Chapter 3: How Should Adaptive Management be Implemented?

From an operational point of view, adaptive management simply means learning by doing (i.e., learning through management) and adapting what one does based on what is learned (i.e., adjusting management as understanding improves). Learning contributes to management by providing information on which to base management strategies, and management reinforces learning by implementing actions that are useful in investigating the resource system. A sequential application of these component activities should produce both improved understanding of resource dynamics and improved resource management (51).

As noted earlier, the emphasis in an adaptive approach is first and foremost on resource management. The value of understanding, and the monitoring and analysis that produce understanding, is inherited from their contributions to the objectives of resource management. Although the focus is on learning, the ultimate goal of the effort is smart management.

This chapter focuses on the implementation of adaptive management. The actual process of using adaptive management is discussed in terms of its key structural elements and the integration of these elements into an iterative cycle of management, monitoring, and assessment. Also highlighted are some legal issues that focus on compliance with the relevant environmental and administrative laws.

3.1. Operational Sequence for Adaptive Management

Implementation of adaptive management can be described in terms of two phases: a set-up phase in which its key components are developed, and an iterative phase in which the components are linked together in a sequential decision process. The set-up phase has five structural elements, namely stakeholder involvement, management objectives, potential management actions, predictive models, and monitoring plans. The iterative phase uses these elements in an ongoing cycle of learning about system structure and function, and managing based on what is learned.

Although adaptive management is described here by a series of steps in the set-up and iterative phases, it is important to recognize that adaptive management is a complex endeavor that includes much more than simply following a sequence of steps. Properly executed, the process involves ongoing, real-time learning, both in a technical sense and in terms of process itself. Stakeholders need to be engaged at the stage of initial problem formulation and remain engaged throughout implementation. By implication, an adaptive approach to management improves on the traditional communications approach in which scientists create knowledge and then pass it on to practitioners, with other stakeholders acting as passive observers (51). Instead, an adaptive approach actively engages parties in all phases of the project, facilitating mutual learning and reinforcing the commitment to learning-based management.

Set-up phase

Adaptive management prescribes the integration of decision making, monitoring, and assessment into an iterative process of learning-based management. To implement the process, certain elements must be put in place, and then used in a cycle of iterative decision making.

Step 1 - Stakeholder involvement

Ensure stakeholder commitment to adaptively manage the enterprise for its duration

Of particular importance in adaptive management is that stakeholders assess the resource problem (see Fig. 1.1) and reach agreement about its scope, objectives, and potential management actions, recognizing that differences of opinion about system responses may exist even when there is consensus on these issues. Clearly, agreement about scope, objectives, and interventions is not possible in the absence of stakeholder involvement in establishing them. Thus, a first step in adaptive management is to engage the appropriate stakeholders (See Case Study 1 and BLM Collaboration Desk Guide on CD for a discussion of stakeholder involvement).

Case Study 1: For decades, there has been concern about the ecological impacts of the operation of Glen Canyon Dam on downstream resources, particularly the riparian areas along the Colorado River in the Grand Canyon, Arizona. In recent years efforts have been made to evaluate and adapt management actions for resource protection through experiments that are monitored for their effects in the Grand Canyon. (See included CD for additional information on this project).

Several activities are involved. First, stakeholders must be identified and encouraged to participate. This might involve personal contacts, public announcements, formal consultations, or other means. Second, a process must be implemented that solicits stakeholder input in the design of the adaptive management project and, in particular, the identification of management objectives and potential management actions. Depending on the project, this may require formal or informal consultations, legally mandated and administered procedures, or other approaches. In any case, stakeholder involvement in identifying key components of the project should be open and transparent. Third, stakeholders must commit to an agreed-upon process of reducing uncertainties and/or disagreements about the effects of management. That is, having reached agreement on the scope of the management problem and its objectives and potential interventions, stakeholders must then commit to an iterative process of objective-driven decision making.

In general, the group of stakeholders should be broad enough to express the uncertainty (perhaps through disagreement) that is the focus of adaptive management. However, adaptive management is not prescriptive about who the stakeholders are, how many there are, or what their perspectives or values are. The scale and complexity of stakeholder involvement can vary greatly among projects and is influenced by the scale and complexity of the application itself. Many adaptive management projects involve only one or a few stakeholders, as with a refuge manager who is unsure how to manage water control structures on the refuge, or a farmer who is unsure how to seed and cultivate some of his farmland, or a fish hatchery manager who is uncertain about how long to age fish stocks before releasing them in a reservoir. Other projects may involve a large number of disparate stakeholders, as with the seasonal release of water from a dam on a large river, or the production of timber on a large regional forest, or the management of a coastal fishery. As a general rule, the number of stakeholders, and the breadth of their perspectives and values, will vary with the geographic, ecological, administrative, and political scale of the adaptive management project.

Stakeholders should play a role in identifying the scope of the project as well as the objectives and potential management actions. Within a context of legal and institutional boundaries, stakeholders help to define the operating environment of an adaptive management project, and they influence both decision making and the opportunity to learn. All too frequently, a decision making process is undertaken without agreement about scope, objectives, and management alternatives. Without this agreement, any management strategy likely will be viewed as reflecting unshared objectives and inappropriate or unnecessary limitations on management. The prospects for conflict increase dramatically in such a situation.

The success of an adaptive management project requires an adequate understanding of the resource issues and the dedication to stay abreast of new information. The interface between scientific investigation and stakeholder understanding becomes increasingly difficult as proposed actions become more technical, and it is not uncommon for both scientists and stakeholders to become impatient and frustrated. Engagement and communication among stakeholders is critically important if arguments on the meaning of science are to be minimized.

Of particular concern in adaptive management is the asymmetry between management interventions, which often must be implemented in a relatively short amount of time, and their impacts, which sometimes require years or even decades to be recognized. This asymmetry imposes special demands on stakeholders to remain engaged over an adequate timeframe for learning to occur. Among other things, it may be useful, and even necessary, to design monitoring and assessment programs at different scales, so as to build understanding incrementally while anticipating unexpected results that may require adaptations in the project. Otherwise, premature interruption of monitoring efforts, or stakeholder pressure to terminate the application of adaptive management, could short-circuit the expected benefits of improved decision making.

Recognizing stakeholder interests and ensuring their involvement for the duration of the management enterprise are requirements for learning–based management in general. But involvement is more than passive participation in information sharing and other stakeholder prerogatives. Adaptive management involves the commitment of time, resources, and active engagement of stakeholders. These requirements often are underestimated. If stakeholders are unwilling to dedicate sufficient time and effort, group deliberations have the potential to devolve into value-based arguments, minimizing the positive impacts of monitoring and evaluation. Program documents should explicitly state the responsibilities of the stakeholders, and every effort must be made to ensure that stakeholders will meet those responsibilities over the life of the project.

Step 1 - Key Points

- A strong effort must be made to identify and engage the appropriate stakeholders.
- All phases of the adaptive management process must be open, transparent, and accessible to stakeholders.
- Stakeholders must strive for agreement on scope, objectives, and management alternatives for the adaptive management application.
- Stakeholders must commit to a process for adjusting management strategy over time, based on resource status and learning.
- Stakeholder organizations must be encouraged to commit time and energy to adaptively manage the resource over the agreed-upon timeframe.
- Stakeholders must commit resources for monitoring and assessment, in addition to decision making.

Bemidji Crude-Oil Research Project; measuring crude-oil thicknesses during the aquifer test.

Step 2- Objectives

Identify clear, measurable, and agreed-upon management objectives to guide decision making and evaluate management effectiveness over time

Objectives, resource status, and learning all influence the choice of management interventions in adaptive management. But objectives also play a crucial role in evaluating performance, reducing uncertainty, and improving management through time. It therefore is important to have clear, measurable, and agreed-upon objectives at the outset, to guide decision making and assess progress in achieving management success (See Case Study 2 for a discussion of setting objectives).

The term "objective" is used here to mean some desired outcome or performance measure that can be used to guide decision making and measure success. Objectives typically are expressed in terms of management performance over the timeframe of a project. For example, measures might be harvest yield, population size, water flows, or the probability of a negative impact on resource status, with an objective of maximizing accumulated harvest, achieving a desired population size, maintaining water flow, or minimizing a probability of extinction.

Because management objectives are used to guide decisions in managing (and often changing) certain aspects of a target resource through time, they should be more specific than common, "broad-brush" statements or overall program purposes that appear in many project documents. For example, generic statements such as "provide public access and recreational opportunities" or "improve water quality to enhance and restore commercial fishing" are purpose statements indicating why management is to be undertaken, rather than objectives that can help to guide decision making.

Objectives should address the resource issue or problem that initially motivated management, and reflect the social, economic, and/or ecological values of stakeholders. Underlying an adaptive approach is the recognition that stakeholders influence what is to be managed and under what circumstances. Finding common ground among disparate and often contentious parties is not an easy task when there are differences in understanding about the resource system and differences in ideas about the desired focus and direction of management. For objectives to be realistic and mutually acceptable, parties must work toward an agreement on the purpose and approach to resource management and seek a common basis for recognizing management success. In particular, objectives should be defined cooperatively through a dialogue among managers, scientists, and other stakeholders.

In the context of adaptive management, objectives must be relevant to the decision making process and possess a number of attributes that render them useful as guides to management (52). To be useful for decision making and evaluation, objectives need to exhibit the following technical features:

- **Specific:**
Objectives should be unambiguous, with specific metrics and specific target conditions. Specificity can be encouraged by articulating objectives with Who, What, Why, and/or Where phrases.

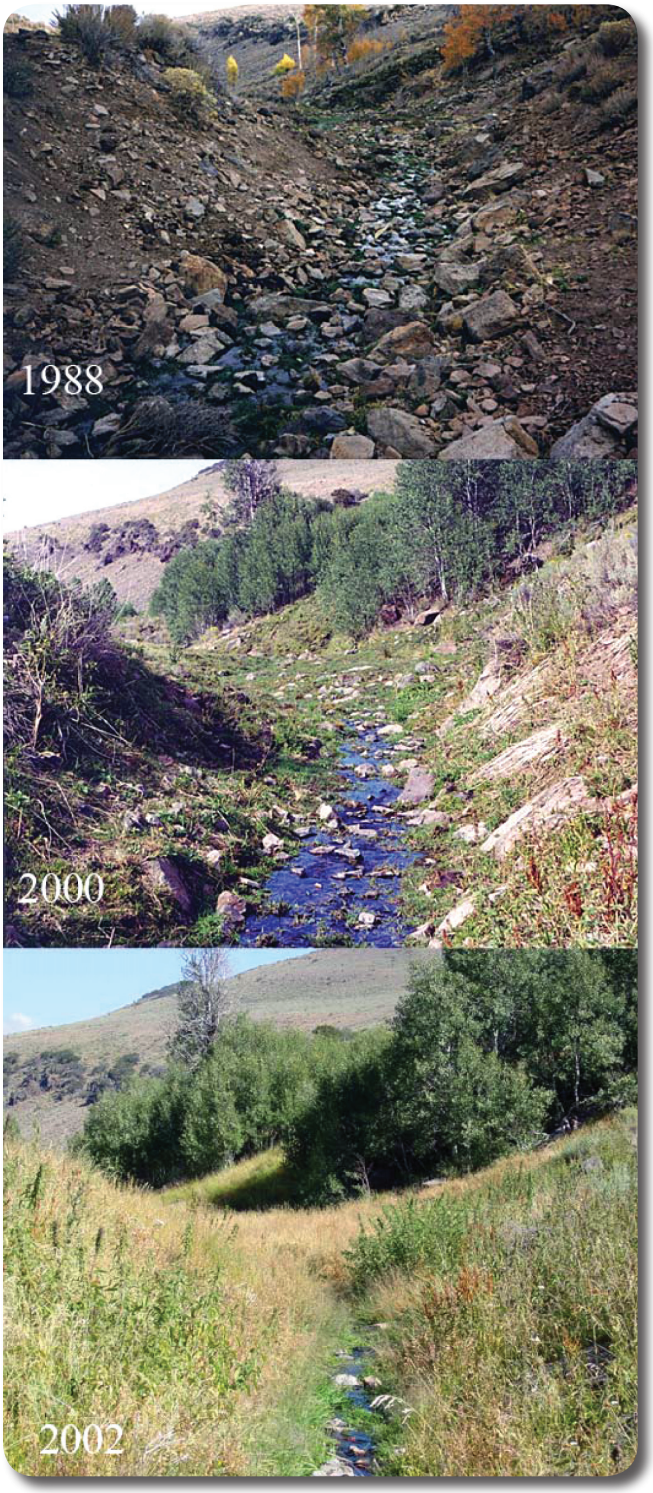
- **Measurable:**
Objectives should contain elements that can be readily measured, so as to promote the evaluation of management actions and recognize their contributions to successful management.

- **Achievable:**
Objectives should be based on the capacities of the natural resource system being managed and the political or social system within which management occurs.

- **Results-oriented:**
Objectives should contain for resource endpoints and/or conditions representing their achievement. For example, a results-oriented habitat objective might describe the habitat conditions expected when the objective is achieved.

- **Time-fixed:**
Objectives should indicate the timeframe for achievement, consistent with the duration of the project. Project implementation may be in stages, but the overall timeframe should be clear.

It is often the case in adaptive management that there are multiple objectives for resource management. For example, one might seek to sustain species richness in a refuge, while attempting to maximize visitor use, maintain a harvest program for one or more species of wildlife, and allocate resources to these activities so as to minimize costs. In such a situation it is important to be able to weigh different objectives in terms of their perceived importance, so as to facilitate the comparison and prioritization of management alternatives.



Step 2- Key Points

- Objectives substantively influence decisions and management strategies.
- Objectives should incorporate the social, economic and/or ecological values of stakeholders, and reflect the value of learning over time.
- To be useful as guides for decision making and evaluation, objectives should be specific and unambiguous, measurable with the appropriate field data, achievable but challenging, results-oriented, and applicable over the timeframe of the enterprise.

Case Study 2: The Trout Creek Mountain Restoration focuses on compatibility between livestock grazing and critical habitat for listed Lahontan cutthroat trout within the Trout Creek and Oregon Canyon Mountains, Oregon. This time sequence shows the dramatic changes along Cottonwood Creek, V Pasture, looking downstream starting in 1988. Until 1989 this pasture was grazed during the summer every year. Despite changes in the timing and intensity of grazing, chronic trespass prevented acceptable levels of riparian improvement. Enforcement, changes in permittees, and fence repairs since then have allowed 2 years of actual rest. Note the increased reproduction in aspen by 2002. (See included CD for additional information on this project).

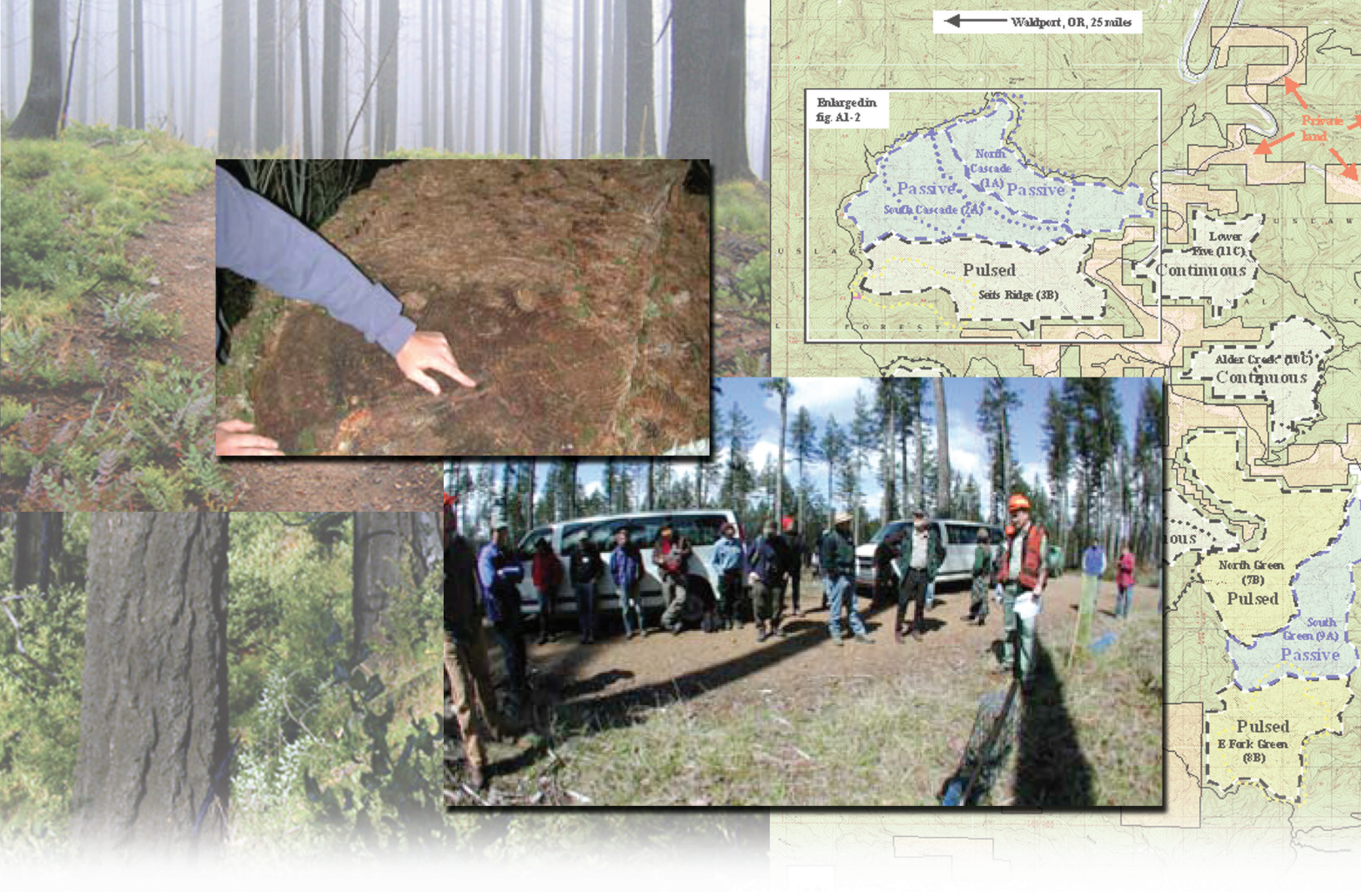
Step 3- Management actions

Identify a set of potential management actions for decision making

Like any iterative decision process, decision making in adaptive management involves the selection of an appropriate management action at each point in time, given the status of the resources being managed at that time. Resource managers and stakeholders, typically working with scientists, have the responsibility of identifying the set of potential actions from which this selection is made (See Case Study 3 for a discussion about identifying management actions).

The management alternatives in an adaptive management project constitute a key element in its operating environment, and they can strongly influence the selection of a management strategy (see Section 5.1). Just as the choices made in daily life depend on one's available options, so too are strategy choices in an adaptive management project constrained by the set of available options. If these options fail to span a reasonable range of management activities or fail to produce recognizable and distinct patterns in system responses, adaptive management will be unable to produce effective and informative management strategies. This argues for careful thinking about the potential actions to be included in a project.

Case Study 3: The Sonoita Valley Planning Partnership is an ad hoc, volunteer association of Federal, State, and local agencies, user groups, organizations, and individuals with a common interest in the upper Cienega watershed, which includes the 42,000 acres of public lands within the Las Cienegas National Conservation Area, Arizona. The goal of the partnership is to perpetuate naturally functioning ecosystems while preserving rural grasslands for future generations. (See CD for additional information on this project).



Case Study 4: The Five Rivers Landscape Management Project began in 1998 as an attempt to apply adaptive management at large scales. The project was designed for 32,000 acres of productive Siuslaw National Forest land in coastal Oregon. (See CD for additional information on this project).

Management alternatives in adaptive management often focus on a potential change in resource status or the alteration of process rates. Examples of the former include culling a livestock herd to maintain a population at carrying capacity, stocking a lake to sustain a fishery, or withdrawing water from a reservoir to maintain an appropriate volume of water in it. Examples of the latter include harvest regulations that target an acceptable mortality rate, alteration of nesting habitat to enhance population reproductive rate, or control of the amount and timing of visitor disturbance so as to influence avian migration patterns positively.

In designing an adaptive management project, management alternatives should be included that will produce different responses and thereby promote learning. One way to structure alternatives for this purpose is to limit their number, and maximize differences among them. An example is the Five Rivers Landscape Management Project (See Case study 4), which used three different management alternatives: (1) passive management in which plantations are allowed to develop into old growth with no intervention other than road closures; (2) frequent light-touch thinning and road maintenance; and (3) heavy thinning followed by 30-year road closures. Another example involves the impact of harvest, which is likely to be easier (and less costly) to recognize with a few widely spaced harvest rates rather than many that are closely spaced. In both examples a smaller number of alternatives helps to reduce implementation costs, minimize problems that otherwise can arise with partial controllability (see Section 5.2), and highlight differential responses of the resource.

Because of natural variation, resource systems often are extraordinarily difficult to control with management actions, and "cause and effect" relations are usually unclear and difficult to recognize. It is important to include options that can help to reduce these difficulties, though this sometimes leads to a broader range of

potential actions than otherwise would be desireable. In any case, the options under consideration should always be designed to achieve specific objectives.

To ensure clarity and transparency it is important to make the management options explicit. Too often the set of options is unstated, and simply assumed to be recognized and understood by managers and other stakeholders. Ambiguity as to the alternatives under consideration can lead to conflict among stakeholders and the possibility of legal challenges to the decision making process.

The identification of management options is often a greater challenge than some anticipate. Just as different stakeholders see the resource system differently and identify different objectives for its management, so will they recognize differences in the feasibility and acceptability of management options. Even when there is rough agreement on their nature and extent, there still may be different perspectives about the appropriate number and composition of management alternatives. It is important to take the necessary time and effort to think carefully about these issues, so as to reach agreement on a realistic and politically acceptable set of alternatives.

Because of natural variation, resource systems often are extraordinarily difficult to control with management actions, and "cause and effect" relations are usually unclear and difficult to recognize.

Step 3- Key Points

- Potential actions consist of activities under management control (for example, harvest, stocking, restoration).
- Alternatives typically focus on alterations of resource status or process rates.
- The suite of available actions should be designed to promote learning.
- The alternatives should be explicit and documented.
- Stakeholders should participate in the identification of alternatives.

Step 4- Models

Identify models that characterize different ideas (hypotheses) about how the system works

Models play an important role in virtually all applications of structured decision making, whether adaptive or otherwise. In order to make smart decisions, it always is important to compare and contrast management alternatives in terms of their costs, benefits, and resource consequences. Models typically express benefits and costs as outputs of management through time. More importantly, they allow one to forecast the impacts of management.

The term "model" is used here to mean a plausible representation of a dynamic natural resource system (See Case Study 5 for a discussion of model development). Models can be as informal as a verbal description of system dynamics (for example, a simple description of reservoir size that is positively influenced by runoff and negatively influenced by water release), or as formal as a detailed mathematical expression of change (for example, an age-structured multi-species model with density-dependent vital rates that are affected by random environmental changes). The models used in an adaptive management project are not restricted to a particular kind. In many instances only a few models are required to capture contrasting views about the system, and these often can be described with limited technical detail.

Case Study 5: In 1995, the U.S. Fish and Wildlife Service implemented an approach known as adaptive harvest management, in which managers seek to maximize sustainable harvests against a background of various sources and degrees of uncertainty. (See CD for additional information on this project).

Although model complexity can vary widely depending on the ecological and management scale of the application, the models used in adaptive management generally share certain attributes (53):

- Resources are described as changing though time, so as to allow learning to occur and management to adapt to learning (Fig. 3.1).
- The resource system is characterized by key components of interest (for example, population size, resource biomass or volume, biodiversity) that are the focus of management and the targets of monitoring.
- Resource changes often are described in terms of processes (for example, reproduction, mortality, spatial movement) that are thought to be directly influenced by management.
- Fluctuating environmental conditions are incorporated as needed to characterize resource dynamics.
- Management impacts are described in terms of costs, benefits, and influences on resource components or processes that are highlighted in the model.
- Models are calibrated with available data and knowledge, to ensure compatibility with current understanding about resource structures and functions.

Models play a key role in representing uncertainty. In adaptive management, structural or process uncertainty is captured in contrasting hypotheses about system structure and function, and the hypotheses are imbedded in the suite of models used to forecast resource changes through time. At any point, the available evidence will suggest differences in the adequacy of each of these models to represent resource dynamics. As evidence accumulates over time, the confidence placed in each model (and its associated hypothesis) evolves, through a comparison of model predictions against monitoring data.

To be useful, the models in a particular project must meet certain conditions, including a requirement that different models predict different outcomes in response to management. However much two models may differ in the way they describe system dynamics, if both predict the same responses to management, then recognizing which is more scientifically credible will be of little use in improving management.

An example that highlights many of these points is the modeling framework used for adaptive harvest management of waterfowl. Adaptive Harvest Management (AHM) was initiated in 1995 as a process for setting annual regulations for the sport hunting of waterfowl in North America (37). For AHM, a simple model was used to account for associations among fall harvest, seasonal survivorship, and spring reproduction (Fig. 3.2). Contrasting hypotheses about the impact of harvest on annual survivorship were easily incorporated into different versions of the model, by describing different functional relations between harvest rates and post-harvest survival. In addition, contrasting hypotheses about the importance of density dependence in recruitment were incorporated by describing recruitment in terms of spring population size. In combination, these hypotheses define four models, each with its own predictions about harvest impacts and each with its own measure of confidence that evolves over time (54). The models and their measures of confidence characterize structural or process uncertainty, which is reduced over time as harvest actions are taken and post-harvest monitoring data are used to update the confidence measures.

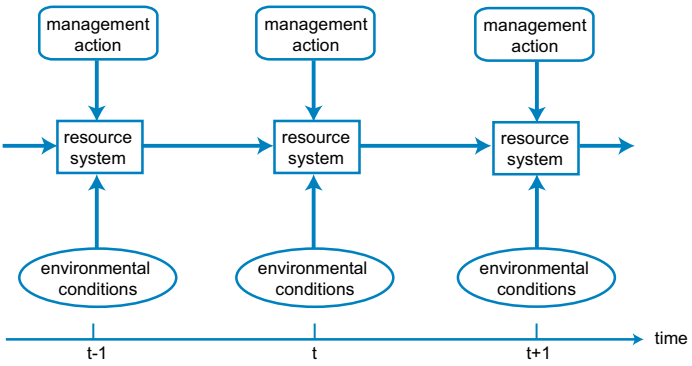


Figure 3.1. Change in resource system as influenced by fluctuating environmental conditions and management actions. Management produces immediate returns (costs and/or benefits) and longer-term changes in resource status.

Like the management options in an adaptive management application, models can strongly influence the identification (and acceptability) of management strategies. If the models fail to incorporate meaningful hypotheses, or fail to produce recognizable differences in population dynamics, an adaptive approach may be unable to produce useful and informative strategies. This argues for engaging managers, resource scientists, and other stakeholders in a thoughtful and deliberate process of selecting the models to be used in an application.

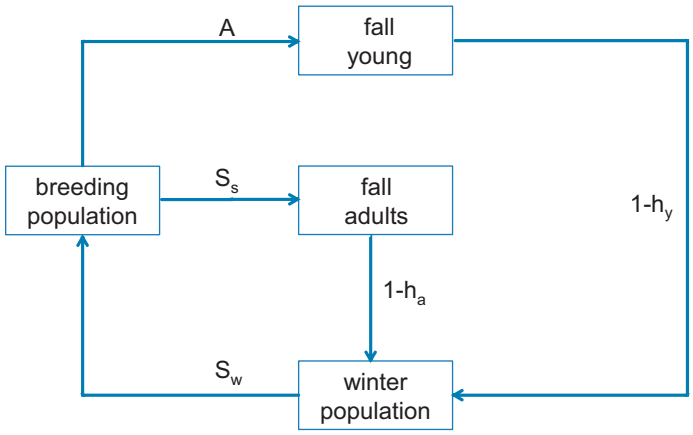


Figure 3.2. Conceptual model of the annual cycle of mallard population dynamics. Model includes survival rates for spring-summer (S_s) and fall-winter (S_w), along with harvest rates for young (h_y) and adults (h_a) and age ratio (A) for reproduction/recruitment.

Step 4- Key Points

- Models in adaptive management should characterize system behaviors and responses to management actions.
- Models should incorporate different ideas (hypotheses) about how the resource system works and how it responds to management.
- The suite of models should capture key uncertainties (or disagreements) about resource processes and management effects.
- Models must be compatible with, and calibrated to, available data and knowledge.

Step 5- Monitoring plans

Design and implement a monitoring plan to track resource status and other key resource attributes

The learning that is at the heart of adaptive management occurs through a comparison of model-based predictions against estimated responses based on monitoring data. It is by means of these comparisons that monitoring is used to understand resource dynamics, and thus to confirm the most appropriate hypotheses about resource processes and their responses to management. By tracking useful measures of system response, well designed monitoring programs facilitate evaluation and learning in adaptive management.

In general, monitoring provides data in adaptive management for four key purposes:

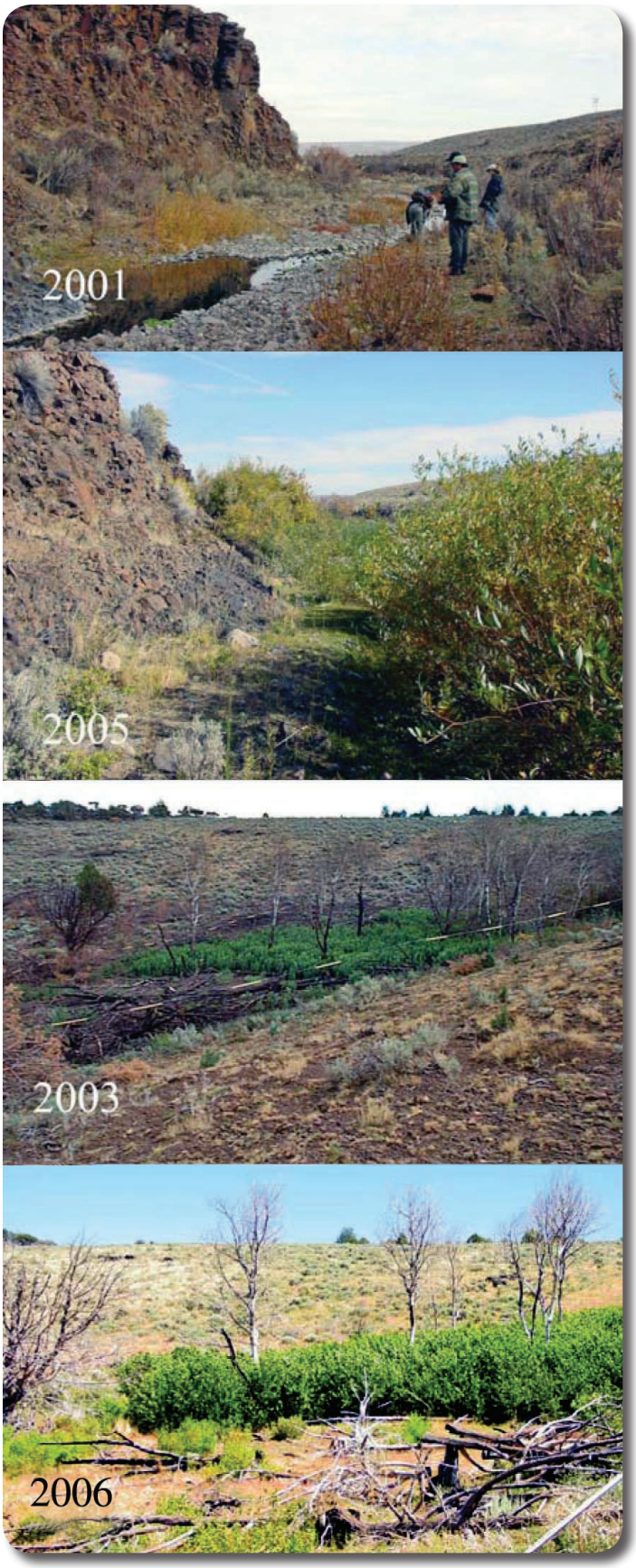
(i) to evaluate progress toward achieving objectives;

(ii) to determine resource status, in order to identify appropriate management actions;

(iii) to increase understanding of resource dynamics via the comparison of predictions against survey data; and

(iv) to enhance and develop models of resource dynamics as needed and appropriate.

Monitoring programs should be designed from the outset to inform decision making with data that are relevant to the management issues in the adaptive management project (55,56). For example, variables such as survival, harvest, stocking, and reproduction rates can be estimated with properly designed monitoring efforts and used to adaptively manage a biological population. Surveys producing such information can be invaluable as sources of longterm data with which to develop the adaptive management project (See Case Study 6 for a discussion about developing a monitoring plan).



Monitoring in adaptive management inherits its focus and design from the larger management context of which it is a part. Thus, field surveys are not motivated by scientific curiosity, nor are survey data gathered with only a vague hope that somehow they will prove useful for management. Instead, monitoring programs are designed to focus on the information needed to make management decisions and evaluate their impacts. There may be scientific or other values in broad-scale surveillance monitoring, and data collected in this way can sometimes prove useful for resource conservation. But monitoring in the context of adaptive management is much more efficient and effective if it targets specific attributes for the specific purposes listed above. Simply put, the value of monitoring in adaptive management is derived from its contribution to adaptive decision making, and monitoring efforts should be designed with that goal in mind (57).

Step 5- Key Points

- A monitoring plan should be designed to estimate system state and other attributes needed for decision making and evaluation.
- The plan should promote learning through a comparison of estimates against model-based predictions.
- The plan should be efficient, in that it produces estimates that have maximum precision for a given cost, or minimum cost for a given level of precision.

Case Study 6: The Bully Creek Landscape Area Management Project of the Bureau of Land Management is within the Malheur Resource Area, Vale District, Oregon. The project represents ground-level resource planning for public lands. On the top are views of Allotment #3 on a tributary of Cottonwood Creek in 2001 (first year after change in riparian management) and 2005 (after 5 seasons of riparian management). On the bottom are views of the Muir Spring aspen stand (with protective fencing) in 2003 (first year after treatment), and 2006, which shows a close-up of the same site with continued aspen regeneration. (See CD for additional information on this project).

Iterative phase

At this point in the operational sequence of adaptive management it is assumed that the key elements are in place. Thus, the appropriate stakeholders have been engaged in articulating the scope and nature of the resource issue. The objectives and management alternatives of the project have been identified. Forecasting models that capture uncertainty (or disagreement) about the impacts of management have been identified. And a monitoring effort has been designed that targets the resource attributes needed for learning, evaluation, and decision making. The stage is now set to incorporate these elements into an iterative decision process that will lead to improved understanding and management.

Step 6- Decision making

Select management actions based on management objectives, resource conditions, and understanding

At each decision point in the timeframe of an adaptive management project, an action is chosen from the set of available management alternatives. The management objective identified in Step 2 is used to guide this selection, given the state of the system and the level of understanding when the selection is made. The appropriate action is likely to change through time, as understanding evolves and the resource system responds to environmental conditions and management actions. That is, management is adjusted both to changing resource status and to learning. It is the influence of reduced uncertainty (or learning) on decision making that makes the decision process adaptive.

There are many ways to design the actual process of selecting an alternative. For example, formal optimization methods can be used to select from the available management alternatives an option that best accounts for current and future consequences (53,58,59). Alternatively, less computation-intensive search procedures can be used to produce suboptimal (but in many cases quite acceptable) management strategies. Finally, one sometimes can rely on less structured approaches or common sense to identify acceptable strategies. Irrespective of the approach, decision making should be driven by the management objectives and informed by resource status and process uncertainties.

Step 6- Key Points

- ❖ At each point in time, selection of a management action is made from the set of possible alternatives.
- ❖ The selection of a management action is guided by objectives, which are used to evaluate alternatives and identify an action that contributes to meeting the objectives.
- ❖ The appropriate action depends on resource status and the current level of understanding about resource dynamics.
- ❖ Management is adjusted over time as resource conditions change and understanding evolves.

Step 7- Followup monitoring

Use monitoring to track system responses to management actions

Monitoring is used in adaptive management to track system behavior, and in particular to track the responses to management through time. In the context of adaptive management, monitoring is seen as an ongoing activity, producing data after each management intervention to evaluate the intervention, update the measures of model confidence, and prioritize management options in the next time period (See Case Study 7 for a discussion of follow-up monitoring).

Field surveys, banding programs, remote sensing, and other monitoring approaches can generate the data needed to estimate key indicators of resource dynamics (20). The information thus produced is used to compare data-based estimates of system components against expectations, and thus to measure performance in achieving management objectives. Monitoring information also factors directly into the learning process, through the comparison of estimates against model predictions. Subsequent decision making reflects the increasing degree of credibility earned by the most appropriate model(s), and management performance is adaptively improved.

Monitoring data play into these assessments in multiple ways. For example, estimates of system state typically are used in the process of identifying state-

specific decisions. In some cases, estimates of resource status are directly included in the objectives, and thus are needed to assess the expected benefits, costs, and consequences of particular decisions. Of particular importance in adaptive management is the use of estimates of status and perhaps other attributes for comparison against model predictions so as to improve understanding of resource dynamics.

In many but not all instances, it is useful to collect data prior to initiating management. For example, if the management objective is to increase the size of a previously unperturbed population over some time period, a "baseline" population size prior to any management intervention can be used to compare population size before and after the initial intervention. On the other hand, an objective of maximizing harvest may not require baseline conditions prior to the start of management. In the latter case, decision making pursuant to the objective is not informed by a comparison of resource status against a starting value. The point here is that the design of a monitoring effort, and in particular the need for initial "baseline" information, is determined by the nature of the project and its objectives. Even when baseline information is needed, its comparative value declines rapidly as the project proceeds through time, essentially because monitoring after each intervention establishes new "baselines" throughout the life of the project.

Case Study 7: The National Park Service (NPS), State of Montana, USDA Forest Service, and the USDA Animal and Plant Health Inspection Service developed an adaptive management strategy in 2000 that allows Montana to maintain its brucellosis-free status and NPS to maintain a bison population that fluctuates in response to ecosystem processes. (See CD for additional information on this project).

Step 7- Key Points

- Monitoring typically occurs after management interventions.
- Resource status and other key indicators of impacts are estimated with monitoring data.
- Estimates based on monitoring data are used to evaluate management impacts and inform decision making at the next decision point.
- Because the amount of monitoring data increases over the course of an application, the amount of information about system processes also increases.

Step 8- Assessment

Improve understanding of resource dynamics by comparing predicted and observed changes in resource status

The information produced by monitoring folds into assessments of decision making, performance evaluation, and learning. For example, the comparison of model predictions against estimates of actual responses is a key element of learning, with the degree of coincidence between predicted and observed changes used as an indicator of model adequacy. Confidence is increased in models that accurately predict change, and confidence decreases for models that are poor predictors of change. In this way evidence accumulates over time for the most appropriate hypothesis about resource dynamics, and understanding of the resource system is thereby advanced.

As important as it is, learning is not the only role played by analysis and assessment in adaptive management. Thus, an assessment of desired against actual outcomes can be used to evaluate the effectiveness of management and measure its success in attaining management objectives. In addition, an assessment of management alternatives as to their projected costs, benefits, and resource impacts contributes to the selection of a management option in the next time period.

Step 8- Key Points

- Assessment/analysis includes parameter estimation, comparative assessments, and prioritization of management alternatives.
- Comparison of predicted and actual responses is used to update understanding of management impacts.
- Comparison and ranking of projected outcomes for management alternatives is used in selection of management actions.
- Comparison of desired and actual outcomes is used to evaluate management effectiveness.

Step 9- Iteration

Cycle back to Step 6

The gain in understanding from monitoring and assessment in Steps 7 and 8 is used to inform the selection of a management action at the next decision point. As understanding evolves, so too does the decision making that is influenced by improved understanding. In this way, the iterative cycle of decision making, monitoring, and assessment leads gradually to improved understanding of resource dynamics, and improved management as a consequence of improved understanding.

As shown in Fig. 3.3, the iterative cycle can begin with any of the Steps 6 to 8. However, it is useful to think of it as starting with a management decision, which is followed by post-decision monitoring and the subsequent assessment of monitoring data. This sequence of activities is repeated over the course of the application, during which learning occurs continuously and the management strategy is continuously adjusted based on what is learned.

The cycle typically terminates at the end of the time-frame with a final management action that is informed by assessment of the data collected just prior to the terminal time. It is also possible, if unlikely, that all uncertainty about ecological structure and function can be eliminated at some point, whereupon the learning-based adaptive approach can give way to non-adaptive resource management for the remaining time.

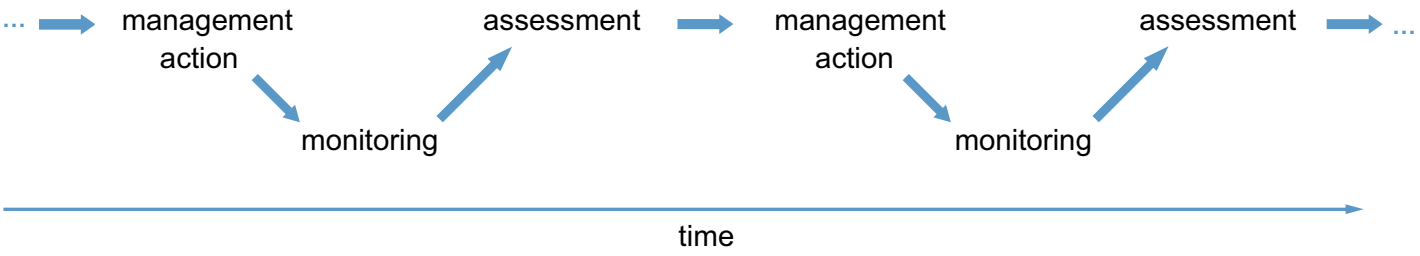


Figure 3.3. Iterative cycle of adaptive management. Management actions are based on objectives, resource status, and learning. Data from followup monitoring are used to assess impacts and update understanding. Results from assessment guide decision making in the next time period.

Step 9- Key Points

- The cycle of Steps 6 through 9 is iterated until the end of the timeframe.
- Iterations can begin at any point in the cycle; however a natural entry point is with decision making.
- The direct linkage from assessment to management action in Fig. 3.3 expresses the contribution of learning to decision making, by providing information on which to base smart decisions.
- The two-step linkage from management action to assessment in Fig. 3.3 expresses the contribution of management to learning, through interventions that are useful in investigating the resource system.

Technical and process learning in adaptive management

The operational sequence described above provides a framework for implementing adaptive management, with a focus on reducing structural or process uncertainty and thereby improving management. However, adaptive management involves much more than simply following the sequence of steps outlined here.

Just as adaptive management can be described in terms of two phases, learning with adaptive management can be seen to occur at two levels. Thus, adaptive management provides an opportunity to learn not only about ecological processes, but also about the adaptive process itself. In Chapter 1, adaptive management was described in terms of a cycle that included not only monitoring, evaluation, and adjustment of management actions, but also problem assessment and design (Fig. 1.1). The latter elements focus on problem formulation, stakeholder involvement, identification of objectives, and the other elements included in the setup phase of adaptive management. In fact, it is useful to think of adaptive management not only in terms of an ongoing sequence of decision making, post-decision monitoring, and assessment as described here, but also in terms of periodic but less frequent recycling through the elements in the setup phase and adjustment of these elements as needed to account for evolving stakeholder perspectives and institutional arrangements (Fig. 3.4). The broader context of learning that focuses on the components of adaptive management as well as technical uncertainty is sometimes called "double-loop" learning (12).

In many applications of adaptive management, both kinds of learning are of key importance. For example, it can be as important to understand and track the social and institutional relations that influence adaptive management elements and stakeholder perspectives, as it is to resolve technical issues about system structure and process (54). Although the motivation of an adaptive approach is to improve resource management by reducing structural uncertainty, its success can be impeded by a failure to adapt to social and institutional changes that inevitably occur over time. Because these changes can themselves be a result of early successes in reaching objectives, it is important to recognize and if possible account for them as decision making moves forward.

The need to better understand and characterize the elements of adaptive management often becomes more pressing as the iterative process of adaptive management rolls forward. Thus, stakeholder perspectives and values can shift as the adaptive process unfolds, and previously unanticipated patterns in resource dynamics can arise that require an adjustment of objectives, alternatives, and other elements of the process. In this sense, learning about the adaptive management process extends the context of adaptive learning to include changes in institutional arrangements and stakeholder values as well as changes in the resource system.

An emphasis on both technical and process learning has important implications for the institutional framework for resource management. Many managers contend that adaptive management is simply common business practice in their organizations and that they have been using adaptive management all along (51). In fact, the use of adaptive management in resource management almost always requires a fundamental shift from the status quo. For example, it typically is necessary to rethink the nature of risk aversion that characterizes decision making in most Federal agencies, and to explicitly recognize uncertainty as a key attribute of natural resource management. Without a willingness to embrace uncertainty, adaptive management is unlikely to succeed (47).

In addition, adaptive management requires a much more open process of decision making, in which stakeholders are directly engaged and decision making authority is shared among them. It also requires that objectives, assumptions, and the other elements of the decision making process be explicit, and therefore amenable to analysis and debate. Finally, it requires a strong commitment by managers to the necessary monitoring and assessment that underlie adaptive management, not as marginal activities but as essential elements of the process. It is undoubtedly true that many, perhaps most, projects in DOI involve monitoring, and in some cases management actually considers the results of monitoring. But that by itself is a long way from structured, adaptive decision making in a learning-based environment.

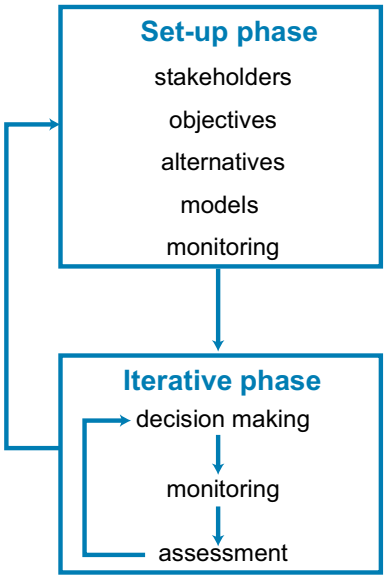


Figure 3.4. Two-phase learning in adaptive management. Technical learning involves an iterative sequence of decision making, monitoring, and assessment. Process and institutional learning involves periodic reconsideration of the adaptive management set-up elements.

3.2. Legal Considerations when Applying Adaptive Management

In addition to ecological and societal factors, a number of legal considerations influence adaptive management and potentially constrain its success. The Federal government is often criticized for the length of time it takes to plan and implement a particular action, and public concerns increase when an agency reconsiders its action and begins planning and compliance activities all over again. Well-designed and executed adaptive management strategies can help to alleviate this concern.

Agency officials should invest significant effort on legal issues at two critical stages of adaptive management: (1) at the time a decision is made to utilize adaptive management for a particular project and (2) at the time the agency seeks to adjust management decisions based on the information derived from monitoring and assessment. Knowing what federal laws and regulations require, and what limitations apply prior to agency decisions, allows stakeholders to anticipate the legal requirements and integrate them into the adaptive management process. However, agency officials should recognize that some laws and implementing regulations prescribe specific activities and assessments in ways that could limit or even preclude the use of adaptive management.

Application of adaptive management will vary depending on geographic setting, ecological complexity and participating stakeholders, as well as the specific statutory provisions authorizing and sometimes constraining actions. Some examples include:

- National Park Service Organic Act of 1916 (applicable to the National Park Service).

- Reclamation Act of 1902 (applicable to the Bureau of Reclamation).

- Surface Mining Control and Reclamation Act of 1977 (applicable to the Office of Surface Mining).

- Federal Land Policy Management Act of 1976 (applicable to the Bureau of Land Management).

As a general matter, statutes of this type impose obligations on a particular agency. In addition, a number of statutes apply to all Federal agencies and serve to either limit agency actions or require certain tasks before an agency takes action. Regulations issued by other Executive Branch agencies can also limit agency actions.

The use of adaptive management within the Department of the Interior does not alter the legal context that applies to Federal agency actions. Simply put, all of the applicable laws, regulations, and polices continue to apply to agency actions whether or not adaptive management principles are used in a particular context.

Statutory and other authorities that apply to Interior agencies

The first place to look for the authorized boundaries of agency activity is in the statutory foundation or appropriations authority that supports the activity. Although few useful generalizations can be made about statutory requirements, the importance of identifying underlying authorities cannot be overstated. Employees working on an adaptive management project should understand the authority under which they are entering into the project and be sure to embark on it only when there is clear statutory authorization.

The statutes discussed here are not intended to provide an exhaustive accounting of applicable law. However, they are some key authorities that agency personnel should consider regarding adaptive management. Many other statutes such as the Clean Air Act, the Clean Water Act, and the National Historic Preservation Act may be involved in particular applications of adaptive management.

One of the benefits of clean water in the Cold River, a salmon stream in Massachusetts

Native American wickiup structures were listed in 2003, on Colorado's Most Endangered Places List by Colorado Preservation, Inc. The Wickiup Project is supported by the Bureau of Land Management, Dominquez Archaeological Research Group and the Colorado State Historic fund.

In the examples below, Departmental employees are assumed to be actively working with non-Federal stakeholders on an adaptive management project. Most projects of adaptive management involve such interactions at some level of the application.

Statutory authorities that apply directly to adaptive management

National Environmental Policy Act. One of the most important statutes for an agency to consider as it implements adaptive management is the National Environmental Policy Act (NEPA). The primary goal of this statute is to ensure that agency decision makers and the public recognize and account for environmental and other related impacts of proposed agency actions.

Compliance with NEPA generally requires a series of procedural steps, and certain NEPA processes involve public participation and public review and comment. In complex or controversial situations, NEPA potentially involves the preparation of a Notice of Intent to prepare an Environmental Impact Statement (EIS), as well as a Draft EIS, a Final EIS, and a Record of Decision assessing environmental impacts of major Federal actions. In less complex or controversial actions, environmental compliance often can be accomplished with a simpler Environmental Assessment (EA) that culminates in a Finding of No Significant Impact. In some cases, an action can be categorically excluded from the requirement for NEPA compliance.

The NEPA requires an EIS of proposed "major Federal actions significantly affecting the quality of the human environment." An EIS must include an analysis of alternatives to a proposed action. The activities resulting from a particular adaptive management process may rise to the level of a major Federal action requiring an EIS, and in any event they likely will need to be analyzed for NEPA compliance. Less complex or controversional actions may be addressed by a less comprehensive EA. Under NEPA, following the completion of an EA the agency will either identify significant impacts (and prepare an EIS), or prepare a Finding of No Significant Impact. Of course, some actions can be categorically excluded from NEPA's documentation requirement.

As an example, a proposal resulting from collaboration between a DOI agency and an environmental nonprofit organization might call for the nonprofit to conduct habitat improvement for a protected species. It is possible that this undertaking could be considered a major Federal action. In such a circumstance, the collaborative activities resulting in a Federal action covered by NEPA must comply with NEPA's documentation and procedural requirements. Given that many Federal actions may be challenged in Federal court, non-Federal stakeholders should be made aware of the possibility of litigation inherent in Federal actions.

An EIS incorporating adaptive management, whether as a "stand-alone" alternative or part of another alternative, needs to clearly describe how the approach would be implemented. This not only includes what types of actions are proposed initially, but also the results that are expected from monitoring and assessment, and future actions that may be implemented based on those results. Decision makers and the public must be able to see how the adaptive management approach would be implemented, including potential future actions and anticipated impacts on the environment.

One common challenge to making adaptive management work in natural resource decision making is that ongoing monitoring may reveal "new, significant information" that requires an agency to prepare a Supplemental Environmental Impact Statement. This requirement is triggered when "[t]he agency makes changes in the proposed action that are relevant to environmental concerns; or [t]here are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts" (40 CFR § 1502.9 (c)). If management adaptations that could occur in light of new information are fully documented and analyzed at the beginning of a NEPA process, the need to supplement NEPA documents may be reduced. Put differently, if an EIS anticipates significant information that can arise from monitoring and assessment, the agency may not need to supplement the EIS when invoking management changes based on the newly acquired information.

An important statute for an agency to consider as it implements adaptive management is the National Environmental Policy Act . The primary goal of this statute is to ensure that agency decision makers and the public recognize and account for environmental and other related impacts of proposed agency actions.

Endangered Species Act. The Endangered Species Act of 1973 (ESA) provides a broad, comprehensive approach to the conservation of threatened and endangered species. By Congressional direction, the ESA is administered by the U.S. Fish and Wildlife Service (FWS) and the NOAA-Fisheries (National Marine Fisheries Service). In general, the FWS deals with terrestrial and fresh water species, while NOAA-Fisheries deals with anadromous fish and marine species. As part of their administration of the ESA, these agencies:

- "List" endangered and threatened species
- Designate critical habitat for listed species
- Publish plans to identify actions needed to assist in the recovery of listed species
- Consult with other federal agencies whose actions may affect listed species
- Work with non-federal entities to develop and approve habitat conservation plans
- Work cooperatively with other nations to conserve listed species
- Administer international agreements to limit trade in endangered and listed species

Of particular relevance to Federal agencies engaged in activities that may affect listed species is Section 7 of the ESA. Section 7 enlists agencies of the Federal government to support species conservation and avoid actions that would contribute to species extinction.

Given the importance of conserving endangered and listed species, the complexity associated with protecting these imperiled species, and the impacts the ESA may have on society and agency decision making, any adaptive management program that may affect listed species or critical habitat is more likely to be successful if it involves FWS and/or NOAA early in the process. Key to efficient and effective consultation is an initial description of the range of potential adaptations and effects of those actions on listed species and their designated critical habitats. Re-initiation of consultation is far less likely to be needed if the initial consultation clearly considers the action to be adaptive and addresses the full range of possible adaptations and their associated potential effects.

In some cases involving large-scale Federal programs, consultation is appropriate at both a broad programmatic level as well as the level of individual projects or actions that may affect listed species. Careful consideration of effects and alternatives can set the stage (for example, through adoption of best management practices or design standards) for expedited consultation on later individual actions.

Agencies whose actions may affect listed species should design monitoring programs with input from FWS and/or NOAA-Fisheries. Learning by doing - the critical centerpiece of adaptive management - is particularly important in ESA situations, where cause and effect can be particularly difficult to ascertain. New information on listed species, or the effects of actions on listed species, may require re-initiation of Section 7 consultation by a Federal agency, or may trigger changes in habitat protection pursuant to approved Habitat Conservation Plans (HCP). Knowing and understanding the ESA and its requirements will be essential to successfully integrating the elements of an adaptive management program with efficient ESA procedural compliance.

Integration of adaptive management principles has been utilized by the FWS in the context of HCPs under Section 10 of the ESA. The FWS has developed guidelines regarding this aspect of HCP planning (included in the reference CD). Particular attention should be given to the issue of which party is to be responsible for any required changes in mitigation and/or minimization of "take" to listed species as a result of monitoring programs. Any effort in this regard must take into consideration the No Surprises assurances that a permittee can receive pursuant to the regulations that implement Section 10(a)(1)(B).

The Endangered Species Act's purposes include providing a means to conserve the ecosystems upon which endangered and threatened species depend, and providing a program for the conservation of the species

Federal Advisory Committee Act ("FACA"). Under FACA, Department officials may not receive advice from a group that the Department has established or that it uses (i.e., manages or controls) unless the Department complies with the provisions of FACA. The FACA requires certain actions to set up and operate a committee or similar group to provide advice to Federal officials. FACA does not require any particular outcome regarding the substance of advice on a particular matter. Rather, it establishes a number of actions and approaches to ensure balanced consideration and input. These actions include filing a charter, providing public notice of meetings in the Federal Register, and making advisory committee information publicly available.

Federal officials who receive advice from non-federal stakeholders should be aware of FACA's potential applicability. However, FACA does not apply to every situation in which a Departmental official receives advice, but only to those situations in which the advice comes from a group that the Department has established or utilized. This means that FACA does not apply to advice received from individuals, even in a group setting (such as "town hall" meetings). Nor does it apply to advice received from preexisting groups, or groups that the Government neither manages nor controls. It does not apply to groups that simply exchange facts or information; or groups that are authorized to carry out operational functions; or groups consisting of only Federal, state, local, and tribal government employees exchanging views, information, or advice on programs with shared intergovernmental responsibilities. Finally, under some circumstances groups may be exempted from the requirements of FACA by another statute (such as the ESA for Recovery Implementation Teams). For more information on FACA, employees should consult FACA regulations in 41 C.F.R. Part 102-3.

Funding authorities

Annual Appropriations Acts and Funding. Agency activities cannot be undertaken without available funds that are allocated for a particular purpose. Occasionally, Congress may insert specific limitations in annual appropriations acts that could affect agency activities. For example, Congress may enact a provision stating that no Federal funds may be spent to map natural gas deposits off the coast of California or to study decommissioning of the Glen Canyon Dam. In these situations, any Departmental effort to map deposits or undertake such a study would be impermissible, even if a non-Federal stakeholder thought the activities would assist a particular adaptive management process or a non-Federal partner donated the necessary resources and/or data for the efforts.

Antideficiency Act. The Antideficiency Act contains a series of controls over the use of Federal appropriated funds to ensure that Federal agencies "pay as they go." Government officials are prohibited (without specific authority) from making payments, or committing the United States to make payments at some future time, unless there are available agency funds to cover the cost in full. The Antideficiency Act applies to applications of adaptive management just as it does to all other Federal activities. In essence, no agreement should be entered into that commits an agency to the payment of funds in the future, in advance of available appropriations to fund activities under the agreement. For example, an agreement by an agency that commits $100,000 in grant funds to a particular organization for each of the next 5 years will likely be improper under the Antideficiency Act, unless there are sufficient agency funds that are available for the grant for more than one year.

Other relevant statutes and authorities

Administrative Procedure Act (APA). The APA provides a procedure by which Federal agency actions may be challenged in court. Although there are several ways to challenge an agency action under APA, the most commonly employed is the claim that an agency action is "arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with law." This standard applies equally to adaptive management projects as to other activities, so agency decisions in a particular adaptive management application may ultimately be reviewed by a court. To survive a court challenge, agency decisions must therefore be rational, reasonable, and carefully articulated.

APA challenges are usually decided on the basis of the administrative record (the materials upon which the agency officials relied in taking action). Challenges to activities in adaptive management applications are no different. Departmental employees must therefore ensure that their decisions and actions are based on, and supported by, a complete and thoroughly documented administrative record. Finally, the APA may also provide the basis for challenges under NEPA, the ESA, and other statutes.

Substantive Statutory Authority. Often a statute that authorizes an activity will also contain specific limitations. For example, a statute that authorizes the Secretary to establish a wildlife refuge in cooperation with a State may also require the Secretary to ensure that State laws apply on the refuge. Conversely, Congress may enact statutes that forbid a particular activity. For example, Congress has forbidden Federal agencies from creating business corporations.

Lobbying Activities. Under 18 U.S.C. § 1913 and related authorities, most Department employees may not expend appropriated funds for "grass roots" lobbying that is designed to influence a member of Congress or official of any government (Federal, State, local, tribal) regarding his or her position on legislation. That is, Federal employees may not engage in lobbying. This restriction prohibits encouraging a stakeholder to undertake lobbying activities in support of the Department.

Freedom of Information Act. The Freedom of Information Act (FOIA), codified in 5 U.S.C. § 552, provides members of the general public potential access to any information created or obtained by the Department and under the Department's control at the time of a FOIA request. Department personnel should keep in mind that documents generated during adaptive management activities will generally be agency records that are subject to release under the FOIA. However, the Department may withhold documents from the public that fall within one of nine specified FOIA exemptions. Agency personnel will want to consider how they intend to gather, store and publish information developed as part of the adaptive management process, and work with their agency's FOIA offices when responding to requests for information.

Data Quality Act. Although relatively new, the Data Quality Act (DQA) is increasingly affecting the work of Interior agencies. Passed in 2001 as part of the Treasury and General Government Appropriations Act, the DQA directs the Office of Management and Budget to publish guidelines applicable to Federal agencies, and provide policy and procedural guidance to Federal agencies for ensuring and maximizing the quality, objectivity, utility, and integrity of information (including statistical information) disseminated by Federal agencies. Each agency should assess the applicability of the DQA to new or ongoing adaptive management projects.

Governmental Integrity. Because agency decisions, whether products of adaptive management or not, will only stand up if they comport with the law and are not "arbitrary and capricious," agency officials must constantly work to ensure that the agency's decisions are supportable based on the information that is available to the agency. In carrying out agency activities, Departmental employees should always act in an unbiased, fair, and equitable manner, so as to ensure that the public will not have cause to question the integrity of the Federal government. All Federal employees should endeavor to act impartially and to avoid giving preferential treatment, or the appearance of preferential treatment, to any private entity.

Making Adaptive Management Work: The Importance of Integrating Adaptive Management and NEPA

NEPA serves as a pre-decisional requirement and analytical process with the goal of ensuring that both the public and Federal decision makers are fully aware of the potential impacts of a discretionary Federal action. Expanding the NEPA framework to accommodate the iterative, data-driven process of adaptive management requires the integration of learning-based strategies into the existing framework of NEPA requirements and the implementing regulations. Of course, compliance with other environmental statutes, regulations, and Executive Orders is also necessary.

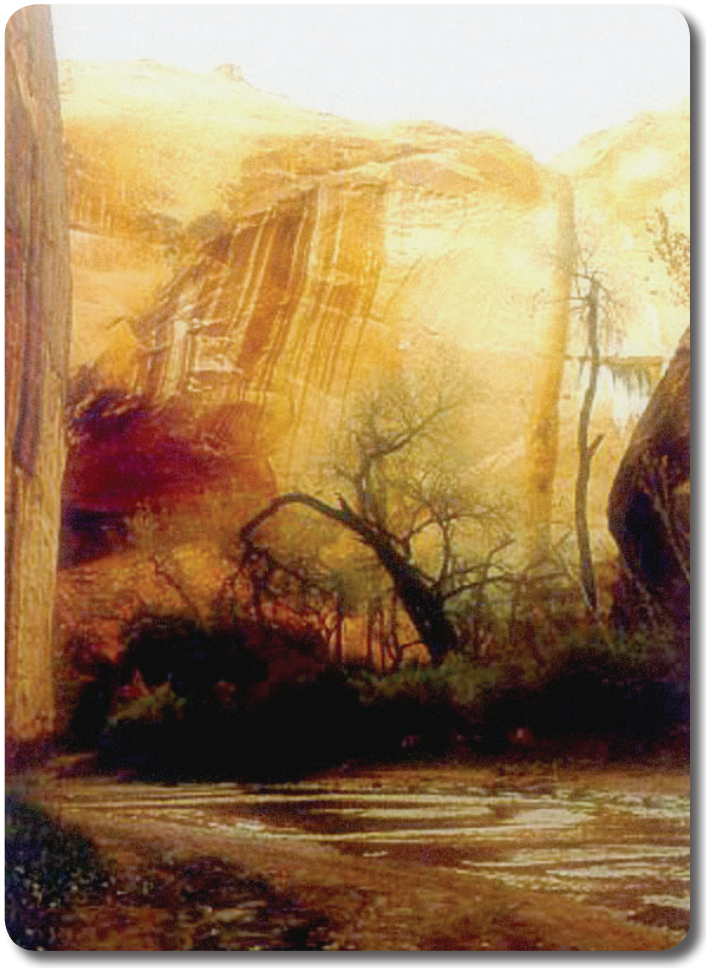
Federal agencies are encouraged to use adaptive management as part of the NEPA planning process, particularly in circumstances where long-term impacts are uncertain and informed decisions in the future will depend on monitoring and assessment at that time. Any adaptive management alternatives in an Environmental Impact Statement can be crafted to allow the necessary flexibility for strategy adjustment as learning advances through monitoring and assessment. Agencies are encouraged to build this flexibility into their management alternatives and NEPA compliance activities. Training of NEPA practitioners in this important environmental concept is paramount.

Because NEPA analysis and compliance is procedural and predictive, and includes the evaluation of "all reasonable alternatives," it is important to include a sufficiently broad range of management options to ensure a comprehensive environmental analysis and a "NEPA coverage" that is adequate for whatever contingencies are anticipated. The idea is to satisfy the NEPA requirements for scientific analysis of potential impacts, and provide full disclosure of those impacts. Thoughtful and carefully structured alternatives should avoid the triggering of additional NEPA compliance later.

Alternatively, another approach to NEPA compliance that has proven successful for adaptive management programs is to prepare a "programmatic" EIS at the start, which broadly covers the likely range of actions that may be taken under the particular adaptive management program. Later, any NEPA compliance needed for subsequent shifts in the management actions as a result of the adaptive management process can then "tier" off of the initial programmatic EIS, saving considerable time and work.

Where appropriate, greater use of Environmental Assessments could help to integrate NEPA and adaptive management, especially if environmental analyses will be needed subsequent to an initial EIS and impacts are not expected to be significant. An Environmental Assessment is generally much easier to prepare than an EIS.

If an agency is constantly undergoing NEPA compliance and documentation, it may be because the original NEPA process failed to fully consider a broad range of potential adaptive management modifications. Frequent follow-up NEPA compliance can erode the public's perception of the integrity of the process, and impede the ability to react to new, relevant information. NEPA is first and foremost a public process, and its credibility and successful implementation is predicated on the public's perception that it is transparent and involves full disclosure of the potential environmental effects of Federal actions.



Coyote Gulch

3.2 Key Points

- Adaptive management must be integrated with all existing legal obligations of the agency; it is not a replacement for environmental compliance.

- Adaptive management must comply with NEPA and other environmental laws. Integration of adaptive management and other legal obligations requires thoughtful "up-front" planning, and involves an investment of time and resources by the agency and other stakeholders.

- Integrating environmental review procedures with adaptive management requires consideration of the range of adaptive actions and attendant environmental effects that can reasonably be anticipated at the time of the environmental review.

- The management alternatives and effects considered in an adaptive management application must be reviewed in light of the relevant environmental laws and regulations, so that environmental compliance applies not only for the initial action, but also for adaptive redirections that may be needed in the future.

- For some adaptive management applications, it may be appropriate to assess environmental effects of future adaptive actions on a case-by-case basis using streamlined environmental assessments or informal consultations. Such an approach may serve to strengthen the case for compliance when uncertainty exists regarding the environmental effects of future adaptive actions.

- Key to successful integration of NEPA and adaptive management is a well planned and thorough up-front consideration of the range of potential actions and their effects, so as to ensure that future actions and their effects are within the scope of the initial analysis and do not require subsequent environmental analysis.