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The Role of Adaptive Management as an Operational Approach for Resource Management Agencies

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ABSTRACT

In making resource management decisions, agencies use a variety of approaches that involve different levels of political concern, historical precedence, data analyses, and evaluation. Traditional decision−making approaches have often failed to achieve objectives for complex problems in large systems, such as the Everglades or the Colorado River. I contend that adaptive management is the best approach available to agencies for addressing this type of complex problem, although its success has been limited thus far. Traditional decision−making approaches have been fairly successful at addressing relatively straightforward problems in small, replicated systems, such as management of trout in small streams or pulp production in forests. However, this success may be jeopardized as more users place increasing demands on these systems. Adaptive management has received little attention from agencies for addressing problems in small−scale systems, but I suggest that it may be a useful approach for creating a holistic view of common problems and developing guidelines that can then be used in simpler, more traditional approaches to management. Although adaptive management may be more expensive to initiate than traditional approaches, it may be less expensive in the long run if it leads to more effective management. The overall goal of adaptive management is not to maintain an optimal condition of the resource, but to develop an optimal management capacity. This is accomplished by maintaining ecological resilience that allows the system to react to inevitable stresses, and generating flexibility in institutions and stakeholders that allows managers to react when conditions change. The result is that, rather than managing for a single, optimal state, we manage within a range of acceptable outcomes while avoiding catastrophes and irreversible negative effects.

KEY WORDS:adaptive management, decision making, ecological resilience, ecosystem management, flexibility, replicated systems, resource management agencies, stakeholders.

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INTRODUCTION

The use of adaptive management as a resource management technique began in the 1970s (Holling 1978). Various definitions of adaptive management are available in the literature (e.g., Walters 1986, Parma et al. 1998, Shea et al. 1998, Callicott et al. 1999), but the basic concepts are simple and appealing. Adaptive management tries to incorporate the views and knowledge of all interested parties. It accepts the fact that management must proceed even if we do not have all the information we would like, or we are not sure what all the effects of management might be. It views management not only as a way to achieve objectives, but also as a process for probing to learn more about the resource or system being managed. Thus, learning is an inherent objective of adaptive management. As we learn more, we can adapt our policies to improve management success and to be more responsive to future conditions.

Adaptive management sounds like an ideal method for management. Some have suggested that adaptive management should be broadly applied within resource management (Lancia et al. 1996, Parma et al. 1998), and it has even been legally mandated as the most appropriate management approach in some instances (Halbert 1993, Glen Canyon Adaptive Management Program). However, resource managers make a wide variety of management decisions in their jobs, ranging from instituting major policies with long time−frames, to short−term, repetitive decisions such as now many fish to stock or how many trees to cut. Given the many types of decisions that managers must make, when is adaptive management the most desirable approach?

My objective in this paper is to suggest ways in which adaptive management can be a useful decision−making approach for resource management agencies. I first discuss the ways in which agencies make decisions and the success of traditional approaches, and then discuss how adaptive management can be useful to agencies in two situations: addressing complex problems in large systems, and ecosystem management of small, replicated systems. The ideas presented are the result of many discussions with agency managers and practitioners of adaptive management over the years. My perspective is that of an agency biologist looking for more efficient approaches to recurring management problems.

HOW AGENCIES MAKE MANAGEMENT DECISIONS

To determine how adaptive management might fit into agency operations, we need to consider the ways in which agencies make management decisions. I have defined five decision−making approaches, each of which builds on and adds to the previous approach. The first four are traditional approaches and the fifth is adaptive management.

The first decision approach is the political/social approach, in which the main concerns are public and political response to a decision. All agency decisions involve political and social considerations to some degree. The political/social approach sometimes dictates a specific course of action to appease a powerful interest or to keep options open for the future. However, a decision to do nothing or to delay action until more data are available is often a political/social decision.

Second is the conventional−wisdom approach, in which managers use an historical method or rule−of−thumb that has been applied to similar situations in the past. In this approach, managers typically rely on historical knowledge of the situation and the resource involved, and assume that the response to management will be similar to that experienced previously. Many of an agency's recurring decisions, such as how many fish to stock, how many board feet to cut, or what level of a pollutant to allow, are probably made using this approach.

Third is the best−current−data approach, which uses current data collected through new or existing sampling programs. Managers analyze these data using the latest techniques, assess their management options, and then choose the one best option to implement. This approach is appealing because it uses the best available knowledge and techniques. Examples of this approach include many habitat enhancement projects and management for various forms of optimal sustained yield.

The fourth is the monitor−and−modify approach. With this approach, a policy decision is typically made using the conventional wisdom or best−current−data methods, and then the policy is implemented along with a monitoring plan. Monitoring data are used to evaluate and periodically modify the policy relative to a specific goal, such as total allowable harvest, production of habitat units, or concentration of some pollutant. The purpose of periodic modifications is to "hone" the management policy and maintain the system in an optimal state. Most management that involves annual resource assessments and policy updating is conducted using this approach, including management of many marine fish stocks.

Fifth is the adaptive management approach. Typically, adaptive management begins by bringing together interested parties (stakeholders) in workshops to discuss the management problem and the available data, and then to develop computer models that express participants' collective understanding of how the system operates. The models are used to assess the significance of data gaps and uncertainties and to predict the effects of alternative management actions. The stakeholders develop a management plan that will help to meet management goals and will also generate new information to reduce critical data gaps and uncertainties. The management plan is then implemented along with a monitoring plan. As monitoring proceeds, new data are analyzed and management plans are revised as we improve our understanding of how the system works.

These five decision−making approaches constitute a progression of increasing complexity. Each successive approach adds features that focus more agency resources on the problem; thus, the costs of implementation and evaluation increase as one moves up the list. For example, implementing the conventional−wisdom approach is quick and cheap, and evaluation is usually conducted informally using personal observations and feedback from field personnel or resource users. Adaptive management, in contrast, requires considerable time and money to organize workshops for stakeholders, develop models and policy assessments, and monitor the effects of management. However, if more complex decision−making approaches lead to more effective management, they may be cheaper in the long run.

Most natural resource managers have responsibilities that cover an extensive array of resources and require many decisions, often made under limited budgets and short time frames. Efficiency in decision making is always desirable, which leads to an Occam's razor approach: never use a more complex decision process than is necessary. Thus, I would argue that managers use the simplest approach that seems appropriate for the problem, and move to more complicated approaches only if the simpler approach fails.

SUCCESSES AND FAILURES OF TRADITIONAL DECISION MAKING

Traditional decision−making approaches have produced a broad spectrum of outcomes, from great successes to blatant failures. The most obvious examples of each seem to fall into two main categories. The failures of traditional management have occurred most obviously with problems in large, complex systems, such as North Atlantic fisheries, the Everglades, management of Pacific salmonids, forest management in the Pacific Northwest, control of non−point−source pollutants, or management of large rivers such as the Colorado River. For most of these problems, traditional management was applied for many years, yet problems persisted or became worse (Hutchings et al. 1997, Yaffee 1997). These types of problems are ecologically complex because many different components interact directly and indirectly, and socially complex because multiple user−groups often have conflicting goals that involve multiple components of the system. Uncertainty is usually high in large, complex systems because data are often limited and the systems are often unique; thus, no pool of knowledge exists from similar systems.

Management has typically addressed these problems with equilibrium−based approaches (Caddy 1996) and has tried to maintain these systems in some optimal state, with as little variation as possible. In some cases, this has reduced the ability of the system to respond to stresses (for example, fire suppression in forests) and has reduced the flexibility of the agency to respond to changes in the system (Gunderson 1999). In addition, under an equilibrium approach, managers did not learn much about how the system operated away from the optimal state; when the system changed in response to some stressor, managers were surprised and unsure how to respond. Multiple agencies often had jurisdiction over different aspects of the problem, resulting in complex interagency coordination and potential turf battles. There have been occasional successes with large, complex problems, e.g., the salmonid fishery in the Great Lakes, but these successes may have been fortuitous, rather than the result of a well−planned management effort, and may not be sustainable (Francis and Regier 1995, Callicott et al. 1999).

Successful applications of traditional decision making have been most evident for problems that involve relatively simple, replicated systems, such as management for trout in small streams, forest management for pulp production, control of point−source pollutants, fishery management in farm ponds, and moist−soil management for vegetation and waterfowl production. For these problems, the objectives were usually straightforward (e.g., produce more fish or pulp, reduce pollutant levels) and were directed toward a single species or goal. The dynamics of these systems were often controlled by strong relationships between a few major components. In addition, a single agency was typically in charge, and the research arm of that agency was often involved in development and evaluation of management options. Managers typically addressed problems one at a time on a site−specific basis. However, because they were managing multiple sites with similar problems, knowledge gained at one site was integrated into the conventional−wisdom or best−current−data approaches for use at other sites. This process functioned well as long as the management objectives and the basic structure and function of these systems remained constant. In essence, these were problems with clear goals and boundaries for which improvements in management came from sorting out scientific and technological issues (Brunner and Clark 1997).

THE TYPICAL ROLE OF ADAPTIVE MANAGEMENT IN AN AGENCY SETTING

Given these failures and successes of traditional management, when is adaptive management an appropriate strategy? To date, most applications of adaptive management have been to problems in large, complex systems such as the Everglades, salmonids in the Columbia River, and forests of New Brunswick (see reviews in Gunderson et al. 1995), North American waterfowl harvest (Johnson and Williams 1999), and the Colorado River (Wieringa and Morton 1996, Glen Canyon Adaptive Management Program). Some of these systems were mentioned previously as failures of traditional management. It appears that, in these cases, agencies have indeed moved to a more complex adaptive management approach when simpler methods failed.

I contend that adaptive management is probably the best approach available for addressing complex problems in large systems. Other authors have addressed how to apply adaptive management to a variety of complex problems (e.g., Holling 1978, Walters 1986, Walters and Holling 1990) and I will not repeat the specifics of their arguments here. In short, adaptive management differs from traditional approaches in that it addresses uncertainty directly by using management as a tool to gain critical knowledge. Adaptive management tries to understand the potential trade−offs among stakeholder interests under different management plans and tries to generate innovative approaches and "win−win" situations whenever possible.

The overall goal of adaptive management is not to maintain an optimal state of the resource, but to develop an optimal management capacity. This is accomplished by maintaining ecological resilience (in the specific sense proposed by Holling 1973 and described further in Holling and Meffe 1996) that allows the system to react to inevitable stresses, and by generating flexibility in institutions and stakeholders that allows managers to react when conditions change (Gunderson 1999). The result is that, rather than managing for a single, optimal state, we manage within a range of acceptable outcomes while avoiding catastrophes and irreversible negative effects. Although this approach is usually more costly to implement than traditional approaches, large and often unique systems are usually considered valuable enough that it is worth spending more time and money in the decision−making process.

Even though adaptive management might be the best choice for complex, large−scale issues, success is not assured (Halbert 1993, McLain and Lee 1996, Walters 1997). Many applications of adaptive management have stopped at the assessment phase and have failed to implement meaningful changes in management (Walters 1997). There are various reasons for this lack of implementation, but most involve either intransigence by powerful stakeholders (including agencies) or the unwillingness of stakeholders to accept the risk of short−term losses that might occur under experimental management (Halbert 1993, Walters 1997, Gunderson 1999).

I suggest that adaptive management has a place in an agency's repertoire for addressing large−scale, complex problems. However, given the rigorous constraints of time and money that agencies face, I contend that most management decisions are made, and will continue to be made, using traditional methods such as the conventional−wisdom or best−current−data approaches, with a healthy dose of political and social concern. Can adaptive management help to improve the way in which agencies apply these traditional approaches? I believe that it can by applying adaptive management to small, replicated systems to address common problems shared by many managers. This suggests a new role for adaptive management within agencies.

A NEW ROLE FOR ADAPTIVE MANAGEMENT WITHIN AGENCIES

An increasing human population, an increasing concern for the environment, and a desire for more direct public involvement in management have put greater demands on resource managers and have increased the complexity of management. To address this increased complexity, many agencies are now taking a more ecosystem−based approach (Cortner and Moote 1994, Haeuber and Franklin 1996 and associated papers, Lancia et al. 1996, Slocombe 1998). In an ecosystem context, the guidelines developed from experience in managing small−scale, replicated systems for narrowly focused objectives may not be appropriate. These small−scale systems become ideal candidates for applying adaptive management to develop new guidelines that can be used in the conventional−wisdom and best−current−data decision approaches.

The concept of applying adaptive management to replicated systems is not new. Walters (1986) contains a chapter entitled, "Adaptive Policies for Replicated Systems." Yet, the idea that adaptive management is appropriate for addressing collective, small−scale problems has received little attention in most agencies, even though there are numerous potential applications for this approach, including management of hydropower production at low−head dams, wetland restoration, fish stocking as a management tool, use of riparian buffer strips, overharvest of panfish, fire ecology in forests, tree regeneration success following timber harvest, habitat fragmentation in agricultural or forested landscapes, and the potential for new farming practices to reduce loss of nutrients, sediments, and pesticides from farm fields. In the remainder of this paper, I focus on some concepts and concerns for implementing this approach from an agency perspective.

An adaptive management approach for small, replicated ecosystems would not focus on separate problems at specific sites, but rather on a general class of problems that require similar types of decisions in different situations and locations. Thus, this approach begins from the holistic view of addressing a general problem that occurs within a collection of similar systems, rather than a reductionist view of site−specific problems to be addressed individually. From this holistic view, managers can develop general principles and guidelines that can be applied broadly to this type of problem, but with modifications to account for site−specific characteristics.

Adaptive management of replicated ecosystems will probably require more involvement with stakeholders to develop management objectives and gain support for management experiments. Management objectives will probably be broadened to address concerns such as diversity of species and habitats, transfer of nutrients or pollutants between systems, maintaining economic benefits, and balancing consumptive and nonconsumptive uses. With replicate systems, objectives could differ among systems to meet needs of specific user groups or to generate contrasts between systems that provide a broader range of information. The workshop approach used in adaptive management should help in this process, but will require more "up front" planning and coordination by managers (Shindler and Aldred Cheek 1999). In addition, the relationship between stakeholders and resource professionals will need to be fostered as the management process continues (Weeks and Packard 1997, Smith et al. 1998).

Data analysis and synthesis for replicated ecosystems will probably be more complex than for single systems. Within adaptive management, computer modeling is the primary method for integrating data from multiple sites and components. Modeling is used as a learning tool (Johnson 1995) for probing these data to determine which system processes are most amenable to management and what critical uncertainties limit our ability to predict how those processes function. Computer visualization tools such as graphics software, animation techniques, and geographic information systems can help participants to understand complex relationships and model outputs. Implementing these techniques will require an agency biologist, or a technical specialist with training in modeling and communications, or an outside consultant.

The results of computer modeling are used to develop efficient designs for management experiments. Just as modeling is the primary tool for probing data, management experiments are the primary tool for probing the system and addressing the critical uncertainties determined through modeling. Compared to traditional management for site−specific problems, using replicated systems should provide more flexibility to develop efficient and decisive experimental designs (Walters 1986, McAllister and Peterman 1992, Sit and Taylor 1998). Ideally, a combination of natural variation among systems and the managers' knowledge of site−specific differences can be used to develop experimental and control sites, contrasting treatments, and multifactorial designs (for examples, see Linnell Nemec 1998, Nyberg 1998). To help avoid future surprises, management experiments should deliberately probe the range of behavior among systems and the bounds within which we can manage. This includes examining the ability of systems to resist stresses, the possibility of multiple stable states, and any potential negative consequences of maintaining a steady state, such as less ecological resilience or more instability. This may require studying systems under extreme conditions, which might occur naturally (e.g., overharvest, excess pollutants) or be experimentally induced (e.g., fire, extreme water levels).

Most experiments will involve some risk of negative effects for stakeholders or the resource. Although systems might be replicates in an experimental sense, some stakeholders may feel ownership in a specific system (e.g., a trout fishing club and their local stream) and may be unwilling to risk "their" system for the greater good. To obtain user support, managers must be forthright about potential losses and benefits of any experiment, but ultimately, some form of compensation for potential losses may be necessary.

With replicate systems, an obvious question is how big an experiment to conduct (Walters and Holling 1990)? The answer will vary depending on the characteristics of the systems involved, the willingness of stakeholders to experiment, and the amount of time and money available to the agency(s). Replicated experimental designs should produce results more quickly than would single−system experiments, but even with an efficient design, it may take years to collect critical information. Obtaining a long−term commitment from an agency can be very difficult, and even if one is obtained, agency priorities and administrations can change. Thus, managers should plan on justifying long−term experiments every few years. It will be helpful if managers can produce short−term products that focus on progress to−date, usefulness of information to other management problems, or how new information has made experiments more efficient.

An efficient monitoring plan is a critical part of any adaptive management application (Walters 1986, Ringold et al. 1996). Modeling can help by suggesting which indicators may be critical to monitor and the appropriate temporal and spatial scales for data collection. Monitoring of replicated systems may require more time and effort than for single systems, but replicated systems may allow for more efficient monitoring designs, such as using alternate time periods for different sets of replicates or conducting detailed monitoring at some sites and more general monitoring at others. Sharing the costs for monitoring among agencies should reduce the burden on any one group. In addition, agencies should be constantly looking for more efficient ways to gather data (Walters 1997), such as having resource users collect data, using remote sampling techniques such as hydroacoustics or satellite imaging, and using methods that require less human intervention such as automated field samplers with electronic data communication.

As with traditional approaches, guidelines developed under adaptive management will be appropriate only as long as management objectives and system functions remain relatively constant. Thus, some type of extended monitoring will be needed to help managers realize when conditions have changed and current guidelines are no longer appropriate. This monitoring could help to evaluate long−term responses to management and might include maintaining an experimental management regime on a few systems, or continued monitoring at a lower level of effort on some systems, perhaps on a rotating schedule. The amount of effort expended will depend on how efficiently monitoring can be accomplished, the pressure to put scarce resources toward other issues, and the agency's willingness to be surprised by future unknowns.

Because adaptive management is more holistic and multidisciplinary than traditional management, it will require more cooperation across disciplines within an agency, and, in many cases, across jurisdictions among agencies and stakeholders. This may be the most difficult challenge that agencies face. Cooperation entails giving up some control to other agencies or stakeholders; thus, the potential for "turf battles" always exists. If participants can agree on the need for an experimental approach to improve their collective understanding of the system, then cooperation in conducting management experiments should be justified, even if participants differ in their objectives. Looking for win−win situations for agencies, as well as for resource users, may be critical.

Open communication and a free exchange of data among agencies, stakeholders, and the public should help to maintain cooperation, trust, and support among all parties (Hutchings et al. 1997, Pinkerton 1999). Interdisciplinary studies at replicated sites can generate large amounts of data. Thus, a central data repository may be useful, perhaps located with an unbiased outside party such as an academic institution. Although face−to−face meetings and workshops will always be needed to address some issues, much routine communication and exchange of information can be accomplished more efficiently with e−mail, electronic bulletin boards, and web sites.

Open communication may well be the ultimate test of a stakeholder's commitment to adaptive management. The long−term goal of developing a trusting relationship between managers and resource users will be thwarted by hidden agendas, power plays, and secrecy. Adaptive management will only be supported by resource users and agencies that see it as a tool with potential long−term benefits for all involved, not just as a method to promote the self−interest of agencies or specific user groups.

CONCLUSIONS

I have suggested that adaptive management has much to offer as an operational approach for resource management agencies. The examples of addressing complex problems in large, unique systems, and common problems in small, replicate systems represent the ends of a broad spectrum of management issues, many of which may benefit from adaptive management. An adaptive approach is usually more expensive than traditional approaches, but may result in more effective management in the long run. Increased effectiveness may be achieved through more efficient short−term management or, perhaps more importantly, by avoiding costly catastrophes, repeated management failures, and management by litigation.

Incorporating adaptive management into agency operations will require some changes in management philosophy. Most importantly, both managers and resource users will need to acknowledge uncertainty in management and try to determine the costs and benefits of reducing that uncertainty. If uncertainty is not critical for a particular management problem, or if it can be addressed with small−scale research, then traditional management approaches are probably appropriate. However, if uncertainty is critical and can only be addressed by manipulating the system(s), then I contend that adaptive management is the most useful approach currently available. There will always be social and economic pressures from some groups (including agencies) to maintain short−term benefits or to exercise control over the resource. These pressures may make management experiments infeasible, at least temporarily. However, to make adaptive management an effective tool, agencies and resource users must begin to see it as the most appropriate approach for some problems, not just as a last resort when other approaches fail.

RESPONSES TO THIS ARTICLE

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