "technology," usually in a one-way fashion, to managers. Typically, research-based learning was from retrospective studies; from well-designed, small-scale experiments with narrowly constructed treatments; and from models. The Northwest Forest Plan called for learning that would evaluate large-scale, complex management strategies well enough to drive changes in those strategies.

Scientists generally see adaptability as essential to managing complex, poorly predictable ecosystems (Walters 1986). Thus, most ecosystem assessments call for adaptive management (Ayensu et al. 1999). But when the scientists look back to assess the results of applying adaptive management, they are often disappointed in what managers have been able to implement (Walters 1997, Stankey et al. 2003). A continued drumbeat of failure will, at some point, lead people to question whether adaptive management is a viable concept or a hollow marketing tool. Here we examine the role of adaptive management as it led to, and played out in, the implementation of the Northwest Forest Plan in its first decade.

Taking stock of adaptive management

Scientists and policymakers have a long way to go in learning how to evaluate adaptive management itself. For starters, agreement on a common definition of adaptive management is rarely found inside or among agencies, and scientists typically define it quite differently from managers. Further, evaluators have yet to define when enough has been learned to determine whether adaptive management is working. A results-based evaluation defines a project as successful if decisions (adaptations) are made on the basis on what was learned, regardless of how well the adaptive processes worked. Pressures for policy change, however, typically operate on a shorter time step than results-based learning does.

The Northwest Forest Plan has just completed its first 10-year adaptive management cycle, providing us with an opportunity to take stock of the concept and to pass on lessons learned (figure 1). We evaluate how well adaptive management worked in the plan from firsthand knowledge, as described in a synthesis (Haynes et al. 2006) based on science findings and monitoring assessments (Gallo et al. 2005, Lint 2005, Moeur et al. 2005, Charnley 2006, Huff et al. 2006). These publications, collectively called the 10-year interpretive report, were presented at a major science policy conference in April 2005 (Stokstad 2005).

The adaptive management strategy for the Northwest Forest Plan had four major elements: (1) a place for it to happen (the adaptive management areas, or AMAs), (2) organizational strategies to apply the adaptive management process across the entire plan area, (3) a major regional monitoring program, and (4) a formal interpretive step that gathered what was learned and translated new understandings for decisionmakers to use. Here we discuss our views of how well these elements of the adaptive management approach worked during the plan's first decade and why.

A handshake helps. The adaptive management strategy helped to facilitate rapprochement between decisionmakers and researchers—what we call the "handshake approach"—which was central to making adaptive management work. This approach, comprising new attitudes and institutions to build mutual respect between decisionmakers and researchers without endangering scientific credibility, emerged as the plan unfolded.

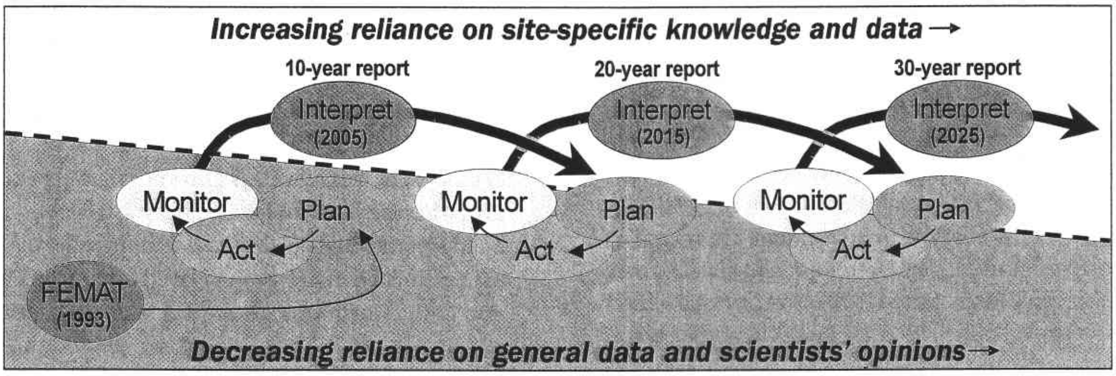

Figure 1. Time steps in the adaptive management cycle, starting with the Forest Ecosystem Management Assessment Team's recommendations (FEMAT 1993), as implemented in the Northwest Forest Plan. Note that the traditional "evaluate" step has been changed to "interpret" because of the added focus on placing new evidence from monitoring and research in a broader, more integrative context as a way to better connect to and influence decisions. Also note that formalizing learning and adaptive steps is deemed essential to shifting the reliance on general data and scientists' opinions to site-specific knowledge and data.

Managers and researchers were not on the best of terms after the plan's release. Many managers were upset about their loss of influence and the immense changes thrust upon them. Members of the scientific community, on reflection, were somewhat humbled as they came to terms with the difficulty and effort needed to write and implement a comprehensive, integrated plan for managing complex and dynamic ecosystems. The approach took form as a team of nearly 60 scientists and managers interpreted the 10-year monitoring and research results, and the remaining uncertainties, to inform managers about the need for change.

The handshake approach emphasizes mutual agreement to close the adaptive management cycle. This closure happened when the 10-year report was handed off to the agency decisionmakers through a series of meetings and a conference in April 2005 (*http://outreach.cof.orst.edu/nwforestplan/index.php*). The approach not only facilitated passing key evidence across the science–policy divide but also gave managers the knowledge to participate in learning more actively.

Allocating land with specific adaptive management mandates is not enough to ensure that goals are met. Looking back on the plan's first decade, we see that some of the AMAs (e.g., the Central Cascades and Goosenest AMAs) made important progress in exploring new roles and responsibilities for citizens, researchers, and managers. As a whole, however, AMAs largely failed in their primary mission to test alternative strategies, eventually becoming noncompetitive in budget allocations (Stankey et al. 2003, Bormann et al. 2006).

A major reason for this failure was that precaution trumped experimentation. A regulator told managers of one AMA that they could not test alternative riparian management to improve fish habitat until they could prove that no harm would come to fish. The notion that nothing should be tried until proof is established contradicts researchers' understanding of the extent that proof is or can be known, including the uncertain—but most likely negative—consequences when actions are *not* taken. If precaution continues to trump adaptation, adaptive management will be hindered. Perhaps because of the intense scrutiny AMAs received, some of the most successful applications of active adaptive management were outside AMAs.

Data from monitoring key ecosystem attributes are useful in both expected and unexpected ways. In addition to addressing prespecified questions, monitoring proved useful in other ways. For example, the simple balance sheet showing a net gain in the area of forest that met late-successional criteria—because forest growth outpaced losses to harvest, fire, and other disturbances—was what most scientists expected, but appeared to surprise and perhaps reassure some of the public (Milstein 2005). The monitoring also documented larger than expected temporal and spatial variability, and provided some real surprises for researchers and others.

New data on temporal and spatial variability are helping agencies focus on the investment in monitoring needed to detect significant trends. Annual variation in owl and murrelet populations demonstrated the need for decadal-scale monitoring to detect trends. Decadal oscillation in Pacific Ocean temperatures—related to fish populations and fire history—demonstrates the need for monitoring on longer temporal scales to understand other trends. A more general appreciation for the extent of uncertainty about system dynamics appears to be emerging among managers. Perhaps this appreciation was demonstrated when a forest supervisor—reflecting that the Northwest Forest Plan's strategy of creating late-successional reserves from extensively managed forest had never been tried before—asked, "Why should we expect that there is only one way to do it?" He also wondered about the strength of evidence on previous approaches proposed but not chosen.

Surprises, not likely to have surfaced without monitoring, point to another benefit. Northern populations of the spotted owl declined sharply and unexpectedly. Researchers remain pressed to explain this trend and are now theorizing that increasing competition from barred owls invading from the north and east may be involved. Some decline was expected from the continuing loss of habitat on nonfederal lands, and observed increases in the area meeting minimum old-growth criteria may not have added significantly to key habitat. Just as surprising, some of the spotted owl populations in the southern ranges held stable or increased, especially in areas more influenced by fire than in the north and in areas with more intense timber harvest on nearby private lands distributed in a checkerboard pattern. Again, new theories are emerging; for example, Franklin and colleagues (2000) suggest that owls may benefit in southern parts of their range from less-dense, brushy hunting grounds where prey, including wood rats, can be found near the owls' nesting habitat of older forest. Such findings reinforce the conclusion that our understanding of the interacting factors controlling population dynamics is weaker, and natural variability greater, than previously thought, and that managers and regulators need to be open to new alternatives for maintaining owls. Postreport decisions direct managers to consider these findings in the design of new management experiments that contrast alternative fuel management strategies in older, drier forests (see *www.reo.gov/library/riec/2005/2089riecnote06012005.htm*).

The costs of a serious regional, interagency monitoring program are substantial. Monitoring the status and trends of northern spotted owl and murrelet populations and habitat, older forests, aquatic habitat, and social and economic conditions cost more than $50 million over 10 years (but only $0.42 per ha per year; table 1). This magnitude of funding was needed to implement a framework for regional monitoring that included a new interagency monitoring team (*www.reo.gov/monitoring*), frequent scientific advice, and a formal interpretive step. The choices of how to allocate monitoring funds reflected a mix of legal requirements (owls), potential legal requirements (murrelets), and balance between ecological resources and social values. The program was generally impressive in the support it received, and in its organization and follow-through. The monitoring program was aided by other governmental monitoring, such as the US Census, but it was limited by faltering record keeping. Record-keeping problems paralleled large (up to 70 percent) declines in budgets and personnel for forests in the Northwest Forest Plan, which lost most of the funding and revenues associated with timber programs.

Question framing by decisionmakers and researchers deserves a high priority. The questions posed by the monitoring program (USDA and USDI 1994) could have been more relevant to the unfolding decisions, and interim interpretations might have identified correctable problems. Several steps were largely missed: choosing—as a key management decision—a limited set of core questions, adding quantitative expectations (except for timber production) to increase the power of subsequent interpretations, and facilitating a broader debate about the durability and answerability of the questions. These shortcomings are now better recognized, and their correction has become a focus of postreport decisions, including a new process to define core long-term questions.

Approaches to assessment need to change in response to the amount and type of scientific knowledge available. Assembling usually scant scientific evidence to inform the choice of a management strategy, as in the original FEMAT assessment, is obviously different from informing an ongoing management strategy based in part on information collected while implementing the strategy, as in the 10-year report. Repeat assessments have several advantages over initial assessments: They permit comparisons of previous assumptions with what happened; the use of stronger, more locally specific data; and better understanding of system dynamics. Thus they link more effectively with current and future decisions. The importance of the handshake approach was that it emphasized closing the adaptive management loop, by presenting what was learned in a way that influenced decisions about future direction and by institutionalizing important steps of adaptive management. Because failure to close the loop and failure to institutionalize are cited as the most common omissions when adaptive management is applied (Walters 1997), the Northwest Forest Plan has made important progress, especially if report findings continue to be considered.

Table 1. Monitoring expenditures of the Northwest Forest Plan, by year and monitoring module.

	Cost per year (millions of dollars)												
Module	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
Spotted owl	1.8	1.8	1.8	1.7	1.6	2.3	2.1	2.4	2.6	2.4	2.5	2.6	25.7
Marbled murrelet	–	–	–	–	–	1.5	0.9	1.1	1.0	0.8	0.8	0.7	6.8
Older forests	–	–	–	–	–	0.8	0.4	0.4	0.5	0.8	0.6	0.4	3.9
Watersheds	–	–	–	–	–	0.4	0.5	1.4	1.1	1.0	1.3	1.2	6.8
Implementation	–	–	0.2	0.3	0.2	0.3	0.2	0.2	0.3	0.3	0.2	0.2	2.4
Socioeconomics	–	–	–	–	–	0.0	0.0	0.1	0.2	0.4	0.4	0.4	1.6
Biodiversity	–	–	–	–	–	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.4
Tribal	–	–	–	–	–	–	–	0.0	0.0	0.1	0.1	0.1	0.3
Program management	–	–	–	–	–	0.2	0.1	0.2	0.6	0.5	0.3	0.5	2.3
Total	1.8	1.8	2.0	2.0	1.8	5.6	4.3	5.8	6.4	6.3	6.2	6.1	50.2

Effective multiscale planning, managing, and interpreting is difficult to implement. The plan pioneered a multiscale planning model by amending existing national forest and BLM (Bureau of Land Management) district plans with regional standards and guides, and by requiring additional analysis at intermediate scales of 20,000- to 50,000-ha watersheds and larger late-successional reserves. The de facto interpretation of regional standards and guides as a rigid set of instructions by many regulators and land-management agency specialists (and some judges), however, stifled local flexibility, limiting how local societal concerns and site-specific understanding of ecosystem function could be accommodated in the standards and guides. For example, fuel reduction in late-successional reserves in drier forests did not become a priority until the 2002 fires, including the 240,000-ha Biscuit Fire, rekindled the debate about the interactions of fire and late-successional habitat. Looking forward, we expect multiscale analysis, planning, and decisionmaking to remain important challenges.

The 10-year interpretive teams struggled with aspects of multiscale analysis and decisionmaking, often succeeding in little more than describing the problem. One reason is the underlying difficulty of integrating disparate scientific disciplines across scales. Because managers are more experienced than researchers at blending science arguments, they have an important role in helping scientists with integration. After the interpretation was presented to key decisionmakers at the April 2005 conference (*http://outreach.cof.orst.edu/nwforestplan/index.php*), a Forest Service administrator commented on the need to at least boil the science down so that the various pieces could be heard over a two-day conference. We suggest that hearing all of the pieces at once is but the first step in integrating information. A second reason for this struggle is the insufficiency of mechanisms for coordinating the decisions of different managers across areas that make up a broader scale.

Conclusions

With any strategy that has never been tried before, problems should be expected, and the Northwest Forest Plan had its share. Nonetheless, this plan was and remains a remarkably bold strategy for its time: It pioneered regionally coherent management strategies, introduced adaptive management at the regional scale, and shifted the focus of multiple-use management from considering timber before other uses to considering other uses, including due consideration of current and future endangered species, before timber.

A major lesson from the first decade of the plan is that the ecological and social uncertainties of trying a new approach go hand in hand with important uncertainties in the institutional processes. Whether adaptive management was a success or not is difficult to assess because results are slow to emerge and alternative outcomes can only be imagined, but we think several important conclusions have surfaced. A handshake approach to facilitate collaboration between the scientists and managers is necessary to make adaptive management work. Also, more formalized and systematic approaches—applied as core agency business—are likely to lead to considerably more effective adaptive management and to better future decisions: decisions that not only are based on stronger evidence but also explore and possibly implement a wider array of options. When elements of adaptive management were treated as core business, as in the regional monitoring and interpretive steps, they influenced agency decisions considerably more than when elements were not treated as core business, as in the AMA network.

Another compelling lesson is that adaptive management is less about current decisions than about mutual learning that might lead to better future decisions. Mutual learning calls for managers to consider learning as a core business and for the science community to improve their performance in civic science and their delivery of integrated, science-based evidence and tools. The future pace of learning and adapting will be determined by the extent to which decisionmakers can take reasonable risks in the absence of proof, and the extent to which different expectations about the temporal scales of biophysical and socioeconomic systems are better matched.

The 10-year reports were released this past year, and agencies responsible for the plan have so far published three decisions (*www.reo.gov/library/riec/2005/2089riecnote06012005.htm*). They have chosen to redesign their approaches to adaptive management to be more systematic and rigorous; to develop more active ways of reducing fuels in fire-prone, late-successional reserves; and to review changes to the monitoring plan. These initial responses breathe hope into the idea that adaptive management will fulfill its promise as a strategy for effective stewardship of forest ecosystems.

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