EVALUATION OF CRITERIA GUIDING TRANSITION OF SCIENCE AND MANAGEMENT ACTIONS IN ADAPTIVE MANAGEMENT PROGRAMS

BY
GCDAMP SCIENCE ADVISORS

JUNE, 2010

TABLE OF CONTENTS

EXECUTIVE SUMMARY

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THE ISSUE

The Glen Canyon Dam Adaptive Management Program (GCDAMP) continues to define implementation of adaptive management (AM) in terms of blending research, monitoring, management actions, etc. in policy experiments directed at managing complex resource issues of the middle Colorado River. In developing the FY 2010-11 work plans and budgets, GCDAMP members desired greater clarification of how adaptive management programs integrate experiments and policy and how they distinguish and transition between science and management responsibilities and funding.

A GCDAMP project that gave impetus to the need for greater clarification in the above areas is the mechanical non-native fish removal program along the river mainstem. The non-native fish removal program was established as a policy experiment to determine if non-native fish and specifically rainbow trout could be effectively removed from the ecosystem. Based on the hypothesis that rainbow trout created negative impacts to the Humpback Chub population, effective removal procedures were developed and included in a 2008 Biological Opinion issued by the US Fish and Wildlife Service as a necessary conservation measure to be implemented by the GCDAMP. Under current budgeting guidelines used by the GCDAMP science and management actions are considered as separable funding items. Hence, the administrative issue arose as to how coldwater species control (specifically non-native salmonids) should be managed and funded. That is, should this project be continued and funded as a policy experiment of the GCDAMP and managed by the Grand Canyon Monitoring and research center (GCMRC)? Or, should it be redefined as a management or compliance activity by one or more management agencies and overseen and funded by the agencies apart from the GCDAMP?

SCIENCE ADVISOR CHARGE AND PROCEDURE

In response to these questions, the Adaptive Management Work Group (AMWG) passed the following motion by consensus on August 13, 2009 reflecting their desire to have the GCDAMP Science Advisors (SAs) continue to develop information on this issue:

> "*The AMWG requests that the Science Advisors survey other adaptive management programs and develop a report which describes their definitions of criteria for defining science-based management actions and the transition from research to management. The report should be provided to the TWG and AMWG members, and TWG should review the report and forward to AMWG options for AMWG to consider with regard to how GCDAMP should handle these issues.*"

The Science Advisors responded to the AMWG's request by doing a review of literature as well as evaluations of how other AM programs manage transitions from science inquiry to management actions or similar practices on specific issues, projects or activities. Based on this information, criteria and guidelines were identified to assist scientists, managers and stakeholders to improve transitions of science and management actions in the GCDAMP process.

PERSPECTIVES FROM LITERATURE ON MANAGEMENT ACTIONS, POLICY AND SCIENCE IN AM

Two key ideas surfaced from the review of adaptive management literature and AM programs that relate to the issue of programmatic transitions between science and management activities. First, most often there are not clear distinctions made between science and management in AM programs. Second, the pursuit of social or institutional learning is but one linkage between research and management in an adaptive management program. Both ideas have implications for decisions about management and science authorities and responsibilities, as well as funding allocations.

Adaptive management is not designed as a science process with a primary goal to reduce uncertainty relating to proposed policy and management actions so they can be implemented. Nor is it simply a management model that determines best management actions to meet policy objectives. Rather, adaptive management is a blend of the two, one that generates opportunity for learning how to understand complex ecosystems, while achieving resource improvement goals. Conceptual models of adaptive management characterize the AM process as more a continuum of using science to evaluate outcomes of adjusted management policies/actions due to changing biological and social dynamics as well as surprises. Uncertainty and risk are embraced as significant continuous elements of the process. As such, the adaptive management paradigm addresses learning differently than the more traditional science model of extensive science applications to reduce uncertainty and risk before management action is taken.

Guidance from the AM literature would support several general clarifications regarding the AM paradigm and the relative role of science and management actions in these programs as follows.

- AM programs in natural resource conservation are management models established to resolve complex, multiple resource issues that harbor significant ongoing uncertainty.
- Active AM programs are most effective in implementing iterative management actions and monitoring response through time to create improved states of resource conditions and learning.
- Two types of learning are involved in the AM model. The first, "single loop", uses monitoring to evaluate the effectiveness of selected management actions as policy experiments, but assumes that the underlying AM hypotheses regarding attainment of resource goals is correct. The second, "double loop" learning allows for the development and replacement of hypotheses over time. That is changes in all processes of the AM model can occur.

The ever-present uncertainty in AM programs requires, as noted, a different purpose for management actions and ordering of the actions by managers. The AM model must rely also on a broader and also slightly different set of criteria for evaluating outcomes from differing management actions. These include probability analysis, uncertainty analysis, stochastic modeling, social consensus, resource tradeoff analysis, structured decision processes, etc.

In terms of the salmonid mechanical harvest program, this program is still viewed in terms of a hypothesis among multiple hypothesis that through learning are likely to help meet humpback chub recovery goals. As such, it is one of a variety of interactive management actions and monitoring activities needed, but one that should help managers continue to learn how to meet these goals.

The review revealed that AM structures and processes used by the GCDAMP and other AM programs do effect transitions between management and science. Many AM program attributes have some influence on these transitions.

OBSERVATIONS ON GCDAMP STRUCTURE AND PROCESSES AND IMPLICATIONS TO PROGRAMMATIC TRANSITIONS

The programmatic transitions among various stages of an AM program, i.e., consensus building, assessments, management actions, monitoring, evaluation, revised management actions, etc., represent a continuum of decision points for managers. Developed criteria associated with the following institutional structures and characteristics of the GCDAMP are helpful in understanding both impediments and supporting mechanisms to science and management transitions.

- Organization, Goals and leadership
- Program and budget planning
- Effective science monitoring
- Responding to external perturbations
- Assessments of Knowledge
- Independent Reviews

Organization, Goals and Leadership

The GCDAMP program has defined purpose, mission, strategies, goals, etc, that are supported by federal law, regulation, policy and funding mechanisms. It has an organizational structure similar to most AM programs. The ability to operate multiple major management activities concurrently while maintaining resources and learning is general evidence that transitioning of management actions to monitoring and back to management actions is realizing selected successes.

However, several reviews of the GCDAMP program over the past five years have identified needs of the program to reevaluate several of its adaptive management processes related to administrative structure, roles of the GCDAMP groups, desired future conditions, monitoring plans, Native American consultation, etc., as well as others areas. Reviews and revisions in some criteria and guidelines could improve transitions between management actions and science, such as the following.

- A review of overall mission and goals needs to occur, such as those relating to criteria guiding the GCDAMP role for overall resource management and recovery of T&E species
- The roles and responsibilities of the GCDAMP groups need to be reevaluated and possibly revised.
- Development of more specific goals and well defined desired future conditions needs accomplishment

Program Planning and Budgeting

In recent planning direction, i.e., 2004-2010, strategic and operational program and budget plans are in place and utilized. Evidence exists that the program, after 15 years of operation, could benefit from the "Double Loop" learning process.

Continued budget shortfalls in areas that were determined to be important management actions and monitoring reveals needed improvements in program planning criteria for determining the minimal information that is explicitly required, and more effective out year budget planning.

Effective Science Monitoring

The AM model uses monitoring of the resource impacts of management actions to validate both accomplishment of resource improvement and learning. In the second decade of the GCDAMP, 2007-2016 it is proposed that core monitoring programs will formally be implemented for each GCDAMP goal. Implementation proposals for this critical program require planning, programming and budgeting commitments by all AMP entities. Concern exists that criteria such as fully specified goals, information needs, and budgets need better planning. Focus is needed regarding the minimal information needs that best inform management actions and science and improve resources.

Responding to Perturbations

An attribute of many AM programs with high variability is that one can be surprised by perturbations that were not foreseen. The GCDAMP has witnessed several in its short tenure.

The issue of warm water releases from Glen Canyon Dam, one such perturbation, did result in some disruptions of management and science processes during the 2003-2006 period, but they were minimal. However, although GCMRC and TWG both identified needs for potential management and science changes and additions to the GCDAMP portfolio as a result of this perturbation, only minor changes appear to have occurred. For example, should improved or changed criteria and assessment guidelines related to predicted warming been a response to this perturbation?

Assessments of Knowledge

The GCDAMP program with GCMRC guidance has recommended criteria for significant reviews of knowledge at five-year intervals, i.e. Knowledge Assessment and Status of Colorado River Ecosystem (SCORE) reports. To maintain effective policy on transitions of management and science these assessments should also be developed to inform redesign of management actions and science programs. Budget planning does not seem effective in maintaining these AM attributes.

Independent Review

Internal and external review processes are critical criteria for evaluating an organizations effective use of management and science to address issues. Reviews have cited needs for many improvements including greater ecosystem focus of the GCDAMP, improved integration of science and management activities, appropriate role assignments of entities, desired future conditions etc.

How a collaborative AM program structures independent review and responds to it can significantly influence, through time, the effectiveness of management and science transitions. Some concern exists over lags in response to issues identified in several reviews.

OBSERVATIONS FROM REVIEWED AM PROGRAMS

Ten currently active CAM Programs were reviewed to evaluate criteria they use in sustaining effective transitions of management and science in the AM process, and how those criteria and approaches might benefit the GCDAMP.

The review confirmed the literature assessment that active CAM Programs have developed criteria and guidelines in AM processes to assist these transitions. Our review first looked at improvements needed in GCDAMP processes and then evaluated other AM programs for criteria that would assist the GCDAMP in making improvements.

The need for several improvements were identified in GCDAMP processes. The following were focused upon in reviewing other AM programs.

- Organization structure, goals, dfcs; etc.
- Program planning and budgeting
- Effective monitoring programs
- Responding to perturbations

Reviews of other AM programs reveal broad opportunities to transfer knowledge gained on management actions and science to assist the GCDAMP. These include fish management and monitoring approaches used in The Upper Colorado, San Juan and Platte River RIPs; First Nation consensus building and dispute resolution in the Lower Bridge River Program; AM processes for program planning and budgeting from the CAL-FED ERP and Kissimmee River RP; analytical tradeoff models and decision support systems from CAL-FED ERP, Lower Bridge River Program, Lincoln National Forest Restoration Program; etc.

CONCLUSIONS

Findings from this assessment were used to craft the following conclusions and recommendations.

- AM is not a science model. It departs from the traditional science model wherein science is implemented until uncertainty is primarily resolved and management actions can be implemented with limited risk.
- AM is a management model that was developed to confront the dynamics and continued uncertainties and risks encountered in large natural resource management issues such as riverine restoration, native species recovery, large forest area restoration, etc.
- AM processes engage broad based stakeholder concerns, use best knowledge to define policy experiments and needed management actions to improve resources and learn, monitor and evaluate outcomes of these actions, and modify actions through repeated cycles of management and monitoring to gain desired outcomes.
- Two general statements often ascribed to the AM model are very appropriate, “you learn by doing”, and “distinctions between management and science are blurred in the process to accomplish the primary goal, resource improvement”.
- Because the management model relies on best science and modeling to both learn and define and refine improved management actions through repeated cycles, it is critical that managers are attentive to maintaining robust AM processes that will maximize

effectiveness and efficiencies in continued transitions of management and science activities.

- Reviews of literature and operating AM programs reveal that several AM attributes and processes are critical to sustaining effective management/science processes through time. Reviews of the GCDAMP indicates that improvements may be needed in several of those AM processes including:
  - Organization, structure, goals, entity roles
  - Program planning and budgeting
  - Effective monitoring approaches
  - Responding to perturbations
- Reviews of other AM programs reveal broad opportunities to transfer knowledge gained on management actions and science to assist the GCDAMP.
- Although improvements are needed in GCDAMP processes to insure more effective transitions of management and science activities, the review also found this to be normal occurrence in many AM programs. It is described in AM literature as "Double Loop Learning" and is critical to effective AM programs.

RECOMMENDATIONS

The following recommendations are proposed related to management/science transitions in the GCDAMP.

- The GCDAMP HBC goal appears to approach a recovery implementation program. If the GCDAMP is incorporating RIP direction informally, it should be clarified in mission, goals and objectives.
- Goals should be made more specific and prioritized more as needed to assist program and budget planning on management actions and science.
- Desired future resource conditions should be developed for all resources to effect appropriate planning of management actions and science.
- Near term program and budget planning must have improved direction from stakeholders and managers as to priority needs. Definitions of minimal levels of resolution, types and amounts of information needed as well as accuracy requirements can be improved.
- Out year program and budget planning (5-10 years) needs to be improved to help identify additional management actions and science needs as well as forced reductions in programs from budget shortfalls.
- Monitoring programs under development must be explicitly designed to detect change in key indicators of resources of concern. A focus on design parameters that identify minimal information needs to define resource changes is important.
- Abilities to identify, in advance, potential perturbations to the system assists management and science transitions. Improvements in program planning and budgeting, simulation models, tradeoff models and decision support systems would benefit these identifications.

EVALUATION OF CRITERIA GUIDING TRANSITION OF SCIENCE TO MANAGEMENT ACTIONS IN ADAPTIVE MANAGEMENT PROGRAMS

BY
GCDAMP SCIENCE ADVISORS

June, 2010

PURPOSE

The purpose of this report is to provide information to Glen Canyon Dam Adaptive Management Program members regarding criteria used in AM programs for transitioning between science and management actions. To provide this information we have evaluated both science literature on adaptive management and active programs pursuing adaptive management.

INTRODUCTION

The Glen Canyon Dam Adaptive Management Program (GCDAMP) was established to implement requirements of the 1992 Grand Canyon Protection Act and Glen Canyon Dam EIS as follows: "Operate Glen Canyon Dam and exercise other authorities in such a manner as to protect, mitigate adverse impacts to and improve values for which Grand Canyon National Park and Glen Canyon National Recreation Area were established, including but not limited to natural and cultural resources and visitor use, and subject to water allocation and development provisions of existing statutes and laws,". The Glen Canyon Dam EIS requires the Secretary to "Initiate a process of adaptive management whereby the effects of dam operations on downstream resources would be assessed and the results of those resource assessments would form the basis for future modifications of dam operations. The concept of adaptive management is based on the recognized need for operational flexibility to respond to monitoring and research findings," (GCDEIS 1995).

In developing the FY 2010-11 work plans and budgets for the GCDAMP, it became clear to members that the GCDAMP needed to reevaluate and better define the management, science, policy and budget implications of how it was addressing research, monitoring, management actions, policy experiments, etc. in the program. Many GCDAMP members wanted greater clarification of how adaptive management literature and ongoing programs address activities of known and unknown outcomes in proposed tests of experimental policy. Issues of science sufficiency, management responsibilities, and appropriate assignment of funding as well as other factors required further clarification.

As an example, a program which illustrates the need for greater clarification is the mechanical non-native fish removal project along the Colorado River mainstem. The non-native fish removal program was established as a policy experiment to determine if non-native fish and specifically rainbow trout could be effectively removed from the ecosystem to reduce predation on Humpback Chub (HBC). Effective procedures were developed and the removal program was included in a US Fish and Wildlife Service 2008 Biological Opinion as a necessary conservation measure to be implemented by the GCDAMP (USF&WS 2008).

The science entity of the GCDAMP, the Grand Canyon Monitoring and Research Center (GCMRC) has concluded that it has successfully completed the policy experiment for the management action, i.e. developing protocols and procedures for achieving desired levels of rainbow trout (RBT) control. However, the proposed Long Term Experimental Program (LTEP) direction of the GCDAMP could modify the policy experiment to also determine whether continuation of control of RBT has positive or negative effects on HBC. Uncertainty still exists as to impacts of the RBT control methods on long term HBC populations.

Under budgeting guidelines in the GCDAMP which separate science and management from a funding perspective, if coldwater species control (nonnative salmonids) is continued, should it be continued and funded as a management action, science program, compliance activity or some combination, and what are the associated funding and program administrative changes needed, if any.

The GCDAMP web site www.usbr.gov/uc/rm/amp/amwg includes the following statements related to management actions.

- The scientific information obtained under the Adaptive Management Program is used as the basis for recommendations for dam operations.
- Through the Adaptive Management approach, scientific experimentation is integrated into resource management actions. Over time, as more is learned about the complexities of the downstream ecosystem, the goal of enhancing and improving downstream resources and dam operations can be realized.

Fundamental questions have surfaced from the above and other areas in the GCDAMP where activities could be defined as a science activity, management action, or both. Questions that have been raised by GCDAMP members include the following.

- What does it mean in the context of adaptive management policy experiments to move from scientific experimental research to management action or conservation measures with known outcomes?
- Do implemented management actions simply fall on a continuum of science relating to how much research or monitoring is involved or needed in their implementation?
- What are the important considerations in evaluating criteria for moving from science to management actions or are these distinctions necessary in adaptive management programs?
- Who takes responsibility for funding and implementation of "gray areas" in implementation of necessary management actions and science in an adaptive management program.

SCIENCE ADVISOR CHARGE AND PROCEDURE

The following motion was passed by the Adaptive Management Work Group (AMWG) by consensus on August 13, 2009 reflecting their desire to continue to develop information on this issue:

> "*The AMWG requests that the Science Advisors survey other adaptive management programs and develop a report which describes their definitions of criteria for defining science-based management actions and the transition from research to management. The report should be provided to the TWG and AMWG members, and TWG should review the report and forward to AMWG options for AMWG to consider with regard to how GCDAMP should handle these issues.*"

The Science Advisors developed approach for responding to the AMWG's request is confined generally to the following objective: ***The SAs will develop a review of literature and brief survey of selected federal and state adaptive management and related programs and gather information on how AM programs transition between science and management***

activities. Based on information obtained the SAs will identify criteria or guidelines that might assist GCDAMP scientists, managers and stakeholders to improve transitions between management and science.

The Science Advisors protocol and operating procedures do not include assessments of policy or legal interpretations of USDOI and GCDAMP decision processes. The request by the AMWG asks for a brief survey of information from the literature and other programs that utilize adaptive management or similar processes and have implemented management actions or similar practices. This request is an activity that conforms to SA protocols.

The project is not intended to create an explicit definition for either "a science activity" or a "management action". Nor is it intended to determine when GCDAMP programs should be transitioned from management actions to science or science to management actions or similar activities. These are policy decisions of the Secretary of Interior. However, the project and this report does provide information to the Secretary, AMWG, GCDAMP managers, scientists and stakeholders from scientific literature and programs applying active adaptive management processes to assist in some of these determinations.

The general approach taken for information development was a review of literature followed by case study methodology. Ten adaptive management program cases were selected that had similar characteristics to the GCDAMP as follows:

- Federal and/or state directed programs
- Utilize adaptive management or similar processes
- Long term programs with legal, policy, or regulatory authorities to resolve landscape level issues involving natural resource and social resource conflicts that include high uncertainty
- Implementing management actions to assure appropriate protection and or management of natural and social resources is significant program thrust
- Science learning to reduce uncertainty of related impacts from management activities is significant program thrust
- Sufficient science exists in some management activities to reduce science investments in selected areas.

EVALUATING ADAPTIVE MANAGEMENT LITERATURE FOR GUIDANCE

Generally, the adaptive management literature reviewed is directed at evaluating effective approaches to adaptive management, including the Department of the Interior's 2007 technical guide for adaptive management (Williams et al, 2007). Focus on reviewed literature was given to observations on AM made in the 1980s, 1990s, and new millennium. The period marks decoded milestones for scientific reviews of programs initiated in the 1980s and 1990s.

The key question in this assessment relates to whether criteria and guidelines for transitioning from management to science and science to management are being used in adaptive management programs and if so, how are they being used.

Adaptive management programs differ from traditional science models where science has been more of an exogenous information input to both decision and management processes. In the traditional science model university and government agency scientists in the 1950s-1970s conducted much of their research apart from the management process. Because scientists were not intimately engaged in either management decision processes or management activities, their science was often improperly specified with limited applicability to management needs. The label “Ivory Tower” science has been used by managers to highlight their frustration of not being able to apply research results.

In spite of the incongruence in science and management processes in the 1950s-1970s both scientists and managers struggled to improve the process. Scientists had fears of being tainted by closer associations with managers. Managers feared that decision processes could be diluted by extraneous information from scientists. Academic programs began to engage managers to “better frame” the science inquiry, and managers, both public and private, realized the importance of reduced uncertainty in good decision making and invested more in science.

Frustration of both scientists and managers in natural resources heightened in the 1960s and 1970s when national and global resource assessments clearly revealed large scale natural resource degradation and the need for improved ecosystem management and science at the landscape level (Ehrlick and Birch 1967, Borman and Likens 1967; Carson 1962; Odum et al 1960; Van Dyne 1966). The US public, manifested in growth of environmental groups and passage of environmental protection laws demanded more effective science/management programs.

The 1970s-1990s included significant changes in the science/management model. Primary paradigm shifts involved more holistic systems approaches in both science and management with concepts such as ecosystem science and operations research not only realizing effective definition but also implementation. Academic and management foundations were provided for these new approaches through advances in systems ecology, decision theory, risk assessment, uncertainty analysis, game theory, conservation ecology, management science, systems modeling, etc. (Bellman 1957, 1961; Clark 1976; Ermoliev and Gaivaronski 1984; Glantz and Thompson 1981; Krutilla and Fisher 1975).

By the 1980s scientists and managers were advancing in these new fields but struggling to address large ecosystem problems with extensive biophysical and socio-economic dynamics and great uncertainty. Traditional disaggregation of science and management processes could not provide effective discovery and resource improvement. However, a proposed process of ongoing management policy assessments by teams of managers and scientists offered promise (Holling 1978).

All of the above factors and others were important in creating the basis for the concept of adaptive management, and they are fundamental to the practice of this management science concept today. The Adaptive Management (AM) paradigm is a management model supported by science, and it differs significantly from the traditional science approach. It is in this context that we seek clarification of criteria and guidelines.

Holling (1978) and Walters (1986) and several teams of scientists from the University of British Columbia are credited with forging this new management approach. Their development of Adaptive Environmental Assessment and Management (AEAM) programs created the basis for the approach (Gunderson et al 1995).

The issue for which clarification is sought applies to both passive and active adaptive management. In a passive approach, predictive models are used to identify key monitoring variables needed to evaluate system dynamics. The monitoring information is used to track outcomes that result from external environmental variation. It is passive because managers don’t purposely perturb the system for response, but rather rely on natural variation in key drivers to result in system responses.

In active adaptive management, management strategies and management actions are adapted as policy experiments to test and sort among alternative hypotheses. Programs are defined passive or active depending on the degree of imposed change in the management direction. The GCDAMP program has used both approaches in recent history but generally active approaches are being pursued. Flow release experiments and non-native fish control both fall in the category of active adaptive management policy experimentation.

Adaptive management was developed as an approach to environmental management that recognized ecosystems as complex, dynamic systems of high variability (Holling 1978, Walters 1986). As such, adaptive management is built on assumptions that these complex systems are characterized by large uncertainties that persist through management/science processes and are full of surprises. System behaviors exceed the bounds of rational expectations.

Adaptive management is an ongoing process that combines assessment with management actions in order to learn about the complexities of system dynamics as well as to achieve intended social objectives (Holling 1978, Walters 1986, Lee 1992). Assessing a system requires synthesizing available data to generate a set of competing alternative explanations about particular sets of resource problems and social objectives. Management actions are designed by considering what actions are robust to uncertainties among alternative explanations and what actions will help test and winnow those uncertainties (Walters 1986). Management actions are evaluated by monitoring system indicators in a process that uses that information to promote learning. While these activities are described linearly, adaptive management is typically an iterative process that develops an ongoing dialogue through time about the functioning of the system and the goals of management.

While the AM approach has been around for almost forty years, it has proven to be "technically capable and socially challenged" (Johnson 1999). The technically capable part of adaptive management processes involves the ability to develop integrative models that help scientists and managers to 1) decide upon an agreed set of hypotheses to test, and 2) to design experiments to evaluate both the understanding of system dynamics and the effects of subsequent interventions and policy tests (Walters 1986, 1997). In the GCDAMP the development of hypotheses (or explanations) and subsequent implementation and evaluation of policies derivative of those explanations has been accomplished in several areas. An example is the salmonid control program.

The socially challenged part of Johnson's (1999) statement refers to the non-scientific parts of AM, in which complicated social and political uncertainties arise. Taking the GCDAMP non-native fish control example, although a control method for salmonids has been developed, its longer-term implementation could have many implications which have considerable uncertainty. That is, will it improve HBC and other native fish resources or create greater predation from other more efficient and effective predators? And, are its social conflicts with cultural values, sports fishing, etc. resolvable?

Two key ideas come out of the literature review on adaptive management and how they relate to the issue of programmatic transitions back and forth from management to science to management. One is the operational aspect of adaptive management as it is being implemented. In other words, what do the processes or methods of adaptive management, as laid out by various authors, suggest about transitions between science, monitoring and management as they apply to the GCDAMP? The second idea involves social or institutional learning. This rephrases the questions of programmatic transition to one of, can the AM processes and methods being applied be improved and also improve resources and learning? Each of these ideas is discussed in the following sections. First we address the operational aspects of adaptive management, i.e. actual implementation of AM and how it relates to the question of transition. Second we examine the role of long term learning in adaptive management and how it relates to administration of AM in the GCDAMP and necessary transitions of management and science.

ROLES OF MANAGEMENT AND SCIENCE IN IMPLEMENTING ADAPTIVE MANAGEMENT

Several conceptual models have been developed that attempt to characterize the implementation of adaptive management. The earliest of these was presented by Holling (1981) and is shown in Figure 1. This model presents a more complex flow chart of resource problem assessment, primarily the left hand side of the figure, and management actions. The assessment phase of adaptive management uses models, simulation, deduction etc. to help winnow among sets of hypotheses about resource issues. That information is used to develop a range of policy options that are tested and evaluated prior to policy formation and implementation.

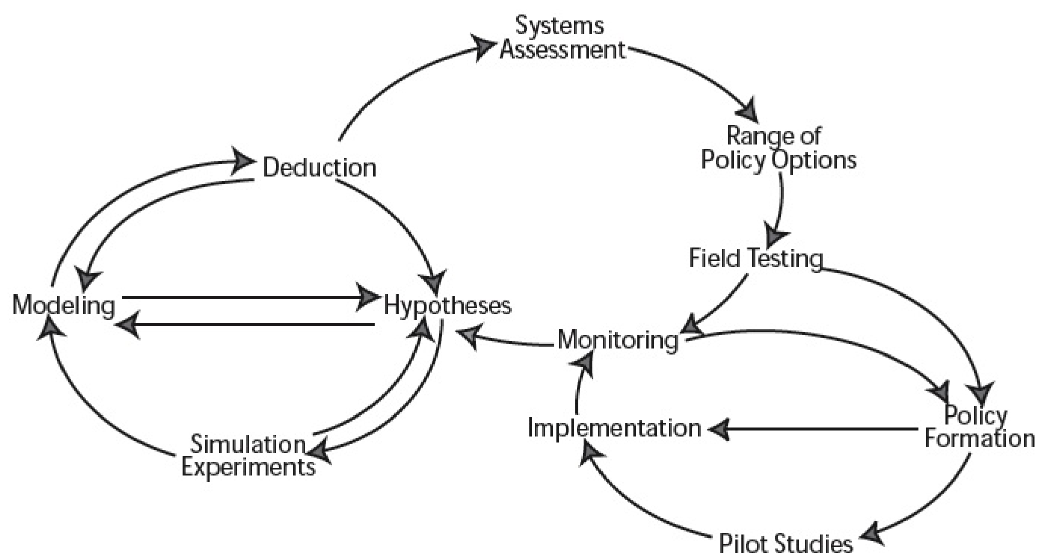

Figure 1. Conceptual model of adaptive environmental assessment and management, indicating the integration of processes that assess, propose, test and evaluate hypotheses of ecosystem dynamics and policy implementation (Holling 1981),

The second model we present was developed by Williams et al (2007) and is shown in Figure 2. In this figure as in the Holling (1981) approach, problem assessment is the beginning of the adaptive management process, followed by design and implementation of particular policy options. The DOI model is more linear, and proposes a cyclical, iterative approach.

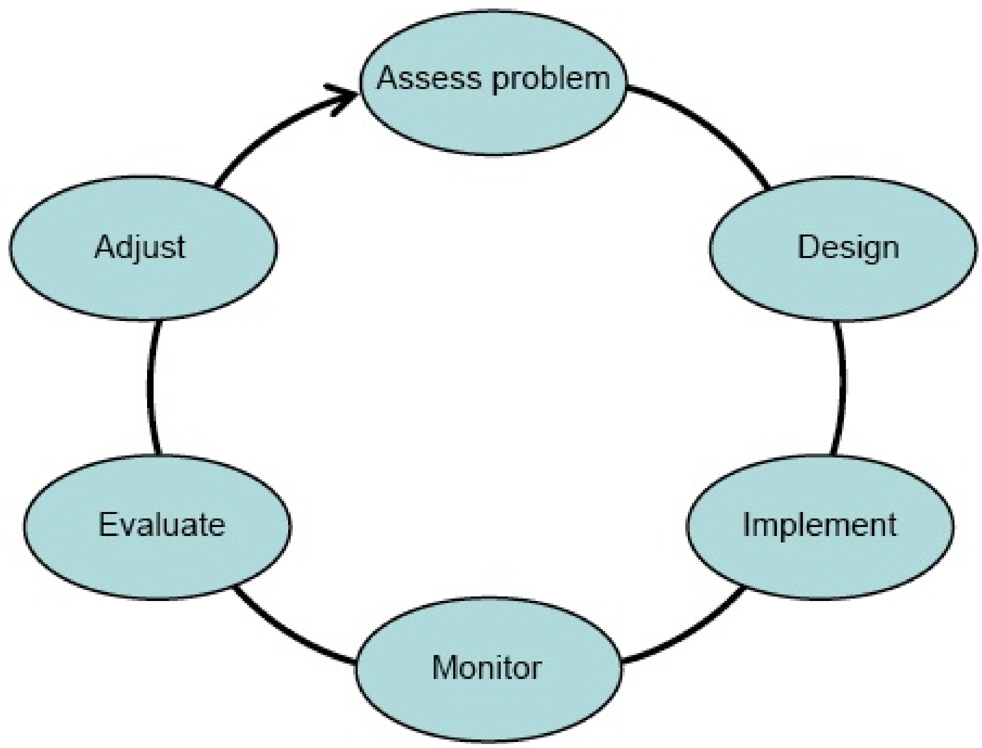

Figure 2. US. Dept. of Interior diagram of steps in the adaptive management process (Williams et al. 2007).

Both diagrams emphasize the circular, integrated and iterative nature of adaptive management. The Holling diagram focuses on the key role of alternative scientific hypotheses in developing and testing policies prior to selection for implementation. The DOI process sees separation of model assessments of a policy to its implementation as a management action as a design feature. Both diagrams depict distinct steps in the process, i.e. that the framework involves shifting the focus of activities from one of assessment to implementation and then evaluation.

Interestingly, there is no distinct separate step in either model for the extensive traditional science inquiry process prior to implementation of an action. That is, neither of the conceptual models depicts science as a process that is distinct (as an identifiable item or bubble) and unto itself. Elements of scientific processes are ever present, i.e. hypothesis formulation, simulation experiments, monitoring, modeling, etc. However, they are cast into the process of adaptive management policy experimentation. This is why many authors state that adaptive management blurs the distinction between science and management (Holling 1978; Walters 1986; Lee 1993; Gunderson and Prichard 2002; Williams et al. 2007). This relates to the principle in an adaptive management framework that there is not clear separation of science and management activities, indeed they are both part of a more holistic model of management.

Both diagrams emphasize the role of monitoring as a critical step in adaptive management. In the adaptive assessment phase of the process, one of the key outcomes is identification of critical ecosystem variables to monitor. Walters (1997) states that monitoring should evaluate the outcomes of management interventions, and as such is a critical part of adaptive management. While monitoring is done for many reasons, it is in the context of adaptive management that monitoring helps to build understanding and provides the basis for learning.

The second idea relating to our issue of management actions and science in AM relates to social learning. The completion of iterative cycles as depicted in Figure 1 and Figure 2 is often referred to as social learning in AM (Williams et al. 2007). Incremental or single loop learning occurs as management action plans, models and policies are implemented and evaluated. The second type of learning is described as double-loop, where the underlying AM model or schema is questioned and rejected or revised to improve AM processes.

With respect to programmatic transitions i.e. moving from more management based activities to science based activities, the role of learning becomes a key consideration. The GCDAMP program has demonstrated the capacity to learn, from iterative passive and active management approaches. The series of flow release management actions made over the past 13 years in the Modified Low Fluctuating Flow (MLFF) policy experiment has fostered extensive learning through monitoring and research. Improved conceptual and predictive models were developed, and extensive research studies and assessments completed to provide knowledge of resource condition, impacts and changes related to these policy experiments. For example, now high flow experimental flood releases are only scheduled to occur when the river is in an enriched condition relating to specific aspects of sediment. Management actions, monitoring and research continue to evaluate sand input, retention, conservation, redistribution etc. under high and low flows.

OBSERVATIONS FROM LITERATURE ON TRANSITION FROM MANAGEMENT ACTIONS TO SCIENCE

Our review of AM literature reveals that the AM paradigm generally minimizes the distinction between science and management activities being implemented. That is, AM policy experiments utilize management actions that managers and scientists feel, based on their assessments, will most likely improve resource conditions and learning. Through the iterative process of implementing and monitoring the results of these revised actions, AM programs can obtain improved responses from resources and improved learning. Some AM programs will require many iterations of management action/monitoring and in a few surprises will occur that disrupt both resource improvement and learning.

Both AM conceptual design and program implementation models characterize the process as more a continuum of evaluating outcomes of adjusted management policies/actions due to changing biological and social dynamics as well as surprises. Uncertainty and risk are embraced as continuous elements of the process. Most often the high uncertainty and risk that these programs confront cannot be resolved due to highly dynamic biological and social interactions. As such, the paradigm addresses learning differently than the more traditional science model of extensive science applications to reduce uncertainty and risk before a management action is taken.

In its application the AM model is not designed as a science model with a primary goal to reduce uncertainty relating to management actions so they can be implemented, nor is it simply a management model that focuses on optimizing actions. Rather it is a mixed model, wherein management actions are designed and implemented to maximize potential opportunity for resource benefit and learning. Iterations of modified management actions and monitoring are the primary mechanisms for gains in both areas.

The issue focused upon in this literature assessment relates primarily to how science and management activities operate together in the Adaptive Management Model to provide management effectiveness. Science in and of itself is an important part of the process. That is, best knowledge is used to both initialize the AM process, i.e. select best management actions and hypothesis, as well as design and implement effective monitoring to provide the learning to make iterative revisions to management actions.

Science is a critical component of the continuing process that permits us to learn and improve decision processes regarding management actions. As noted, its focus is different, however, than the traditional science model, because uncertainty in many AM programs cannot be resolved to levels that will mitigate high risks in the management decision processes.

The ever present uncertainty in AM programs requires a different purpose for management actions and ordering of the actions by managers. We find from the literature that the AM model must rely also on a broader and also slightly different set of criteria for evaluating outcomes for specific resources and management actions, contrasting of actions, resource outcomes and decision processes (Table 1). In major part this relates to the fact that the resource issues and settings require the manager to invoke decisions in highly dynamic and uncertain biophysical and social environments and, therefore, often assume higher risk. As such methodologies such as tradeoff analysis structured decision process, etc. are invoked.

Table 1: Contrasting differing criteria and methods in traditional science models and AM models.

Traditional Science Model	**AM Model**
Problem definition	Consensus building
Science question	Policy experiment design
Bivariate statistics	Simulation modeling
Analysis of variance	Uncertainty analysis
Power tests	Bayesion statistics
Predictive modeling	Fuzzy regression
Multivariate statistics	Stochastic modeling
Probability analysis	Conflict Resolution
Resource tradeoff analysis	Structured decision processes

In the AM paradigm, implementing management actions hypothesized to best improve resources and learning, and effective monitoring of resource improvements is the validation for continuation of activities. Because uncertainty cannot be resolved the above differing criteria are needed to assist the manager in determining the degree of risk that will be tolerated in the decision process.

Guidance from the AM literature would support several general clarifications regarding the AM paradigm and the relative role of science and management actions in these programs as follows.

- AM programs in natural resource conservation are often established to resolve complex, multiple party, multiple resource and multiple objective issues that cover large physical areas and harbor significant ongoing uncertainty.
- Active AM programs are most effective in implementing iterative management actions through time to create improved states of resource conditions and learning. Improvements in resources of concern through management represent the primary thrust of the AM paradigm. Learning is accomplished through the ongoing monitoring activities to evaluate changes in environmental processes and resources of concern.
- Two types of learning are involved in the AM model. The first, "single loop" learning evaluates the effectiveness of management actions in the policy experiments. The second, "double loop" learning allows the applied AM model itself to be evaluated over a longer period.
- "Single Loop" learning is most focused in AM on the continued iterative process of management action/monitoring/evaluation/ revised management action.
- Longer term learning allows one to evaluate overall AM effectiveness, and revise accordingly and then monitor. This is referred to by Williams et al (2007) as "double loop" learning and involves evaluating institutional structures such as AM methods, goals, objectives, etc. GCDAMP is currently at a stage of long term AM learning which indicates that changes in the GCDAMP approach should be evaluated.

Literature addressing the operating principals of adaptive management are fairly consistent and clear in clarifying general guidelines for its application and the roles and transitions of management and science (Holling 1978; Walters 1986; Gunderson et al 1998; Williams et al 2007).

OBSERVATIONS ON GCDAMP STRUCTURE AND OPERATIONS AND IMPLICATIONS TO PROGRAMMATIC TRANSITIONS

The programmatic transitions among various elements of an AM program, i.e. consensus building, assessments, management actions, monitoring, revised management actions etc. represents a continuum of decision points for managers. The following section provides observations on criteria and guidelines that can improve AM institutional structures and operations. Hopefully they will be helpful to GCDAMP members in understanding science and management transitions. Several structural and operational characteristics of GCDAMP are referenced.

- Organization, Goals and Leadership
- Program Planning and Budgeting
- Effective Science Monitoring
- Responding to Perturbations
- Assessments of Knowledge
- Responding to Independent Review

Organization and Leadership

Adaptive management was developed to address complex natural resource issues where uncertainty is pervasive i.e. ocean fisheries management, migratory waterfowl management, landscape level public lands wildfire management, etc. Functional organizational structure and purpose as well as quality management and leadership are critical for effective management/science transitions.

The GCDAMP program has defined purpose, mission, strategies, goals, etc., supported by federal law, regulation and policy and funding mechanisms. It has an organizational structure similar to most AM programs with administrative components considered important for effective operation, i.e. policy group, technical group, science group, independent review group, etc.

The ability to operate multiple large management and science activities concurrently while maintaining stability in critical resources and learning is general evidence that transitioning of management actions to monitoring and back to management actions is being successful. This requires ongoing collaboration of managers/scientists through extensive documented meetings, actions, developed assessments and decisions. Generally, many of these criteria appear to be met in the GCDAMP. However, internal and external reviews of the program have cited needs for improvement.

Several reviews of the GCDAMP program over the past five years have identified needs of the program to reevaluate several of its adaptive management processes related to administrative structure, roles of the GCDAMP groups, goals, desired future conditions, leadership, Native American consultation etc. (GCDAMP Science Planning Group Report 2006; Susskin et al.2009; GCDAMP Science Advisor Review 2007; GCDAMP Roles AD HOC Report 2009; USGS Workshop on LTEP 4/10/07; USGS Knowledge Assessment, 2006; SCORE Report 2005; NRC 1999). When one reads these reports the need for improvement in several key criteria in organization, goals, leadership, consensus building, program planning and budgeting, research and monitoring, etc. as well as other program areas is evident.

Although several organization and leadership criteria are noted as needing attention, the following have emphasis.

- A reevaluation of overall mission needs to occur as relates to threatened and endangered species and recovery of such species, i.e. should the GCDAMP incorporate a Recovery Implementation Program (RIP).
- The roles, responsibilities and authorities of the GCDAMP groups need to be reevaluated and possibly revised to respond to changing program activity. Native American consultation and dispute resolution need improved criteria.
- Development of well defined goals and desired future conditions for resources of concern need accomplishment.
- To assure seamless operation of the GCDAMP through changes in administration the Secretary Designee and GCDAMP may benefit from an executive director or similar position.

Individual entities of the GCDAMP, i.e. AMWG, GCMRC etc, have had pulses of strong productivity but reviews have identified lapses over time in each program which have hampered progress of the whole. Strong executive leadership in these programs have been cited as a potential factor for improved long term accomplishment.

The literature on adaptive management indicates that criteria such as individual AM leaders can play a large role in the advancement of programs and facilitate transitions among stages in a program, i.e. science to management. To improve management to science transitions, more definitive specification of roles are needed relating to differing entities in the GCDAMP, how the AM processes function, and the authorities and responsibilities of differing AMP members (federal, state and tribal agencies) as relates to management actions and science. These issues are addressed at length in the GCDAMP Roles Report (2009).

Walters (1997) found that the presence of strong leadership is critical to the success of adaptive approaches to solve fisheries issues. Gunderson et al. (1995) found small groups of leaders in different settings can also be a determining factor to success.

Program Planning and Budgeting

Effective program planning is a principal criteria in insuring management action/science transitions in complex natural resource programs such as the GCDAMP. This involves comprehensive planning efforts for overall adaptive management process and procedure, strategic planning for long term management and science programs and tactical planning for annual operation plans and budgets.

In evaluating recent planning direction, i.e. 2004-2010, strategic and operational program and budget plans are in place and utilized. Examples are the GCDAMP 2004 Strategic Plan, GCMRC 2009 Strategic Science Plan, and GCDAMP and GCMRC Annual Program and Budget Operation Plans 2004-2011. However, the 2010-2011 GCDAMP program and budget development process raised concerns over potential use of science base funds to conduct management and or compliance activities (non-native fish control). The GCMRC raised concerns about continual erosion of science capability by the transfer of funds from needed science programs to management and compliance activities. Yet some GCDAMP members feel the long term fish control program is simply one of the many flow and non-flow management actions being implemented in the long term MLFF policy experiment. A deficiency seems to exist in criteria and guidelines to resolve the conflict of funding competing science and management activities. This specific concern was in part the impetus for this paper and clearly could impact management/science transitions in the program.

As noted in the above sections, the GCDAMP could benefit from a review of its overall AM structure and processes. The current issue related to the non-native fish control program does not appear so much a conflict over improper AM processes, but rather a need to revise original organizational guidelines on funding science and management actions and possibly clarification and refinement of management and science entity roles and responsibilities in AM policy experiments. Evidence exists related to management of the GCDAMP that the program, after 15 years of operation, could benefit from the "Double Loop" learning process (Williams et al, 2007).

Funding of the GCDAMP as relates to total level, and allocations to various operations i.e. administration, management actions, science, independent review etc. is a policy matter of the Secretary's office. The current issue does reveal a need for the AMWG in its advisory capacity to the Secretary to review the GCDAMP strategic Plan sections relating to roles and responsibilities of various GCDAMP entities and required budgets to accommodate current needs of these roles. Several findings seem to support this need. For example, the past three annual program and budget cycles have resulted in increasing lists of both management actions and science that have to be deferred due to budget short falls. Current out year budget planning does not appear appropriate for a program of this need and scope and guidelines do not seem clear regarding the GCDAMPs authorities to pursue cooperative funding ventures.

Effective Science Monitoring

The AM model uses monitoring of the resource impacts of management actions to validate both accomplishment of resource improvement and learning. Having credible and effective monitoring programs is one of the most critical criteria for evaluating the mix of science and management actions and there transitions.

The GCDAMP is currently using a structured and collaborative process to develop and validate most appropriate monitoring approaches for the specified GCDAMP goals. Over the second decade of the GCDAMP, 2007-2016, it is proposed that core monitoring programs will be formally implemented for each GCDAMP goal. A collaborative process of the TWG and GCMRC, reviewed by the AMWG, protocol evaluation panels, Science Advisors, and other scientists is currently validating the process. Implementation proposals for this critical program reveal significant overall requirements, both in programs and budgets.

Over the first 10 years of the GCDAMP the necessary transitions of management actions to science to management actions were impacted but not heavily constrained by structural ,managerial or budget issues of the program. However, over the past five years the three issues have become problematic in effecting transitions. Although current budget shortfalls appear to be a driving factor, needed revisions in program structure also exist.

The effectiveness of monitoring and research to improve the designs of management actions will be a primary factor influencing future resource improvements and learning in the GCDAMP. Criteria that can guide monitoring designs to obtain clear specification of managers information needs, including types, resolution level, accuracy, priorities, etc. are critical.

Assessments of Knowledge

The accomplishment of research and monitoring in GCDAMP is based on criteria and principles that apply whenever and wherever the need for science exists. As noted, however, in AM the science process must confront the vagaries of extremely high variance and uncertainty, and invoke a broader set of analytical and other tools.

Because of the greater dynamics and uncertainty, continued assessments of knowledge are critical in AM programs to more effectively redesign management actions in policy experiments and inform managers of associated risk. This ever-present uncertainty surrounding goal attainment requires continued updates to knowledge assessments as critical criteria in the iterative management action/monitoring process.

The GCDAMP program with GCMRC guidance has recommended criteria for significant reviews of knowledge at five-year intervals, i.e. Knowledge Assessment and Status of Colorado River Ecosystem (SCORE) reports. These are critical for maintaining effective policy on transitions of management to science and should occur I 2011/2012. Criteria and guidelines for their development should be strongly based in ecosystem management and science, clarifying the critical integration required between management actions and monitoring in the AM process. The assessments should be used to better inform designs for management actions to improve resources and learning.

Responding to External Perturbations

An attribute of many AM programs with high variability is that one can be surprised by perturbations that were not foreseen. The GCDAMP has witnessed several in its short tenure, including unexpected variability in rainbow trout populations in the CRE, multiyear drought causing significant low flow inputs to Lake Powell and high output temperature to CRE, strong opposition of Native American communities to continued trout removal from the LCR confluence area, etc. Each of these and others have effected how the GCDAMP has transitioned from management to science.

Issues such as rainbow trout population control involve impacts to science, management and policy. This issue and potentially others will require significant GCDAMP effort to assure progressive transition among management and monitoring activities.

The issue of warm water releases from Glen Canyon Dam, also a significant perturbation, seemingly did not result in significant disruptions of management or science processes during the 2003-2006 period. However, although GCMRC and TWG both identified opportunities for management actions and science to take advantage of the natural policy experiment, minor changes occurred. An outcome could have included a risk assessment of potential impacts of predicted future warming.

Responding to Independent Review

Internal and external review processes are critical criteria for evaluating an organizations science knowledge related to management decisions. Reviews have cited concerns over focus of the GCDAMP science (NRC 1999); AM processes and science/management integration (GCDAMP Science Advisors, 2007); appropriate role assignments and leadership (GCDAMP Roles Ad Hoc Report 2009); desired future conditions (GCDAMP DFC Group 2009), AM processes (Susskind et al 2009) etc.

The GCDAMP from inception in 1996 established several levels of program reviews which are extensive and continuous. Some of the reviews are required in the 1995 GCDEIS Record of Decision by the Secretary of Interior for operations of the program. Strategic reviews are required by the EIS and have included the National Research Council (NRC) and the GCDAMP Science Advisors Group (SA) reviews. The NRC has generally evaluated the long term response of the program to its original requirements as established in the GCDEIS (1995).

The SAs are a required Independent Review Panel (IRP) of the EIS to evaluate overall strategic and operational management and science planning direction including budget appropriateness. As such, they review all major science and management plans and their budgets. They also provide advice to the Secretary, AMWG, GCMRC and TWG on issues of concern. Approximately 4-6 reviews are developed each year and the SAs are engaged on a continuous basis in their service role.

GCMRC utilizes other independent review panels (IRPs) including Protocol Evaluation Panels (PEPs) to evaluate science protocols, and many independent scientists to evaluate study plans, proposals, manuscripts, reports etc. The AMWG and TWG also utilize the SAs for science and technical reviews and other service. Further, member agencies perform annual and term reviews of the effectiveness of various elements of the program.

The GCDAMP is also evaluated by external management, science and policy experts who have academic and other interests in the results of application of the AM paradigm on resources of concern (Susskin et al. 2009). These reviews have highlighted AM concerns mentioned above that effect management/science transitions.

Independent reviews are important to evaluate the effectiveness of the transition in management and science and recommend how they can be revised to best improve management and science procedures. Accepting for observations of the NRC, no formal assessment has occurred to evaluate how the GCDAMP responds to reviews or how reviews have influenced criteria as to when and where changes in management/science transitions should occur. This assessment also did not include a charge to accomplish this task.

Evidence exists that the GCDAMP has extended lag times in responding to reviews. Examples are recommendations related to goals, dfcs, ecosystem science approaches, monitoring plans, science and management integration, etc. These lags cause disruption in management/science transition and progress of the GCDAMP

EVALUATING SCIENCE AND MANAGEMENT TRANSITIONS IN LARGE ADAPTIVE MANAGEMENT CONSERVATION PROGRAMS

In addition to evaluating the literature for guidelines on transitioning of science and management in adaptive management programs, we reviewed a group of operating adaptive management programs in the U.S. and Canada.

The application of the concepts and theories of adaptive management as developed by Holling (1978), Walters (1986), Gunderson et al (1995) and others has not had a long history from which to evaluate operating procedures. Yet, its application is quite broad based in North America and several other continents.

Assessment Approach

Our approach used in the review of adaptive management programs was to first identify needs for improvement in how the GCDAMP transitions between management and science processes and isolate criteria and guidelines used by other adaptive management programs that might improve GCDAMP processes.

Potential areas of improvement in GCDAMP abilities to transition between science and management were categorized by the general areas where these transitions are effected. This "double loop" learning is considered by many adaptive management specialists to be critical to adaptive management programs long term enhancement as a management tool (Gunderson and Pritchard Jr, et al. 2002).

The intent of this review of selected active adaptive management programs and the discussion of how they utilize management actions and science is not to imply that any explicit guidelines are best for all programs or GCDAMP. In fact, all programs reviewed have extensive accomplishments and offer opportunity for learning to other programs. Adaptive management is not an exacting science and in fact variance and uncertainty are defining attributes. Leaders in this field of management, i.e. Hollings (1978), Walters (1986), Gunderson et al. (1995) all have observed great variance in how it is applied. The intent instead is simply to identify methods that might improve transitioning between science and management in the GCDAMP.

Adaptive Management Programs Reviewed

Although ten active adaptive management programs were selected for review, additional programs were screened to select the ten for interviews. The general approach taken for information development was case study methodology. Cases selected had similar characteristics to the GCDAMP as follows:

- Federal and/or state directed programs
- Use adaptive management or similar processes
- Long term programs with legal, policy, or regulatory authorities to resolve landscape level issues involving natural resource and social resource conflicts

- Implementing management actions to improve appropriate protection and or management of natural and cultural resources is a significant program thrust
- The use of science to reduce uncertainty of related impacts from management activities is a significant program thrust
- Sufficient science success exists in reducing the uncertainty of outcomes of management activities to define reduced science requirements in some areas.

An effort was also extended to incorporate several programs that are focused on providing the science and management basis for recovery of endangered fish in western reverine settings, a priority goal of the GCDAMP. Following are programs that were screened in the assessment. Reviewed programs are in italics.

- Adaptive Waterfowl Harvest Management: USDI/FWS
- Interagency Bison Management Plan: National Park Service, Yellowstone National Park.
- *Apache Sitgreaves NF Restoration Program,, AZ*
- *Lincoln National Forest Restoration Program, NM*
- *Kissimmee River; Florida*
- Columbia River Programs; PNW
- *Cal-Fed; California*
- *Platte River; Wyoming/Colorado/Nebraska*
- *Trinity River; California*
- South Florida Restoration Task Force, Florida
- Jornada Experimental Range; NM
- Northwest Forest Plan; PNW
- East Cascade Greater Forest Ecosystem; PNW
- *Lower Colorado River Multi-Species Conservation Program; SW*
- Interagency Basin Management Plan
- *Upper Colorado River Recovery Implementation Program*
- *San Juan River Recovery Implementation Program*
- *Lower Bridge River of British Columbia, Canada*
- Klamath River Basin Restoration Program
- Chesapeake Bay Restoration Program
- Comprehensive Everglades Restoration Plan (CERP); Florida

Proposed GCDAMP Actions to Improve Management/Science Transitions

The GCDAMP utilizes many operations guidelines and criteria for the TWG, GCMRC, SAs etc., that effect how management actions and science are implemented, integrated, etc. These are specified in various GCDAMP strategic operations, protocol and procedures documents.

As noted above, internal and external reviews of the GCDAMP have cited needed improvements in various program elements that can effect its performance. We identified selected criteria related to needed improvements in the following areas for evaluation.

- Organization and leadership
- Program and budget planning
- Effective monitoring
- Responding to perturbations

In the review, our intent is to evaluate needed improvements in the above GCDAMP program areas and identify guidelines, criteria and procedures from reviewed adaptive management programs that could have application to these needed improvements (Table 2).

Table 2: Areas of Needed Improvement in GCDAMP Attributes to Enhance Management/Science Transitions.

Organizational Structure, Goals and Leadership

- Improvement in criteria and guidelines for insuring effective collaborative adaptive management processes (CAM); i.e. improve consensus building; dispute resolution process; joint fact finding. etc.
- Improvements in roles and responsibilities of GCDAMP entities.
- Improved specification of criteria related to goals, desired resource conditions and program priorities.

Program Planning and Budgeting

- Improved guidelines and criteria regarding type, amount, resolution and accuracy of information needed to better define management actions and experimental policies
- Improved 10 year strategic program and budget criteria that incorporates guidelines for tradeoff analysis methods and structured decision analysis

Effective Monitoring Program

- Improved criteria for monitoring that focus on cost effective detection of critical system and resource indicator changes for priority resources and issues of concern.

Responding to Perturbations

- Improved CAM criteria for resolving disputes, clear understanding of tradeoff and risks, revised out year program and budget planning.

Organizational Structure, Goals and Leadership

Improved guidelines and criteria are needed for collaborative adaptive management (CAM) processes. Improvement in guidelines for consensus building and dispute resolution will effect management action/science transitions. Areas that exemplify the need for improvement in consensus building are; time intervals required by the GCDAMP to reach a consensus and resolve issues on criteria for management actions in a long term LTEP; Protocols for a HFE; criteria and protocols for non-native fish control; etc. Improved guidelines could result in reduced conflict in AM processes and shorter time intervals for transitioning between management and science activities.

An area that exemplifies needed improvement in both consensus building and dispute resolution is the 2010 decision of member Native American Tribes to oppose selected non-native fish control policies. Tribes, based on cultural values, oppose unnecessary taking of life. In the consensus building process Tribes agreed to the policy experiment as a science effort assumed to have short tenure. Tribal concerns now exist that proposed continuation of non-native fish removals as a management activity violates cultural values and does not follow appropriate consultation and dispute resolution with the Tribes.

Significant time and resources have been dedicated to developing Rainbow Trout non-native fish control management actions and monitoring. Could improved criteria for AM consensus building and dispute resolution have helped to resolve this issue and avert similar issues in the future?

In review of other adaptive management programs, many revisit and revise elements of their mission, goals, and operating protocols in the first 20 years. Much of this revision relates to inherent program dynamics, the need to reevaluate originally cast hypothesis, i.e. "double loop" learning.

Some programs have very focused mission, goals, objectives, operations protocols, etc., that have limited need for revision. Examples are the San Juan River, Upper Colorado River, and Platte River Recovery Implementation Programs, etc. However, even in these programs many initial hypotheses of how resources and society respond to policy experiments and management actions do require revision. Interviews with program managers document that formal guidelines and criteria and processes for gaining and sustaining input and consensus from stakeholders is critical to transitions between management and science and that these criteria must be revisited and revised as part of the "double loop" learning process.

Some adaptive management programs screened have highly developed AM approaches to very complex multi-objective management and science programs. Most often this enhancement correlates to the broad scope of issues addressed. Examples are the Cal-Fed Program, Chesapeake Bay Program, South Florida Program, Northwest Forest Plan, etc. These programs are so large, individual projects in the programs often have more comprehensive activities and larger funding than the GCDAMP.

In some AM programs it can take one to two decades after implementation to resolve stakeholder consensus on fundamental issues such as program goals, or desired future resource conditions. For example, the Kissimmee River program was challenged with two decades of science and consensus building to formulate acceptable definitions of its mission to restore "ecological integrity" to the Kissimmee River and even more years to craft and implement agreed upon goals, objectives and management actions.

Most programs screened and reviewed adhere closely to the adaptive management principles outlined in the literature review. That is, management actions for policy experimentation are structured from best knowledge, implemented, monitored, results evaluated, actions revised and implemented again. Management action/monitoring cycles are repeated in programs reviewed to enhance targeted resource condition and learning.

Because of their size and inevitable bureaucratic trappings, large CAMs such as Cal-Fed and the Chesapeake Bay programs utilize very organized and well developed criteria, guidelines and procedures for building consensus and resolving disputes. In major part this relates to the need to constantly integrate information for analysis and decisions from much larger and more diverse interest groups. It is recommended that some of the diverse approaches utilized by these programs for consensus building, conflict and dispute resolution be evaluated for use by GCDAMP.

In reviewing programs that address the scope and scale of problems that are similar to the GCDAMP, the Lower Bridge River program of Canada and Kissimmee River program of South Florida provide examples of unique approaches to consensus building where explicit protocols are crafted to accommodate diverse stakeholder positions.

The Kissimmee River Program (KRRP) often is credited with some of the earliest applications of adaptive management principles in large rivers. When authorized, the program was the largest river restoration project ever attempted (Toth et al. 1995). Nearly two decades of science, management and stakeholder efforts at learning and constituency building were necessary to both design and solidify support for the complex restoration progression. Pilot demonstration projects from the 1980s, deemed necessary to gain and sustain public support were active into the 1990s. Now with a tenure approaching 40 years, KRRP administrators have seen multiple cycles of consensus building and declined support, each time requiring revised criteria and guidelines for approaches to rekindle support for the program. Selected Kissimmee River criteria for building and sustaining consensus through time is continually adapted and includes:

- Defining through collaboration processes, revised goals, DFCs, and objectives, etc., based on manager/stakeholder needs.
- Written clear operating protocols for developing consensus, dispute resolution, consultation, etc.
- Open and neutral forums for all aspects of adaptive management processes.
- Continuous planning for and building needed consensus capacity.

The Lower Bridge River, a tributary of the Frazier River in southwest British Columbia. provides habitat for diverse birds and wildlife, cultural importance to the First Nations, significant salmon runs, recreation benefits and power from three hydroelectric facilities. The CAM program developed in the early 2000s was established to address multi attribute conflicts associated with regulated flows for power production. Like the GCDAMP, over the 1970s to 1990s conflicts among power, cultural resources, fish and recreation and other interests required implementation of adaptive management approaches in 2000 to gain resolves. The program developed a structured decision making model (SDM) for evaluation of resource tradeoffs and decision making with strong involvement of First Nations.

The Lower Bridge River cultural program has been important in minimizing disputes and assuring needed transitions of management and science to enhance resources, including cultural resources. The program acknowledges that experimental results alone will not gain resolves involving multiple management objectives and wide variances in cultural values (Failing et al 2004). A long term sustained process of consensus building that follows key guidelines as referenced by Williams et al (2007) was necessary.

The Bridge River program, like the KRRP, utilizes the following AM criteria to insure continuous progress on transition of management and science.

- Fully engage stakeholders in all elements of the planning, discussion and decision processes
- Clear identification of goals, objectives and desired future conditions
- Open and transparent processes for development of proposals and decisions
- Incorporation of meaningful consultation of First Nations and all stakeholders

In the Canadian Supreme Court decisions are explicit regarding the fact that meaningful consultation embraces a broad array of required interaction of parties. The Lower Bridge River program incorporates meaningful consultations by demonstrating that parties have mutually explored and learned all aspects of an issue including all feasible science and management options and outcomes, clarified uncertainties and dynamics that must be considered, and clarified tradeoffs that will occur in differing alternative approaches (Gregory et al. 2008). For example, for cultural resources, extensive First Nation consultations were used to develop values for cultural and spiritual quality that could have been benefited or degraded by differing science and management activities. These values were structured into protocols and scales to insure both consistency and transparency to other parties in tradeoff analysis.

The GCDAMP could possibly benefit from assessment criteria used for consensus building and dispute resolution by the Lower Bridge River and other AM programs reviewed.

Improved specification of roles and responsibilities of CAM program entities is needed to improve transitions of management and science. In 2004 the AMWG identified that conflicts might exist regarding roles and responsibilities of various entities of the GCDAMP i.e. Secretary Designee, AMWG, GCMRC, TWG, SAs, and that these conflicts could affect management and science activities. Reviews by a Roles Ad Hoc Group were requested. A Roles Ad Hoc Group was convened in 2005, and reconvened in 2007 and 2008. The result of reports produced identified needed improvements in roles and responsibilities to better ascribe to the adaptive management model and improve GCDAMP performance (Roles Ad Hoc Group 2009).

All CAM programs reviewed developed selected revisions of entity roles in the first two decades of operations. Programs that seem to have greatest need for revision are restoration programs led by formal stakeholder groups serviced by technical and science committees or groups. Programs that seem to have less need for change are programs that have a more narrow focus such as species recovery implementation programs (RIPs).

Examples of the latter are the San Juan River (SJRIP), Upper Colorado River (UCRIP) and the Platte River Recovery Implementation Programs (PRRIP). All of these programs are focused on recovery of long lived fishes in the Colorado and Platte Rivers as well as accomplishing requirements for habitat improvement, consultation and water development. Many AM programs in the west are often established for and have as a primary focus protection and recovery of one or more threatened or endangered fish. The GCDAMP is not designated explicitly as a species recovery program, although one of its priority goals relates to maintenance or improvement in native fishes with specific emphasis on the Humpback Chub. In the last five years the program has increased both management and science activities toward this goal. Recent EA and BO requirements have created even greater program focus toward recovery activities.

The roles and responsibilities of involved management agencies are more easily deefined in many RIPs and more limited disruptions and issues arise in science/management transitions. This often relates to the following guidelines and criteria followed in these programs.

- Programs are voluntary collaborations of federal, state and local government entities, and other stockholders
- Law and regulation are explicit regards federal, state and local government requirements for recovery as related to management, science, and even funding.
- Authorities, roles and responsibilities of federal, state and local government entities are also specific relating to recovery program implementation.
- Introduced dynamics and variance in these programs are primarily related to biophysical and socio-economic responses to management actions.

Program Planning and Budgeting

Improved program planning and budgeting is needed to better define acceptable types, content, resolution, accuracy, etc. of information needed to inform improved management actions and decision processes. In transitioning from needed information to design of management actions to monitoring science, both managers and scientists must work closely on criteria and guidelines to make the transitions efficient, effective and minimal cost.

Managers have a critical role in defining the types, amounts, resolution, and accuracy etc. of information needed to guide decision making criteria. The range of tradeoff analysis and decision criteria used in AM programs are from simplistic word models to complex analytical models. The greater a programs dependence on complex analytical tools for evaluating risk, penalties, tradeoffs, final decisions, etc. the greater the requirements for data. Science and associated data gathering and assessments for AM programs must be explicitly guided by defined management information needs. Otherwise it will lack efficiency and effectiveness. Guiding criteria are:

- Focus on explicit need, resolution level and accuracy
- Use effective and efficient methods
- Evaluate cost effectiveness

Managers must understand that orders of magnitude increases in data requirements may occur as managers require greater data resolution and accuracy. For example, data costs to prove why and how some change is occurring is much greater than simply to prove that change is occurring. Generally, the former mode is the province of research studies whereas the latter is monitoring.

Improved guidelines and criteria are needed to evaluate and resolve out year program requirements and related impacts to management/science transitions. The GCDAMP has apparent capacity to develop two year budget planning and potentially resolve funding needs. The strategy seems unclear for out year planning.

Obviously, available budget, both base and marginal new funds, is the single greatest factor that will affect GCDAMPs ability to transition its science and management needs in the short run. This is demonstrated in the 2010, 2011, and 2012 annual budget planning wherein existing ongoing science programs are reduced to accommodate new management and science programs.

The Cal-Fed program has decade long program and budget planning, professional budget staffs and multiple sophisticated program and budget planning tools at the program and project level. Further, they can be applied to assure best approaches in assumed increasing, stable or declining budgets. In the review of CAM programs we found what one would normally expect, that larger programs had more structural adaptive management programming, funding, development, and management and science capability.

Management capability, including personnel, technical capacity and budget resources may not be changed significantly when AM approaches are adopted. This relates to the fact that required levels of management normally exist prior to CAM programs being developed. Adopting adaptive management approaches simply revises how management resources are applied to the problem or issue. The same is not true for science, adaptive management, budget development and public relation activities, processes and resources. These generally increase with implementation of AM.

Larger programs such as the Cal-Fed, Northwest Forest Plan, South Florida CERP, etc. have significant resource capacity to accomplish out year budget planning and make adjustments in required funding or programs to respond to need. Most often out year planning is 5-10 years, but longer plans exist. GCDAMP currently uses a two-year budget planning cycle with some projecting to three years. Often endangered species recovery implementation programs have ten year or greater planning horizons. The Lower Colorado Multispecies Conservation Program has a 50 year budget plan.

GCDAMPs out year budget strategy appears to be based on a declining real budget. If this is the budget strategy, it needs more structured criteria and guidelines on how to mitigate out year impacts on science and management transitions. GCDAMP should consider adapting criteria and guidelines from larger adaptive management programs to better accomplish this strategy over both short term (two year) and long term (ten year) program cycles.

In the GCDAMP, expected outcomes of various alternative management actions provided by science are discussed, often accompanied by tables of data where tradeoffs are presented or can be interpreted. Developed analytical tradeoff models (ECOSIM) are used in some settings. This approach could be improved with established consistent criteria and guidelines used for developed findings. Capabilities exist to utilize existing simulation models (ECOSIM) more often or devise different tradeoff models that could create consistency in evaluating tradeoffs among management actions and deriving decisions on selected options.

Both the A/SNF and Lincoln National Forest Restoration Programs utilize forest ecosystem simulation models to evaluate outcomes of differing management actions. The A/SNF have utilized the Terrestrial Ecosystem Analysis and Management System (TEAMS), a simulator that accomplishes both biophysical and socio-economic tradeoff assessments. The Lincoln National Forest Restoration Program uses the Ecological Simulation Model (ECOSIM) for biophysical tradeoff analysis and the Forest Multiresource Analysis System (FORMULAS)for socio-economic tradeoff analysis. These approaches are similar to the GCDAMP model ECOSIM. Models of more and less analytical sophistication are used in other CAM programs.

Complex quantitative models are not always necessary to conduct effective tradeoff analysis for mangers and stakeholders. However approaches chosen should provide consistency and repeatability in differing applications.

To assist transitions of management and science some programs reviewed have developed formal criteria and guidelines for their decision processes. Selected programs have decision models with very structured criteria and guidelines, which include elements to accommodate assessment of uncertainty and risk in the decision process.

The Lower Bridge River Program uses a Structured Decision Making (SDM) model providing both tradeoff analysis and decision support capability. The decision support system incorporates both objective and subjective measures (cultural resources, wildlife, etc).

In evaluation phases of both short term and long term program and budget planning the GCDAMP could improve programmed transitions of management and science by establishing improved criteria and guidelines for the following:

- The GCDAMP needs to improve AM processes for manager and stakeholders specification of the minimal information needs for conducting effective tradeoff analysis
- If the GCDAMP decade plan is to operate on a constantly declining real budget, it should improve guidelines to assure resource protection
- Consistent GCDAMP guidelines do not exist for conducting structured tradeoff analysis of multiple resource changes for differing management action scenarios. Differing criteria, guidelines and methods have been used for differing assessments.
- Current GCDAMP criteria and guidelines do not formally exist for structured decision processes regarding selection of one alternative management action over another. Differing criteria and methods are used over time.

Effective Science Monitoring Programs

Implementing effective integrated multi-attribute monitoring programs focused on detection of critical indicator changes for priority resources are criteria important for improving transitions between management and science. Implementation of the GCDAMP long term monitoring program as scheduled over the next five years will finalize the primary science tool for supporting adaptive management. It's effectiveness for assuring rapid transition of management action evaluation and revision will depend on its capabilities to detect resource change and inform needed revision in management actions.

The implemented GCMRC PEP process and its criteria and guidelines for insuring the above objectives are met appears effective in insuring improvements in monitoring individual resource attributes. However, because the PEPs disaggregate assessments of differing resources, i.e. physical, biological, cultural, etc. it could potentially mask benefits that could be derived across an array of multi-resources when one evaluates remotely sensed methods.

The dimensions of monitoring needs are primarily determined by specified information needs of managers and stakeholders. Levels of resolution of specified multi-resource data, number and type of attributes for each resource, and time and space dependence of data often influence strongly whether remotely sensed methods prove superior. Improved specification of data needs with these guidelines could assist assessment of the value of increasing remotely sensed methods.

Monitoring programs should be designed to track only those attributes that are critical to defining change in priority resources of concern to managers and stakeholders. This minimalist approach forces clearer evaluation of alternative monitoring strategies, methods and costs. All CAM programs through time reevaluate their monitoring program efforts based on advances in technology, increased knowledge of resource dynamics and interaction, changes in priorities by managers, etc. Necessary changes should receive extensive review for effectiveness.

Review of monitoring designs and implemented strategies of existing CAM programs reveals that the science and management process for the GCDAMP monitoring program is similar to approaches used in many other programs, i.e. manager/stakeholder specification of need, science evaluation, testing of alternative methodology (PEPs, Pilots), implementation of monitoring programs, etc.

Review of issues and approaches taken in the Kissimmee River and Trinity River programs, as well as others, might strengthen this plan and its implementation. Criteria for closer examination are as follows:

- Improved manager/stakeholder specification of priority information needs, level of resolution, accuracy, etc.
- Planned approaches to integration of measurements of multi-resource attributes and related use in assessment models.
- Monitoring program contribution to specifically redesigning management actions.

Responding to Pertubations

Improved CAM processes are needed to more effectively respond to perturbations both internal and external to the GCDAMP. Some perturbations can be predicted or identified early in management and science planning, and others will simply be surprises. All significant perturbations need to be responded to in two ways. First, resolve issues related to the occurrence and second create mechanisms to best identify and resolve any recurrence. Criteria and guidelines used by CAM programs for dealing with perturbations to best support management/science transitions are many.

The GCDAMP has had several perturbations in its tenure. Some were easily resolved with existing programming while others required new programming.

AM criteria, several mentioned previously, are used by CAM programs reviewed to both identify and evaluate perturbations and resolve their related impacts. These criteria and related programs in the GCDAMP should be reviewed for potential improvements.

Out year program and budget planning (5-10 years) can help identify potential perturbations that could be evaluated prior to occurrence. Several methods such as risk assessments and tradeoff analysis could occur to evaluate mitigation requirements in both management actions and science. The Kissimmee River program has a very structured process as do other longer-term adaptive management programs.

Effective monitoring programs are critical to defining perturbations in process, often detecting them quickly, defining what attributes are being impacted and providing guidance on possible resolves. The CAL-FED ERP has multiple program examples of well-developed approaches. Developed decision processes and tradeoff evaluation capabilities such as being used by the Lower Bridge River Program permit more rapid comprehensive approaches to respond to perturbations and best approaches to gain resolves. Cal-Fed sub programs use sophisticated analytic approaches, rapid response assessments and decision methods. Even smaller programs such as the LNF Restoration Program also use analytical and rapid response approaches.

Guidelines and criteria used in several GCDAMP attributes could be improved to help forecast the potential occurrence of perturbations, detect their occurrence, mitigate their impacts and inform program changes to ward against future unwanted events. The following are proposed for consideration.

- Improved consensus building and conflict resolution guidelines could prevent social perturbations such as current Native American oppositions to non-native fish removal.
- Out year (10) program planning and budgeting with associated risk assessments could have possibly better prepared GCDAMP to utilize the natural warming of 2003-2006 as a policy experiment. That learning could have improved management/science transitions should predicted long term warming actually occur.
- Improved tradeoff analysis and structured decision processes will better support the GCDAMP in responding to perturbations, especially surprises. Although complex analytical methods are not necessary, methods employed should be repeatable and provide consistent outputs.

CONCLUSIONS AND RECOMMENDATIONS

This review of literature and selected adaptive management programs has attempted to provide information on a question generally cast as follows;

- What criteria and guidelines exist in AM literature and operating programs to assist in transitioning among management and science programs?

Our review concludes that the AM paradigm as originally designed and as implemented by practitioners is a holistic management model, with the following characteristics;

- It is not a science model, although it is strongly dependent on science in its implementation.
- AM applications depart from the traditional science model wherein science is implemented until most uncertainty is resolved and management actions can be implemented with little risk.

- AM development was necessary to confront the dynamics, continued uncertainties and risks encountered in large natural resource management issues such as riverine restoration, native species recovery, large forest area restoration, etc.
- AM processes engage broad based stakeholder concerns; use best knowledge to define policy experiments and needed management actions to improve resources and learn; monitor and evaluate outcomes of these actions; and modify actions through repeated cycles of management and monitoring to gain desired outcomes.
- Two general statements, often ascribed to the AM model are very appropriate, "you learn by doing" and "distinctions between management and science are blurred in the process to accomplish the primary goal, resource improvement".
- Because the management model relies on best science to both learn and define and refine improved management actions through repeated cycles, it is critical that managers are attentive to maintaining robust AM processes that will maximize effectiveness and efficiencies in these continuing transitions of management and science activities.
- Review of literature and operating AM programs reveal that several AM attributes and processes are critical to sustaining effective management/science processes through time. Reviews of the GCDAMP indicates that improvements may be needed in several of those AM processes including:
  - GCDAMP organization, consensus building, entity roles, goals, dfcs etc.
  - Program planning and budgeting
  - Effective monitoring approaches
  - Responding to perturbations
- Reviews of other AM programs reveals broad opportunities to transfer knowledge gained on management actions and science to assist the GCDAMP. These include fish management and science approaches used in the Upper Colorado, San Juan and Platte River RIPs; First Nation consensus building and dispute resolution in the Lower Bridge River; AM processes on program planning and budgeting from the CAL-FED ERP and Kissimmee River RP; analytical tradeoff models and decision support systems from CAL-FED ERP, Lower Bridge River, Lincoln National Forest Restoration Program; etc.
- Although improvements are needed in GCDAMP processes to insure more effective transitions of management and science activities, the review found this to be normal occurrence in many AM programs. It is described in AM literature as "Double Loop Learning:" and critical to effective AM programs.
- Overall, GCDAMP appears to follow the AM paradigm and its processes quite closely. Although this was not a review of GCDAMP or other AM programs regarding effectiveness, anecdotal evidence suggests all programs reviewed are implementing AM procedures and demonstrating accomplishments toward established goals

Recommendations

Based on the review of AM literature, other AM programs, and internal and external reviews of needed improvements to GCDAMP processes, the following recommendations are proposed to improve criteria and guidelines for GCDAMP management/science transitions.

- The GCDAMP Mission regarding recovery implementation programs for the endangered species should be reviewed. If the GCDAMP is incorporating this direction informally, it should be clarified in mission, goals and objectives.
- Criteria to assure that goals are made more specific and prioritized more effectively are needed for effective management actions/science transitions.
- Desired future resource conditions should be developed for all resources to effect appropriate planning of management actions and science.
- Near term program and budget planning must have improved direction from stakeholders and managers as to their priority needs. Specifications should include minimal levels of resolution, types and amounts of information needed as well as accuracy requirements.
- Out year program and budget planning (10 years) needs to be improved to help identify additional management actions and science needs as well as forced reductions in programs from budget shortfalls.
- Monitoring programs under development must be explicitly designed to detect changes in key multi resource indicators of resources of concern of stakeholders. Focus on design parameters that define the minimal information needs to detect resource changes is important
- Abilities to identify, in advance, potential perturbations to the system assists management and science transitions. Improvements in program planning and budgeting, simulation models, tradeoff models and decision support systems would benefit these identifications.

APPENDIX
OVERVIEW OF ADAPTIVE MANAGEMENT PROGRAMS

APPENDIX
OVERVIEW OF ADAPTIVE MANAGEMENT PROGRAMS REVIEWED

Twenty programs that utilize adaptive management principles were screened in this assessment. The ten programs reviewed are as follows:

- Kissimmee River Program
- Cal-Fed Program
- Lower Bridge River of British Columbia
- Trinity River Restoration Program
- Lincoln NF Restoration Program
- Platte River Program
- San Juan River Recovery Implementation Program
- Apache Sitgreaves NF Restoration Program
- Upper Colorado River Recovery Implementation Program
- Lower Colorado Multispecies Conservation Plan

The programs were reviewed as regards how they administer, manage, integrate etc. science and management activities in their program direction. The general objective was to understand the criteria and guidelines being used in transitioning between science and management actions.

Following is a brief overview of the programs evaluated.

THE GLEN CANYON DAM ADAPTIVE MANAGEMENT PROGRAM (GCDAMP)

Origin

- Construction (1963) and operation of Glen Canyon Dam (GCD) on the Colorado River caused significant changes in riverine physical resources, i.e. water and sediments and their related impacts to flora and fauna. Long-term AM program established in 1996 to monitor effects of management actions on resources.

Goals

- A set 12 of goals and related desired outcomes for resources, collaboration, AM, and knowledge is developed. First decade of program (1996-2007) significantly oriented to science assessments of best management practice, research, and monitoring.

Legal Context

- Authorized through Grand Canyon Protection Act (1992), GCD EIS (1995), and GCD EIS ROD (1996), including adaptive management process.

Structure

- Formal FACA of 25 representatives of state water agencies, federal agencies, Native American Tribes, environmental community, stakeholders, etc.
- Directed by a DOI Secretary Designee and includes an Adaptive Management Work Group, Technical Work Group, Grand Canyon Monitoring and Research Center and Science Advisory Group
- Formal consultation of federal and state agencies, Tribes and stakeholders

Participants: FACA Committee

- Bureau of Reclamation, Upper Colorado Region
- Arizona Game & Fish Department
- U.S. Fish & Wildlife Service
- Depart. Of Energy-Western Area Power Administration
- Hualapai Tribe
- Grand Canyon River Guides
- Arizona Water Conservation Board
- Colorado River Commission of Nevada
- NM Interstate Stream Commission
- Grand Canyon Wildlands Council
- Dir. Division of Water Resources, Utah
- UAMPS
- Utah Associated Municipal Power
- The Hope Tribe
- Navajo Nation
- Souther Paiute Consortium
- Pueblo of Zuni
- San Juan Paiute Tribe
- Bureau Of Indian Affairs
- Interstate Streams Engineer
- Federation of Flyfishers
- CREDA
- Grand Canyon Trust
- National Park Service
- Wildlands Council

Program Development

- 1992: GCPA
- 1996: GCDEIS Record of Decision
- 1996-2008: Management Actions: research, monitoring, consultations

Program Management/Decision Process

- Recommending body Adaptive Management Work Group (FACA)
- Use collaborative consensus process and/or voting of FACA member; 2/3 majority required for decision vote

Accomplishment Toward Improving Resources Through Management Actions and Science

- 1996-2008 Policy Flow Experiment of MLFF of GDEIS
- 1996-2010 Policy Experiment of MLFF with 2008-2010 LSSF revision
- 1996: HFE Management actions/monitoring; also 2004, 2008.
- 2000: LSSF Management actions/monitoring; also 2008-2010

THE SAN JUAN RIVER RECOVERY IMPLEMENTATION PROGRAM (SJRIP)

Origin

- Concerns regarding impacts to fauna and flora related to construction and operation of the Animas La Plata Irrigation Projects on the San Juan River and related Navajo Reservoir operations

Goals

- Recover populations of Colorado Pike Minnow and proceed with water development and use in the basin

Legal Context

- Authorized and funded through PL 106-392 (amended). Compliance based under ESA and formal recovery program requirements

Structure and Participants

- Formal cooperative agreement of program participants for ongoing collaboration and actions
- Formal ESA section 7 consultation on water development and water management activities

Participants

- State of Colorado
- State of New Mexico
- Jicarilla Apache Nation
- Navajo Nation
- Southern Ute Indian Tribe
- Ute Mountain Ute Indian Tribe
- U.S. Bureau of Indian Affairs
- U.S. Bureau of Reclamation
- U.S. Bureau of Land Management
- U.S. Fish and Wildlife Service
- Water Development Interests
- Conservation Interests

Program Development

- 1997 – Animas La Plata Consultation
- 1987 – 89 Fish Survey
- 1990 Recognition of consultation
  - Draft BO/jeopardy determination
  - RPAS
  - Research; Recovery Program; Decision on Navajo Reservoir releases
- 1992 Program and cooperative agreement signed
- 2002 ESA Sec 7 consultation

Program Management/Decision Process

- Program Mgt: USF&WS; SJRIP Long Range Plan
- Coordination Committee: Decision body ⅔ majority rate of participants
- Biology and Hydrology Committees; Recommendations, ⅔ vote

Accomplishment Toward Reducing Uncertainty Through Management Actions; Monitoring and Research

- Native Fish Assessments
- Native Fish Introductions
- Non-native Fish Assessments
- Flow impact assessments on native/non-native fish
- Native fish barrier assessments/recovery monitoring

- Flow management; mimic natural hydrograph
- Razorback Sucker; meeting stocking goals; CPUE increased 2001-2007; reproduction and local evidence since 1998; juveniles since 2002
- Colorado Pike Minnow; meeting stocking goals; CPUE increased 2001-2007, Barrier removals at Cuder diversion, Hogback diversion, and PNM Opened 36 miles of habitat.

UPPER COLORADO ENDANGERED FISH RECOVERY PROGRAM

Origin

- Concerns in 1984 about impacts of water use and development on four endangered native fishes; Pike Minnow, HBC, Razorback Sucker, Bonytail Chub; i.e. ESA/water depletions conflict

Goals

- Recover four endangered fishes while continuing water use and development

Legal Context

- Operates under formal legal requirements of ESA and section 7 compliance requirements: Public laws; 106-392 (2000) and 109-183,

Structure

- Program functions under general principles of adaptive management and requirements of long-range operational recovery program. Management actions identified, implemented, evaluated and revised based on results of research and monitoring.

Participants

- State of Colorado, Utah, Wyoming; USF&WS, BOR, NPS, WAPA, Colorado Water Congress, Utah Water Users; Wyoming Water Association, Colorado River Ecology Distributions Association, The Nature Conservancy, Western Resource Advocates

Program Development

- 1984: Implementation of negotiations to resolve ESA/depletions conflicts
- 1985: Recovery program proposed
- 1987: Framework document
- 1988: Cooperative agreement signed
- 1993: Section 7 agreement signed
- 1993: Section 7 agreement final
- 2002-2010: Expanded capital projects

Program Management/Decision Process

- Implementation Committee (ED), Management Committee, Biology Committee, Water Acquisition Committee, I&E Committee
- General Agreements
    - ESA compliance achieved

- BOR & WAPA operate projects consistent with ESA Section 7 and existing contracts
- F&WS determines sufficient progress for recovery action plan
- Program provides flows F&WS determines essential to recovery
- Participants responsible for viable program
- Costs equitably distributed
- Agencies retain authorities and laws and compacts maintained
- Participation voluntary
- Decision process is by consensus

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM (PRRIP)

Origin:

- Concern over Pallid Sturgeon and bird species; Interior Least Term, Whooping Crane, Piping Plover decline in the Central and Lower Platte River Basins. Colorado, Wyoming and Nebraska proposed to create the PRRIP in 1997.

Goals:

- Goals are represented as milestones for period increments. In the programs first 13 year period increment there are three primary goals (elements)
- Increasing stream flows in Central Platte for fish and wildlife in specified time periods
- Enhancing habitat for target bird species
- Accommodating new water developments

Legal Context

- Program operates under a formal cooperative agreement of three states (CO, NE, WY) and the USDOI; US BOR EIS; USF&WS Biological Opinion and federal legislation.

Structure

- Formal Cooperative agreement of program participants
- Directed by Governance Committee (GC) with representatives from Wyoming, Colorado, Nebraska, US Department of Interior, Water users, and Environmental Groups

Participants

- State of Wyoming
- State of Colorado
- State of Nebraska
- U.S. Dept. of Interior
- Water Users
- Environmental groups

Program Development

- 1997: Cooperative agreement signed
- 1998: Governance committee plans program implementations assessments initiated
- 2006: EIS and ROD approved by USDOI
- 2006: Biological opinion approved by USDOI
- 2006: Nebraska governor authorizes program
- 2007: Management actions implemented

Program Management/Decision Process

- Governance committee develops and approves 13 year program milestones and annual budget.
- Program managed through executive director.
- Entities responsible for recommending program and budget direction are Water Advisory Committee (WAC) and Land Advisory Committee (LAC)

Accomplishments Toward Resource Improvement Through Management Actions and Science

- Adaptive management strategies
- Fish assessments
- Bird assessments
- Strategic and operational land plan
- Strategic and operational water plan
- Water reallocations
- Land acquisitions and conservation practices
- Monitoring and research plan

LOWER COLORADO RIVER MULTISPECIES CONSERVATION PROGRAM (LCRMSCP)

Origin:

- Concerns over water depletion in lower Colorado River, conservation of species and habitat and other resources in accordance with ESA. Foundation in federal, state and other participant's agreement

Goals:

- Conserve habitat and work toward recovery of T&E species as well as reduce likelihood of additional species listing
- Accommodate present water diversions and power production and optimize opportunities for future water and power development
- Provide basis for incidental take authorization

Legal Context:

- Responds to NEPA and ESA
- 2006 EIS and related NEPA requirements
- ESA Section 7 and 10 compliance requirements and related HCP

- Other law of river related compacts

Structure:

- Unique 50 year program agreement
- USBOR manages river operations
- AZ, CA and NE users own water rights
- Sec. 7 USBOR consultation and Sec 10 permit for non-federal activities
- LCR previous expressed modifications considered in program goals, compliance etc., i.e. all past dams, diversions, etc. in baseline as well as changes not expressed. Includes effects into Mexico

Participants:

- Federal agency group
- Arizona participants (26 entities)
- California participants (11)
- Nevada participants (5)
- Native American Group
- Conservation Group
- Other groups

Program Development:

- 1990s Concerns over lack of formal protection and management program.
- Initiation of EIS
- 2006 Completion of EIS
- 2007-2010 Formalized program plans; Science and Monitoring Plan

Program Management/Decision Process:

- Managed by a steering committee using a consensus based process and formal dispute process. Follows developed Annual Work Plan and Annual Budget.
- Budget 1-20 yrs average $20 million per year: 26% science, 61% habitat creation and maintenance, 5% fish augmentation. 8% administration.
- Cost share 50% fed, 50% states

Accomplishments Toward Improving Resources Through Management and Science:

- Native fish assessments
- Non-native fish assessments
- Flora/fauna assessments
- Non-native fish management (removals, regulation)
- Target areas for habitat development and restoration; flood plains, marshes, backwaters, etc.
- Target areas for habitat maintenance based on species needs
- Flow management from dams
- Native fish augmentation combined with programs for self sustaining populations
- Systems wide science and monitoring program
- Final science strategy and science reports
- Site selection criteria for habitat maintenance and development
- Annual work plans and budget

KISSIMMEE RIVER RESTORATION EVALUATION PROGRAM (KRREP)

Origin:
- Approved channelization (1954) of an original 160 kilometer stretch of the Kissimmee River in South Florida to 70 kilometers for flood control Significant degradation to the ecological integrity of the river system with broad impacts to physical and biological resources.
- USDOI and State of Florida approved restoration of river in the 1970s. Represented the largest river restoration in the U.S.

Goals:
- To restore as possible the ecological integrity of the Kissimmee River including physical, biological and related social components. Application of CAM principles in both restoration and long term management of the restored river.

Legal Context:
- Endangered Species ACT, National Environmental Protection Act
- Kissimmee River EIS and Record of Decision
- Formal Cooperative Restoration Program of U.S., Florida and local governments.

Structure:
- Formal corporative agreement of program participants for ongoing collaboration, planning and management.

Participants:
- U.S. Departments of Interior, Commerce, Agriculture, Reclamation; Florida State Departments of Water, Natural Resources; local county and municipal groups, private stakeholder groups.

Program Development:
- 1970s. Environmental resource and social assessments.
- 1980s. Development of demonstration and pilot projects and assessments of results of hydrologic changes on ecology.
- 1990s – 2000s. Design and implementation of comprehensive restoration strategies and comprehensive ecological evaluation program.

Program Management Decision Process:
- Program management guided by long term strategies and short term operational plans.
- Management and decision processes by cooperative U.S. and Florida Natural Resource agencies. Stakeholder input through South Florida Water Management District Planning Programs.

Accomplishment Toward Improving Resources Through Management Actions and Science:
- Hydrologic assessments
- Biology assessments
- Flora assessments
- Adaptive management protocols and processes

- Demonstration of hydrologic management
- Demonstration of biology restoration
- Development of ecological restoration plans and programs
- Development of comprehensive ecological evaluation program

LOWER BRIDGE RIVER COLLABORATIVE ADAPTIVE MANAGEMENT PROGRAM

Origin:

- Development of the hydroelectric Terzaghic Dam (1960) significantly reduced river flows and altered flow regimes so as to significantly impact downstream fish, recreation, cultural and other resources. General public concern resulted in development of CAM in early 2000s to gain alternatives for resource improvements.

Goals:

- Develop collaborative adaptive management program for consensus building, structural decision process, meaningful First Nation consultation, and conflict resolve.
- Design alternatives to attain multiple resource outcomes.

Legal Context:

- Canada federal and provincial law and regulation protecting commercial and sports fisheries, native flora and fauna, industry and culture.
- Federal and provincial agreement on cooperative Lower Bridge River alternative management approaches.

Structure:

- Collaborative adaptive management program of cooperating agency managers, stakeholders and scientists.
- Working groups developed on volunteer participation.

Participants:

- Federal water, power and natural resource agencies; British Columbia water, power, natural and cultural resource agencies; water and power interests; environmental interests; recreation interests.

Program Development:

- 1980s – 1990s. Development of assessment data on flows.
- 2000 – 2005. Development of adaptive structured decision making (SDM) framework.
- 2000 – 2005. Development of experimental flow plan hypothesis and proposed management actions.
- 2005 – 2010. Implementation of management actions and monitoring.

Program Management/Decision Process:

- Recommendations from working groups provided to Ministries of Environment and Power.
- Use of designed Structural Decision Making Model

- Use of structured consultation approaches with First Nations.

Accomplishments Toward Improving Resources Through Management Actions and Science:

- Evaluation of biophysical resource data, proposed management actions
- Implementation of structured decision making model
- Experimental flow plan
- Implementation of management actions
- Monitoring of resource change

THE APACHE SITGREAVES NATIONAL FOREST (ASNF) STEWARDSHIP RESTORATION PROGRAM

Origin:

- 1980s- 1990s. Loss of mature Ponderosa Pine forest component to insect and disease and catastrophic wildfire, threatening ecological integrity of forest watersheds.

Goals:

- Establish collaborative adaptive management processes for developing capacity for consensus and dispute resolution on landscape level forest restoration approaches.
- Develop demonstration and pilot approaches for ecological restoration of large forest landscapes.
- Design and implement 100,000 – 150,000 acre stewardship restoration program.

Legal Context:

- Proposed large scale terrestrial and riparian restoration supported by multiple federal law and associated regulation; Clean Water Act, National Forest Management Act, Endangered Species Act, Healthy Forest Restoration Act, etc.
- Improved management practices regulated by NEPA and A/S Forest Plan, EIS.

Structure:

- A/SNF Natural Resource Working Group for Restoration is recommending body to Forest Supervisor. Associated technical and science committee's develop and recommend various management actions, monitoring, pilot programs, etc to USFS

Participants:

- Natural Resource Working Group (NRWG) incorporates federal agency, state agency, tribal, local government, agricultural, industry, business, water, environmental and general public interests. NRWG is a volunteer group.

Program Development:

- 1990 – 1994. Baseline ecological assessments of forest and riparian ecosystems.
- 1995 -2000. Development of baseline assessments of 17,000 acre Blue Ridge Pilot Restoration Areas.
- 2000 – 2005. Post treatment assessments. Develop and implement multiple resource monitoring program.

- Develop A/SNF Strategic Restoration Plan.
- 2005, Develop and implement 125,000 acre landscape forest stewardship restoration program.

Program Management/Decision Process:

- Recommendations on program planning and implementation by NRWG and committee's, i.e. science, technical committees.
- Decisions on management actions by A/S Forest supervisor and Tribes with consultation by USF&WS and other agencies.
- Program management by A/SNF, White Mountain Apache Tribe and other federal, state, and local agencies of authority.

Accomplishment Toward Improving Resources Through Management Actions and Science:

- Landscape forest resource baseline assessments
- Riparian landscape forest resource baseline assessments
- Socio-economic baseline assessments
- Forest restoration pilot and demonstration implementation and assessments on 17,000 acres.
- Monitoring program development and implementation by Multi-Party Monitoring Board
- Design and implementation of 125,000 acre stewardship restoration program.

THE LINCOLN NATIONAL FOREST (LNF) COLLABORATIVE STEWARDSHIP RESTORATION PROGRAM

Origin:

- 1980s and 1990s loss of mature mixed Conifer forest landscapes to wildfire and insect and disease. Watershed health decline and impacts to water quality and quantity resulted in local government demands for restoration of forest ecosystems.

Goals:

- Establish LNF Collaborative Forest Resource Working Groups to design program approaches with Mescalaro Apache Tribe
- Develop and implement demonstration LNF/Mescalaro Stewardship Restoration Program
- Develop large landscape stewardship restoration program.

Legal Context:

- LNF/Mescalaro cooperative stewardship restoration supported by NFMA, HFRA, ESA, NEPA and associated regulation.
- LNF/Mescalaro/State and County government cost share agreements for forest restoration.

Structure:

- LNF Otero County Forest Restoration Working Group and Ruidosa Forest Restoration Working Group provide recommendations to Forest Supervisor and Regional Forester.
- Forest Supervisor and staff serve on two working groups, which are volunteer organizations of approximately 25 – 50 active members.

Participants:

- Volunteer workings groups (2) comprised of federal agency, state agency, tribal, local government, agricultural, energy industry, business, water, environmental and general public interests.

Program Development:

- 1998 – 2002. Develop baseline ecological assessments of forest and riparian ecosystems
- 2005. Develop LNF Strategic Restoration Plan
- 2006. Implement LNF/Mescalaro 16,000 acre pilot stewardship restoration program
- 2007. Design LNF Monitoring Plan
- 2009 – 2010. Design LNF/Mescalaro Stewardship Restoration Program.

Program Management/Decision Process:

- Recommendations on restoration program planning and implementation by LNF/Otero County and Ruidosa Working Groups.
- Decisions on management actions by LNF Forest Supervisor and Mescalaro Tribe with consultation of federal and state agencies.
- Program management by LNF, Mescalaro Tribe, and other federal, state and county agencies of authority.

Accomplishments Toward Improving Resources Through Management Actions and Science:

- LNF forest and riparian baseline resource assessments
- Socio-economic baseline assessments
- Hydrologic baseline assessments
- LNF Strategic Restoration Plan and Monitoring Plan
- LNF/Mescalaro 16,000 acre stewardship restoration project.

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TRINITY RIVER RESTORATION PROGRAM (TRRP)

Origin:

- Construction of Trinity and Lewiston dams in the Trinity River Basin, CA in part created significant impacts to fish and wildlife populations in the Trinity River Basin. The 1984 Trinity River Basin Fish and Wildlife Management Act authorized the Secretary of Interior to develop and implement a management program to resolve resource issues.

Goals:

- Improve hatchery capability to mitigate salmon and steelhead losses.
- Restore natural salmon and steelhead production
- Fish harvest management.
- Compensate for wildlife impacts
- Stabilize watersheds to reduce sediment inputs to river.

Legal Context:

- 1984 Trinity River Basin Fish and Wildlife Management Act.
- 1992 Central Valley Project Improvement Act.

- Trinity River Mainstream Fishery Restoration EIS, 2000.
- Supplemental EIS, 2001.

Structure

- Eight member Trinity Management Council (TMC) established to recommend program alternatives to the Secretary of Interior.
- Trinity Adaptive Management Work Group, River Restoration Program Staff and Scientific Advisory Board assist TMC in recommendations.

Participants:

- TMC Members; Bureau of Reclamation, U.S. Fish and Wildlife Service, U.S. Forest Service, National Marine Fisheries Services, California Resources Agency (Departments of Water, Fish and Game), Trinity County, Hoopa Valley Tribe, Yurok Tribe.
- Members of AMWG (15-20), Restoration Programs Staff (12), SAB (5).

Program Development:

- 1984 Trinity River Basin Fish and Wildlife Management Act.
- Development of action plans for main goals; 14 member Task Force.
- 2000 EIS and ROD establishing program.
- Establishment of TMC, support entities and initiation of science and management activities.

Program Management Decision Process:

- Secretary of Interior is final decision body for program direction.
- TMC is empowered by Secretary of Interior to take a strong leadership role in policy issues, decision-making and recommendations.

Accomplishment Toward Improving Resources Through Management Actions and Science.

- 1980s – 1990s Completion of Trinity River Flow Evaluation Studies.
- 1990s – 2000s Completion of EIS, evaluation of alternatives and selection of preferred alternative.
- 2000 – 2010 Completion of monitoring and research assessments, BO.
- 2000 – 2010 Implementation of management actions.

CAL-FED Bay-Delta Environmental Restoration Program(CAL-FED ERP)

Origin:

- The CAL-FED Bay-Delta Environmental Restoration Program (ERP) is one element of the comprehensive CAL-FED Program, which addresses water quality, water supply, flood control and ecosystem integrity in California's Central Valley and Bay-Delta regions. Due to extensive threats to the environment from development in the region, the Environmental Restoration Program (ERP) was initiated in 2000. The CAL-FED ERP is one of the largest and most comprehensive restoration programs in North America.

Goals:

- The two following overreaching goals are underpinned by six general goals and multiple objectives and information needs for each general goal.
  - Increase amount and quality of aquatic and terrestrial habits in Bay-Delta ecosystem.
  - Improve the ability of Bay-Delta ecosystem to support diverse and self sustaining environmental and social resources.

Legal Content:

- Multiple Federal and State laws, regulations and policy are in place supporting overall CAL-FED direction, major program elements and projects

Structure:

- Multiple working groups represent a diverse group of programs for different physical areas of the Bay-Delta.
- The CAL-FED programs, including all programs in the ERP element independently propose annual programs and associated budgets to CAL-FED administration and upon approval implement programs.

Participants:

- In numbers and diversity of representation, the ERP element of the CAL-FED program is comprehensive as regards local, regional and national interests involved in the region. All levels of federal, state, county, tribal, city and town governments; agricultural; forest; tourism; manufacturing; etc. industry; environmental groups; general public; etc. are represented.

Program Development:

- Although many elements of the CAL-FED program had been in operation, the CAL-FED Ecological Restoration Program was not approved by the California Legislature until the fall of 2000.
- Significant activity has occurred in 2000 – 2010 on developing the science basis for ecological integrity of the Bay-Delta. Focus has been on development of systems of models and best knowledge for defining policy experiments and management actions.

Program Management/Decision Process

- Program management is accomplished by a structured set of recommending and advisory groups to federal, state and local government agency managers.
- Due to the environmental and socio-economic impacts associated with many decisions, they can involve the Governor of California and Secretary of Interior.

Accomplishment Toward Improving Resources Through Management Actions and Science

- 2000 – 2005: The CAL-FED ERP, as developed, is one of the most comprehensive CAM Programs in North America. Extensive planning and programming has occurred to accomplish three immediate objectives.
  - Fully define and implement the governance model for the program, i.e. Collaborative Adaptive Management (CAM).
  - Implement science strategies and programs to define and gain ecological integrity.
  - Develop complex set of conceptual, simulation, predictive, etc. models to guide management action, definition and assessments.

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