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Adaptive Management on Public Lands in the United States: Commitment or Rhetoric?

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ABSTRACT / Adaptive management (AM) is the process of implementing land management activities in incremental steps and evaluating whether desired outcomes are being achieved at each step. If conditions deviate substantially from predictions, management activities are adjusted to achieve the desired outcomes. Thus, AM is a kind of monitoring, an activity that land management agencies have done poorly for the most part, at least with respect to ground-based monitoring. Will they do better in the future? We doubt it unless costs, personnel, and future commitment are seriously addressed. Because ecosystem responses to management impacts can ripple into the distant future, monitoring programs that address only the near future (e.g., 10–20 years), are probably unreliable for making statements about resource conditions in the distant future. We give examples of this. Feedback loops between ecosystem response and adjustment of management actions are often broken, and therefore AM again fails. Successful ground-based monitoring must address these and other points that agencies commonly ignore. As part of the solution, publics distrustful of agency activities should be included in any monitoring program.

Adaptive management is the "... process of implementing policy decisions as scientifically driven management experiments that test predictions and assumptions in management plans, and using the resulting information to improve the plans" (FEMAT 1993, p. 5). It is intended to give local communities the opportunity to develop and apply creative solutions to natural resource conditions consistent with existing laws and ecosystem health (FEMAT 1993). Adaptive management applies especially to proposed agency activities within dynamic ecosystems whose multiple interactions and feedback loops are mostly unknown. It is management based upon uncertainty. Management actions are taken as hypotheses because we are unsure of the results. Land management projects are implemented one step at a time and tested at each step. By such means, proponents suggest, potentially adverse and unpredicted effects can be detected in early stages (Munn 1988), and any deleterious activity can be corrected before serious, widespread, or irreversible damage takes place.

Adaptive management (AM) is a major component of ecosystem management, a set of scientific principles of land management endorsed by and guiding many public land management agencies (Christensen and others 1996). We propose that resource monitoring is the crux of AM and its weakest point. Agencies often seem unclear about application of AM as part of ecosystem management implementation. Perhaps AM is merely a rhetorical device, used by technocorporate elites (Fischer 1990) to substitute a technical preoccupation for an "apparent" endorsement rather than true change in resource policy. If this is the case, then whether or not AM works may be immaterial. Even under well-intentioned applications, however, agencies are often unaware that AM fails under a variety of common circumstances. We contend that AM may be little more than a weak flashlight beam to guide us through the inky, dark night, illustrated in the cartoon. Numerous causes of failure can be proposed, such as poorly defined monitoring objectives, the above-mentioned rhetorical indifference to a technological fix, or a more deep-seated agency resistance to policy change. In this paper, however, we limit ourselves to what we consider AM's weakest link, the information feedback system. We also limit ourselves to ground-based monitoring, wherein lies our experience and much of the literature (Elzinga and Evenden 1997, Morrison and others 1996, USDI 1995, Manley and others 1993, Ludwig and Moir 1987, White and others 1999), as distinguished from monitoring by remote sensing.

KEY WORDS: Monitoring; Feedback; Controversy; Uncertainty, Costs; Politics; Agency credibility; Participatory management

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Monitoring: The Crux of Adaptive Management

It is one thing to promise a complicated and expensive activity and another to actually execute it. Adaptive

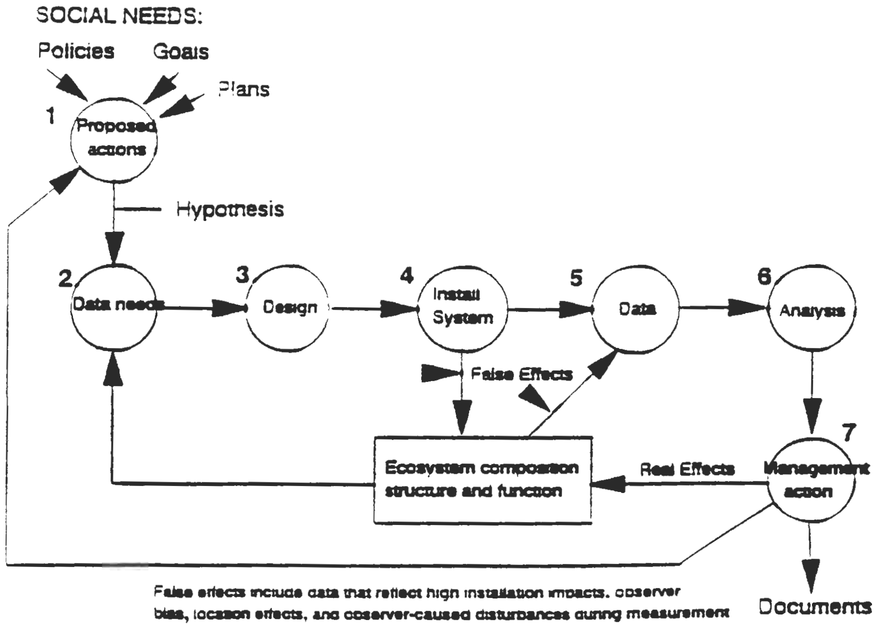

Figure 1. A seven-step generalized adaptive management, ground-based monitoring system.

management is predicated upon a continuous, usually iterative, flow of information between people and ecosystems. The data stream is achieved by monitoring, and particularly monitoring for trend and effectiveness: is the management application accomplishing the intended result?

The steps of a ground-based adaptive management system are shown in a generalized monitoring system (Figure 1), which can be operative at any spatiotemporal scale [see also Everett and others (1993), Baskerville (1985)]. This flowchart is an expanded version of the plan–act–monitor–evaluate cycle proposed in the Pacific northwest and elsewhere (Bormann and others, 1994, Haynes and others, 1996). Each of the seven steps must be performed, but the sequence can be broken or defective and fail at any step.

Achilles Heel of Adaptive Management

Most land-management agencies spend much of their energy, time, and money at step 1, the planning stage. Planning is done within a public arena specified in part by the National Environmental Policy Act (NEPA). The essential dimensions of the monitoring program (Figure 1) depend upon problem recognition and formulation emerging from the NEPA process. In application this process has its weaknesses; nevertheless, issues of "what, why, where, when, and how" to monitor that emerge from the process need to be articulated. If these questions are unclear, monitoring is nearly guaranteed to fail (Gibbs and others 1998, Elzinga and others 1998). The scientific basis for planned activities is also reviewed. Often the impacts of proposed activities are controversial, and their effects upon ecosystems are unknown. The nature, importance, and probability of future ecological surprises is seldom explored or made explicit. To placate or get the support of skeptical and adversarial elements of the public, the planners propose AM. The doubters (including scientists) are told that the activity will be modified or stopped at the earliest sign of adverse impact or when it becomes clear that there is significant divergence from the trajectory towards stated goals.

But when does this become clear? What if there is a high level of environmental noise? This vexing question aside, one major shortcoming of AM is that it is based on short-term or high-frequency ecosystem responses. Early responses are often transient and may not reveal critical thresholds or longer lag periods. To the extent that human impacts ripple into the distant future, harmful results may be beyond the scope of short-term corrective actions. We walk the primrose path. In this mere instant of watching, we are not offered any viable answer to Hardin's (1985) question, "and then what?" (i.e., what happens after the activity occurs?). Surprises are inevitable (Gunderson and others 1995), and the prescience or seeds of surprise may or may not be embedded in the data stream and may or may not be discovered by the watchers. If the long-term consequences of a proposed action are of little interest to senior bureaucrats or political elites more concerned with their short-term survival, how do we commit them

to long-term monitoring? Hardin suggested one tactic: don't walk away from the ecolate question ("and then what?"), but stick around and demand an answer. Our inability to read the long-term future may be the *sine qua non* of serious monitoring. No monitoring, no project implementation.

Many, if not most, monitoring programs in planning documents are scaled to the immediate future. Although the recovery plan for the Mexican spotted owl (*Strix occidentalis lucida*) gives a biological rationale for monitoring the population and habitat status of the owl within a 10- to 15-year horizon (USDI 1995, p. 78), it specifies little about the ten generations of owls subsequent to the monitoring period.

To illustrate another possibility, consider this example: Suppose that in the year 1905 land managers were considering the effects of fire suppression on western ponderosa pine (*Pinus ponderosa*) forests. They decide to implement a monitoring system at several western locations to test the hypothesis that fire suppression will increase timber yields by 5% in the next 10–15 years, an important topic at that time and a very testable hypothesis using statistical procedures. A seven-step monitoring program was initiated and diligently pursued for 15 years. The expensive monitoring program was discontinued after managers concluded that the hypothesis was true, and fire suppression became the agency's policy for decades. Why did no one then conclude that forests in the 1990s would be widely interpreted as "unhealthy" and even dangerous? What statistician would extrapolate a 15-year data stream another 70 years? And even this is a mere fraction of the lifetime of a pine tree. Would latent ecological surprises be flagged and noticed by blips in the data stream, such as the year, 1919, whose climatic uniqueness resulted in pine reproductive success never before experienced (Savage and others 1996)? Are we smart enough to do this?

The Achilles heel is simply that most, if not all, adaptive management programs are poorly scaled to slower, longer-term ecosystem responses. Managers need feedback quickly. They promise corrective actions only in the near or not-so-distant future. In practice, however, they react from crisis (ecological surprise) to crisis, in part by not noticing warning signs from a management action that develop beyond the time span of the not-so-distant future (Holling 1995). Of course, short-term effects are important in some ecosystems, such as arid grasslands, where seasonal events drive processes such as primary productivity of grasses. Here herds of large herbivorous animals adjust quickly to seasonal and annual conditions, and managers must inspect their pastures even daily (Savory 1999), but short-term monitoring, however worthy, does not do away with issues such as slower ecosystem processes, long-term feedbacks, or a high level of environmental stochasticity. The need for long-term monitoring is amply demonstrated by funding proposals to the National

Science Foundation for the Long Term Ecological Research program.

Research Science Will Provide the Answers

Faith in science is often unfounded or wishful thinking. Research seldom has clear answers to contested management issues. [This is not to downplay numerous success stories; e.g., Halvorson and Davis (1996).] At the onset scientists may be unsure about what ecosystem parameters yield the best interpretations or how to measure these parameters. How does one measure the effects of salvage logging in catastrophically burned ponderosa pine forests? What is ecosystem health (e.g., Odum 1985, Rapport and Whitford 1999, National Research Council 1994) and its most cost effective or sensitive measures? Can we scientifically measure the success of ecological restoration projects or even agree on a definition for ecological restoration (Higgs 1997)? Even the best monitoring designs and data streams provide, at most, conclusions that are limited by statistical caveats. The universal scientific conclusion is "more research is needed," which is, of course, ingrained in the scientific method. Scientists bold enough to venture into the murky future are often hammered by their scientific peers who point out the statistical uncertainties. What happens to adaptive management when the experts don't agree? One of the most visible globally scaled, monitoring-based controversies among scientists is the subject of global warming (Balling 1995). Are scientists better qualified than managers when it comes to forecasting ecological surprise? The combination of state-of-art ecological models and sound data is often limited to the near future, because error propagation, high noise levels, ecological surprise, and even the seeds of chaos often preclude all but ballpark projections. Policy implications and management strategies concerning uncertainty are discussed by Moir and Mowrer (1995) and references therein.

Why Monitoring Fails

We list seven major reasons why monitoring plans fail. The underlying reasons for most of these are a mixture of politics, careerism, economic concerns, stressful overwork, and lack of accountability.

1. Management hopes the issues will fade away or that the crisis will wane. Reaction to the western spruce budworm aerial spray program in the Southwest in the early 1980s (Integrated Pest Management Working Group 1986) clearly illustrates this. When the spraying was finished, there was only one year of postspray monitoring of stream macroinvertebrates despite the fact that the macroinvertebrate indicators of water quality were depressed at some locales. Funding for the massive spray program carried no follow-up funds to monitor return of streams to prespray conditions. Today budworm levels are low, and the issue is merely latent until the next outbreak. And then what?

2. Monitoring is too expensive and never achieves adequate funding. A good example is the Mexican spotted owl issue (White and others 1999). Diminishing levels of funding and trained personnel is a frequent cause of failure. As federal agencies are down-sized and given fewer management funds, pseudomonitoring replaces scientifically credible monitoring. In pseudomonitoring there is data feedback that is subjective, often anecdotal, certainly controversial, and does not hold up under rigorous statistical examination. Pseudomonitoring is mostly what federal agencies are already doing, if they are doing anything at all. What parameters of ecosystem structure, composition, or function (e.g., Odum 1985, Rapport and Whitford 1999) are presently being measured in a scientifically credible way? It might be worthwhile to ask management this question and have them explain their monitoring design. There are simply not the funds or trained personnel for other than the most immediate and contentious issues. And future prospects are dismal.

3. The time delay is too long; i.e., management gets no data, stale data, messy data, or inappropriate data for timely decisions or actions. One of the longest time delays came from monitoring the condition of western range allotments on public lands. Trends in range condition were monitored from 1940 to the 1980s by a method known as Parker three-step clusters (Parker and Harris 1959, Moir 1989). Today the network of Parker three-step clusters is, with some notable exceptions, mostly defunct and insensitive to such current issues as soil erosion or loss of genetic diversity (National Research Council 1994).

4. The system, including field hardware, is not maintained, although interest in the issues may be rekindled. The most serious loss to effective monitoring is inability to return to the same, exact field locations for repeat measurements. Photo sites, corner stakes, and other markers are lost. In the case of permanent plots within the Southwest's forest habitat type and biodiversity data base (Muldavin and others 1990), many plots themselves were eradicated. An example is the analytic plot that characterized the Southwestern ponderosa pine/blue grama forest type. Today a paved highway runs through that site. In another case, a backcountry campsite was inadvertently located in an existing monitoring site. Unfortunately, such examples are com-

mon, especially if present management is not interested in answers that monitoring provides.

5. Triage: there are too many issues. Are we truthful with ourselves and the public concerning promises of monitoring in forest plans? Yes, we will monitor the following and more: population levels of the federally listed species; habitat quality for wildlife; recovery of forests after catastrophic fires; stream quality, including levels of macroinvertebrate populations; watershed conditions, including plant cover and soil erosion; when the limits of acceptable change are being approached or exceeded in wilderness; air quality; the effectiveness of timber sales for meeting desired conditions; the conditions and maintenance of public facilities; visitor impacts in recreation areas; changes in range conditions; etc. There are all kinds of activities taking place out there. Whenever a proposed activity becomes contentious, we promise to monitor the outcomes. Can agencies adequately attend to all, or even some, of the issues? Or are these promises empty rhetoric? Once the project gets going the damage may already be done, whether or not we monitor.

6. The issue is too hot to handle, and no action is better than some action in lose–lose situations. We can disagree about the condition of this or that. If the numbers are fragmentary or incomplete, we are both right. When good numbers become available, someone may be held accountable. The situation is always lose–lose when the resource was irreparably degraded before we began monitoring. In highly controversial situations, the manager in the hot seat can always be transferred. However, the situation can be win–win as well. For example, a new ranger to a district can implement credible monitoring to measure recovery of an already degraded resource. Whether or not recovery occurs, the ranger demonstrates to the public a shared concern for the degraded resource.

7. There is reluctance to commit future managers to present obligations. Is this cowardly because of what the activity might portend? Or arrogant because it confers obligations upon future managers? Are our questions really binding to future generations who must continue to collect data that we mandated? Will there not be improved ways to address the issues? Will these even be issues then?

Any of the above circumstances weaken the level of commitment and break the information stream. Once broken, like Humpty Dumpty, it's never put back together. Note that all of the items above assume the seven-step system is otherwise well designed, functioning, and the questions relevant into the future. Unfortunately the law of entropy also applies to information streams. In our experience, should any of the transitions (1–7) fail, the whole system usually collapses, whether or not any of the above enumerated items apply. One can suggest that these itemized monitoring failures are not the real problem, since monitoring is a technical science that can be done correctly. Maybe more sophisticated, better-funded projects will not save the day. More important than these technical matters may be better coping with the psychosocial malaise of a bureaucracy reluctant to change (Cortner and Moote 1999).

Who Monitors?

Who watches the land? The ills discussed above are partly related to who funds, develops, conducts, analyzes, interprets, and makes adjustments. The federal government has a generally poor record (Moir 1989, National Research Council 1994, Hess 1993). Their level of commitment and required expertise may well be lacking under current and, more critically, projected staffing and funding. In large bureaucracies the feedback may be too slow and accountability lacking (Maser 1996, Hess 1993). Do we abandon adaptive management because it is difficult and expensive to set up rigorously? Do we give it our best attention, including sufficient funding and commitment to the future? Or do we give more attention to institutional psychosocial problems that militate against a more sensible and sustainable future?

Creative solutions to the monitoring dilemmas have been offered, and a few are in practice. For example, scientists have their long-term ecological research (LTER) sites. Continuous monitoring occurs in LTER sites, and funding agencies are committed at least to the foreseeable future. Breeding bird surveys are examples of long-term commitments (Robbins and others 1986). Other systems, such as the Big Bend National Park ecological survey are in their fifth round of remeasurement on approximately decadal frequency (Wondzell and Ludwig 1995). Why do some ground-based monitoring systems work, despite the obstacles described above?

We suggest some key factors to successful monitoring and to adaptive management. As mentioned we need to understand the frequency and amplitude of the processes and functions of the ecosystem. The resource issue must be clearly defined (meeting statistical rigor) and have compelling social, economic, and scientific concern that is measurable. In such cases there may already be a concerned public, often with conflicting interests. However, disparate local and regional interests can provide creative alliances and can assume responsibility and overseeing duties when their interests converge or when ecosystem collapse seems imminent. Nongovernmental organizations, nonprofit foundations, and even the more militant protest groups have been suggested as part of the solution (Maser 1996, Gunderson and others 1995).

Shifting from Short to Long Term

Our recommendations are not original. We present them as counterpoint to arguments above that monitoring systems can and do fail. Recognize the slower, longer cycles in ecosystem dynamics and design the monitoring frequency to accommodate those cycles. Short-duration, transient effects, such as a pulse of annual plants after a forest fire, may have little predictive importance, but periods of El Niño weather cycles are important (Swetnam and Betancourt 1990). Short-term monitoring may be extended in time but may not be efficiently designed for long-term cycles or feedbacks.

Analyze the management situation beyond the limits of data and modeling. The limiting "and then what?" demands an answer, especially from reluctant senior management, as part of up-front monitoring design. So consider what happens when extreme events occur; when there are high levels of noise; when and if complex, nonlinear, highly interactive ecosystem processes converge at some critical point; and when ecological thresholds might be exceeded in the long term (Rapport and Whitford 1999). Such analysis might have falsified the conventional wisdom, mentioned earlier, that complete fire suppression in ponderosa pine forests was desirable for sustainability of timber production.

In concert with other concerned interests, identify threshold outcomes, trigger points, or any other critical indicator where an activity must adapt or cease. Probing activities (i.e., management actions intended to obtain an immediate response, whether intended or not) are legitimate (Walters 1986). However, restrain probing types of activities to the local environment and be cautious when generalizing the results to other areas. Adaptive management is addressed, after all, to local resource issues and problems.

Ecological similarity and other quantitative distance measures, as well as ordination techniques, can serve as analytical tools for extrapolating results to larger landscapes (Gauch 1982, Ter Braak and Prentice 1988). There are also tools of landscape analysis that can provide a contextual framework for designing monitoring programs for longer time periods (e.g., Turner and Gardner 1991, Urban 1994).

In conclusion, any assertion of adaptive management that requires ground-based monitoring should be accompanied by addressing the weaknesses described above. We must have a compelling reason to commit future resources in order to rigorously follow up on monitoring activities begun in the 20th century. If we cannot do that, and still wish to pursue adaptive management, we must share the duties, personnel, and expenses of monitoring with partners equally committed to watching the land and sustaining future resources (Maser 1996). Indeed, adaptive management would have broader acceptance if local concerned publics themselves were part of the monitoring program (Cortner and Moore 1999, p. 101 ff). Finally, we suggest that land managers are not practicing adaptive management unless they have in place a monitoring program that addresses the concerns we have discussed.

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