COASTAL LOUISIANA
ECOSYSTEM ASSESSMENT & RESTORATION (CLEAR) PROGRAM:
A TOOL TO SUPPORT COASTAL RESTORATION

Final Report To:
Department of Natural Resources
Coastal Restoration Division
Baton Rouge, Louisiana

DNR Interagency Agreement No. 2512-06-02
OCR Interagency Agreement No. 435-600636

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Technical and Scientific Challenges for
Responding to Large-Scale Ecological Restoration
Chapter 8
CLEAR Volume IV
June 2008

Light S.S. 2008. Technical and Scientific Challenges for Responding to Large-Scale Ecological Restoration, Chapter 8. In, R.R. Twilley (ed.), Coastal Louisiana Ecosystem Assessment & Restoration (CLEAR) Program: A tool to support coastal restoration. Volume IV. Final Report to Department of Natural Resources, Coastal Restoration Division, Baton Rouge, LA. Contract No. 2512-06-02.

Technical and Scientific Challenges for Responding to Large-Scale Ecological Restoration

CLEAR Volume IV, Chapter 8

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Submitted to the CLEAR Office February 8, 2008

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Summary of Tasks 1 & 2
Findings and Implications

Purpose and Approach to Tasks 1 & 2

The Purpose:

The purpose of this sub-contract is to support the development of adaptive management strategies for Louisiana coastal areas. To that end, Tasks 1 and 2 will provide (a) an assessment of the scientific and technical issues for analyzing coastal programs and functions and (b) a review of restoration efforts from other regions of the country. These tasks will yield draft conclusions and implications for the Louisiana Office of Coastal Restoration and Management (OCRM). Dr. Stephen S. Light was retained to complete these technical and science-based tasks and the following related products:

- **Task 1 Product:** Dr. Light will be responsible for preparing a matrix (with support from OCRM staff) that analyzes technical and scientific for coastal and programs and functions.

- **Task 2 Product:** Dr. Light will be responsible for drafting a report describing other technical and scientific programs from regional restoration programs around the nation.

<u>Overarching Question of the Task Order:</u>

"How do you integrate the legacy of existing restoration projects/programs that may be operating at a smaller scale (project) into new efforts operating at larger ecosystem and landscape-level scales?”

<u>More Detailed Considerations</u>:

- Task 1—the assessment of technical and scientific functions and programs —is based on Dr. Light’s skills, experience, and knowledge of existing (e.g., CWPPRA, LCA) and future (e.g., CIAP, CPRA and LACPR; WRDA, OCS) Coastal Louisiana programs. Dr. Light’s understanding of these programs has been gained through his attendance at in-person meetings and conference calls and through review of background documents and other supporting information.
- Task 2—the analysis of challenges faced and lessons learned from comparable large-scale restoration programs and their applicability to Coastal Louisiana—should address the need for integrative science through decisions pertaining to operations, planning, assessment, monitoring, and field-testing.
- Appendix – the appendix contains list of case studies drawn from and a bibliography used to support all findings.

Intended Use of Products: The work products— the assessments and the report—have two primary intended uses. First, they will help position OCRM leadership for advocating for greater system-wide planning and operations of ecological restoration. Such a model would account for the social and political realities that will help shape the future of science and engineering for restoration and protection. Second, the work products will be used to (a) complement organizational and institutional analyses and (b) inform subsequent meeting(s) and/or workshop(s) organized by others.

The Approach:

The integrating framework known as the Adaptive Process was chosen for conducting the assessment of technical and scientific functions and analyzing pertinent case studies. The Adaptive Process was developed initially in the late 1960s (Ralf Yorque, 1968), discussed in seminal work by Walters and Hilborn (1978), and updated by Holling (1981). It was updated again in 2007 (Light and Gunderson, forthcoming 2008) based on extensive review and testing of the process against case material over a 4-year period.

The Adaptive Process consists of three phases (See Figure 1):

- Adaptive Learning Phase
- Adaptive Assessment Phase, and
- Adaptive Design Phase

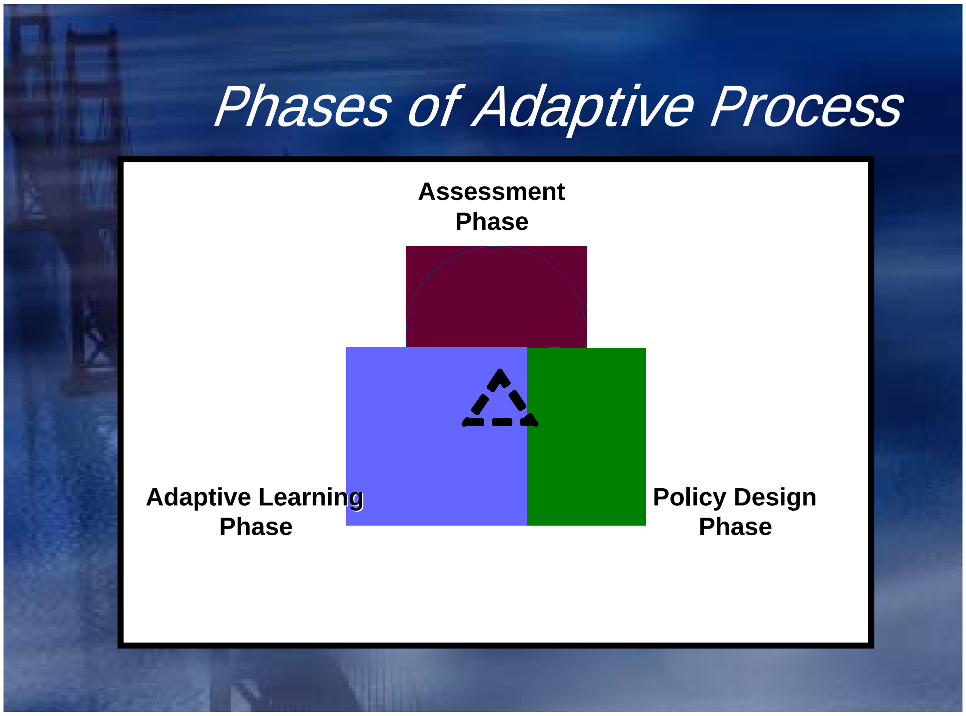

Figure 1 Three Phased Adaptive Process

Unfortunately, most portrayals of Adaptive Management miss the key features essential for successful implementation. These portrayals show only a limited version of the Deming "learning wheel" or "Plan, Act, Review, Revise" used in Total Quality Management programs. Such portrayals are not only simplistic and inaccurate but also misleading. These images give one the impression that, like "planning," there are a series of discrete steps to be followed that, in the end, will reveal the preferred solution. A detailed discussion of the trappings and failures of less informed and ill-conceived attempts at describing or applying the Adaptive Process is beyond the scope of this task order. Instead, the tasks and the chosen approach are well informed and comprehensive. This paper provides a description that is consistent with and an extension of the original Adaptive Management works.

The three phases of the Adaptive Process shown in Figure 1 are further revealed as a set of interlocking and mutually reinforcing components of a dynamic system (See Figure 2) where none of the components are ever fully "out of play." At the core of the interlocking phases is the Hypothesis. The entire Adaptive Process pivots around the hypothesis, which is a reminder that all natural resource policies and actions are really small boats adrift in an uncertain sea full of surprises and the unknown.

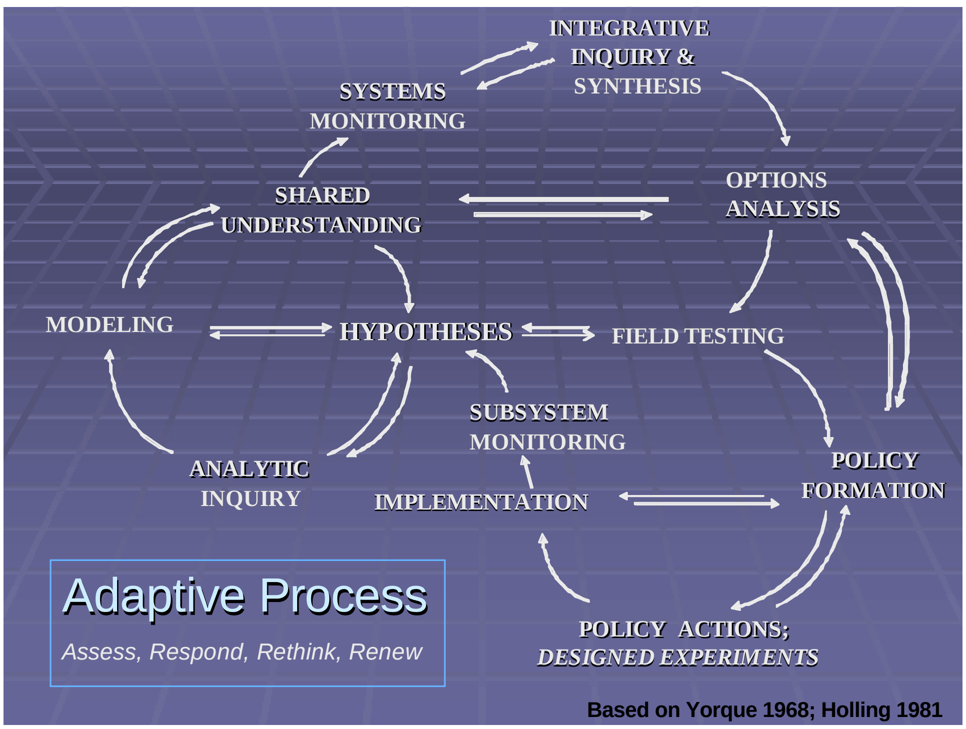

Figure 2 Components of the Three Phased Adaptive Process

For the purposes of this task order, the Adaptive Process has been arrayed by components embedded in phases with consideration given to the inputs and outputs requisite to each phase (See Figure 3).

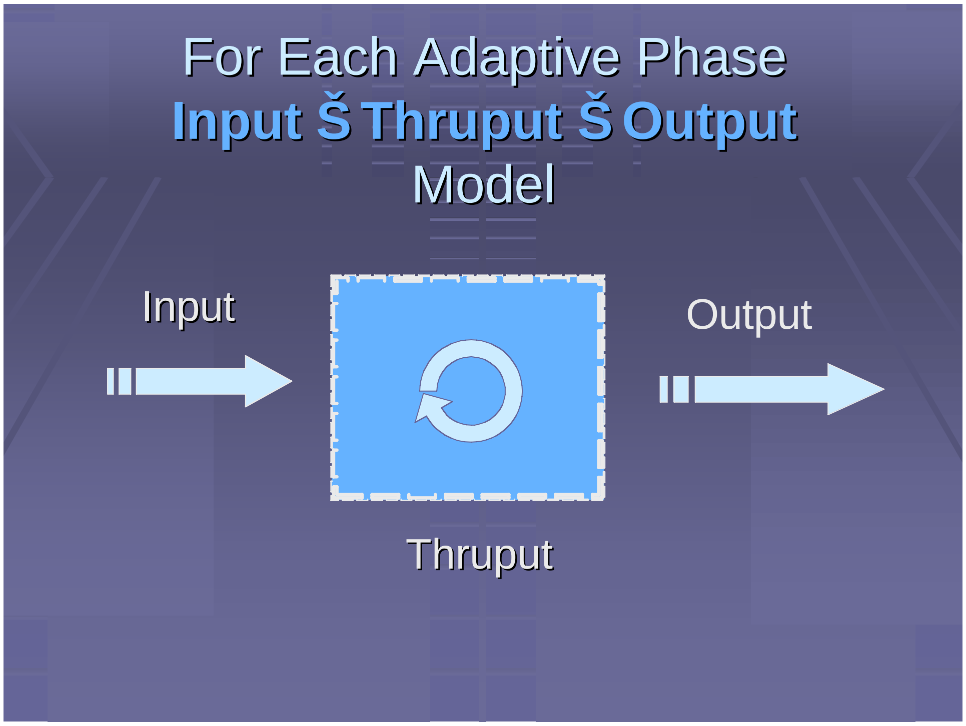

Figure 3 Input-Thruput-Output Models for each Phase of Adaptive Process

This Input-Thruput-Output framework makes the subsequent assessment and analysis more tractable. It does so by explicitly addressing the relationship between one phase and the next of the Adaptive Process and within a phase, the relationship between components For the sake of parsimony and elimination of redundancy, a select few “input” and “output” rows in the Tasks 1 and 2 matrices have been omitted without sacrificing valuable content in the following table.

Overall Conclusions and Implications

Technical and Scientific Issue	Findings	Implications Integrative Science & Technical Functions and Programs
1. Legacy to Landscape, the Challenges and Fitting Responses	a. Legacies are barriers. All large-scale restoration and recovery programs exhibited institutional, cultural, policy, and operational legacies that serve as barriers to implementing restoration programs. b. New approaches are starting to emerge as ways to negotiate such legacy issues. For example: i. The Army Corps of Engineers hires the Fish and Wildlife Service to address "science blind spots;" ii. F&W Cooperative Units are working to bridge the gap between traditional disciplinary science and integrative science; iii. Programmatic EISs are used as a way to develop restoration approaches at a landscape level that involves integrative science. Such methods avoid many agency procedures by breaking the cultural "mold;" iv. Pool stage drawdowns on the Upper Mississippi River help to break the "mold" by temporarily shifting operational rule curves.	a. Legacies can be viewed as challenges to overcome instead of roadblocks, which stymie large-scale restoration efforts. b. Managers must be willing to take risks. No one in Alturas, CA, waited to be told that they could develop a programmatic EIS for the restoration of the Sage Steppe region. Together with representatives of the local government, the lead managers concluded that restoration was the right approach. c. The PEIS that governs the Missouri River Recovery program helps integrate science and management in spite of history and institutional cultures that reinforced stovepipes and poor working relationships. d. Informal groups of scientists in the Everglades, Missouri River, and Upper Mississippi River basins have helped work through "legacy" stumbling blocks.
2. Drilling Down – One Distinctive Value of the Adaptive Process	a. One of the major problems that blocked improvements in Adaptive Management in the past, was not having a framework and process that were robust enough to allow practitioners to see both the forest and to be able to drill down into the roots to better	a. The three-phased Adaptive Process and its components provide the key to a process that facilitates the understanding of both functions and programmatic relationships.

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	understand the major components and their interrelationships.	
3. From Engineering Planning to Adaptive Design	a. Planning in general and engineering planning specifically are forms of social engineering, which are by definition non-adaptive. Records of Decisions are intended to lock in a set of allocation. Prescriptive decisions are intended to persist through the life of the management plan. Similarly, engineering planning has been traditionally a "Plan it, Build it, Leave it" approach to water resource development. b. Adaptive Management has never used the term "planning" except in a very restricted operational sense. Adaptive Management is a design process because the emphasis is on properly framing the problem, not following a set of predetermined steps to arrive at a set of alternatives that may only differ in incremental ways.	a. The Louisiana CPRA is a framework document that establishes a methodological approach and priorities but does not set forth a list of predetermined projects. Instead, the characteristics of the major biophysical provinces are laid out, issues are specified, and initial options for consideration are outlined. The CPRA did a remarkable job of not getting trapped by either traditional planning methods or their expectations. b. The CPRA was based on principles of Adaptive Management. The staff followed up by fleshing out the whole Adaptive Process. There was no need to resort to planning processes. By design, Adaptive Management involves action, monitoring, and adjustments. Even the formation of policy is not a cookie cutter approach but tailored to specifics; emphasis is on creativity and ingenuity.
4. Action as Inquiry	a. Seasoned science practitioners from around the nation agreed that unless management action included the rigors of scientific inquiry (controls and inference) that the program did not qualify as Adaptive Management. There was no hedging on this issue. b. If there is insufficient flexibility to do management by experiment, then less rigorous attempts to employ degrees of inference and control must be present.	a. The implication is that scientific management needs to lead and not follow other forms of management, regulatory, planning, etc. Regardless of what name you give it, scientific management is where policies at all levels are treated as hypotheses and actions as inquiry. b. The tag of "adaptive management" is really not important; using a method that gives priority to uncertainty and precaution is!
5. Systems	• One of the biggest surprises in	a. The best way to demonstrate the

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Level Operations and Manageme nt – New Function	applying the template of the Adaptive Process to large-scale restoration efforts was the realization that the alignment between "legacy and landscape" required a management and operations capacity at the systems level. All major restoration efforts have legacy issues dating back 60-100 years.This means that as new projects and programs come on-line, adjustments will be needed so that the old and the new fit together appropriately to ensure continued performance and effectiveness. Every large-scale restoration program faces this challenge. One of the best initial responses to the issues pertaining to legacy and landscape is to optimize the existing operations. Whether dealing with land or water management practices, one should first determine the system's capacity for adaptation, as well as how functions and programs can be combined operationally, so that ecological benefits do not continue to be lost or options foreclosed.	implications is to give an example. Management and operations of Lake Okeechobee have been "buckling" under the increasing load of functions programs since the 1970s . In response to the increasingly difficult situation, a new interdisciplinary team has been developed to help balance operational requirements (flood control, hurricane protection, water supply, and management programs involving wetland restoration, estuary protection, and water quality improvement). Sometimes every week, month, or season present new challenges that require appropriate responses. It is not the kind of management that can be "planned" or given to "artificial intelligence" or "rule curves" – this interdisciplinary team has to design novel solutions to emerging situations.
6. Adaptive Learning – Where one loop won't do!	a. The most widely used mantra in Adaptive Management is "learning by doing." However, no one really pays systematic attention to how learning is integrated into monitoring, assessment, and decision-making processes. b. When asked, even some of the most seasoned practitioners do not understand that Adaptive Learning is totally different from Deming's learning wheel or other variants of that theme.	a. Learning, as a distinct phase integral to scientific management for large-scale restoration, must be taken seriously. b. The basic questions of: who learns, how do they learn, what do they learn, AND how does learning change the way technical and scientific functions and programs respond in the future, are non-trivial. c. Integrative science must strive to close the gaps between agencies, disciplines, constituencies,

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	Why? c. Adaptive Learning is not "continual improvement." This is a myth that has grown up around scientific management and is very misleading. Scientific management intentionally perturbs the system to reveal learning that would otherwise remain latent in the system. Scientific management also challenges its assumptions upon which hypotheses are based. d. Adaptive Management or scientific management for restoration is like a 12-step program. We should start by admitting that our policies are not in control, that we have little idea of what trajectory nature is on, and that we are addicted to overexploitation and treating nature as the enemy or victim. It may sound ridiculous, but it is the hard-nosed truth. If anyone should doubt this analogy, remember that the Mississippi River should flow into a delta formation not a delta decline or collapse period. e. Learning is as much qualitative as it is quantitative. It is commonly believed that scientific management is all quantitative. Yes, Adaptive Management uses numerical models, but the real breakthroughs in thinking are qualitative, and the closing of gaps in scientific knowledge usually starts with a hunch. Moreover, a new conceptual ecological model makes common tools available that effectively communicate	management, and policy. The Adaptive Process goes into this in some detail. The Adaptive Learning and Assessment phases should ensure that all credible participants understand the derivation of policy options. There is only one rule in the Adaptive Learning Phase: keep everyone in the game. d. Within the Adaptive Learning Phase considerable attention is given to the development of "shared understanding." If people are going to be asked to share in risk-taking during the action phase, then everyone must understand the basis for those risks. There is no slight of hand, or invisible hand, there is only the open hand. Constituents are invited to sit knee to knee with policy makers, scientists, and managers. All participants should contribute feedback to questions of design and proposed actions to form policy.

Technical and Scientific Issue	**Findings**	**Implications Integrative Science & Technical Functions and Programs**
	relatively complex scientific information.	
7. The Centrality of Hypotheses	a. Policy and management actions are hypotheses masquerading as answers. As one looks at the Adaptive Process, the hypothesis is like the center pivot around which everything else revolves. This is a major shift in the way scientific management was originally conceived in the United States by Gifford Pinchot. At the turn of the 20th century, Pinchot and Theodore Roosevelt were looking for a way to get politics out of resource management and put it in the hands of experts scientifically trained to make the tough decisions independent of outside influences. This was part of the populist vision of continual progress. Unfortunately, just the opposed happened: managers were co-opted by powerful interests and the "iron triangle" took over – managers, politicians and powerful interests.	a. The implications of the new scientific management are that no experts can deliver authoritative answers; the world of natural-resource management and restoration is fundamentally complex. Many would say we have heard this before, and that testing hypotheses is old news. b. The problem is that most of society is operating under the rules of the "old school" of scientific management —which acts under the influence of powerful interests, unlike the "new school" of scientific management. c. However, the conditions have changed, and the myth of unbridled progress has been busted. Natural capital, not physical (man-made) capital, is now the limiting factor in economic viability. For example, water is currently touted as the "oil and gold" standard of the 21st century, whereas in the past it was regarded as a free and abundant good. d. In this new game of resource scarcity, the rules are set by an uncertain future of how the relationships between energy, water, growth, infrastructure and the environment will unfold. As just one indication of how uncertain and transformative this new future will be, the western states are now talking about the unthinkable: interruptible water rights.
8. Effective Communication of Scientific Informatio	a. Modeling is considered one of the major tools of the new scientific management. Few remember, however, that a major academic bloodbath	a. Uncertainty about the future will continue to spur demand for an integrative scientific understanding of how the world works. Modeling is a natural part

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n	occurred over the rise of computer modeling in systems ecology and integrative science in the 19 70s. The reliance on computers for the intricate accounting of largely invisible natural processes became a problem due to the “black box” nature of the models. Nevertheless, models have become an integral part of the “new science,” but their role has been badly handled. b. As an example, as part of the Adaptive Learning Phase, models were not initiated with appropriate experts. Instead, a cross-section of decision makers and those who would have to endure policy prescriptions participated in model development. This meant that the selection of model parameters and relationships became part of a public consensus building process. c. Effective communication of scientific information is best accomplished in learning settings, not in public hearings. People are demanding not just “white” boxes but “open” boxes, where the interested parties have ample opportunity to frame the problem as well as develop potential solutions.	of the cognitive problem-solving process. People create mental maps using simple models of key relationships and then test them to determine effective courses of action. Cognitive dissonance occurs when people realize that their models are not working but continue to act as if all is well. b. Restoration of large-scale ecosystems is about creating new ways of thinking and acting. In the final analysis, ecosystems are a reflection of human systems. Each responds to the other. At the most fundamental level, the metaphor or model of nature as “enemy” or “victim” is at the heart of the problem of ecological restoration. This image must change to embrace nature as “ally” and “partner.” c. While society in general must learn to think of nature from local to planetary scales, climatologists and local government officials agree that landscape and basin-level scales are where new relationships and meaning must be created. d. Agencies are rethinking their education programs to determine how citizens can assist in monitoring and learning about how ecosystems behave and change.
9. Feedback Policy	a. The same survey of seasoned science practitioners that felt that action as inquiry was an essential component of scientific management also agreed that the biggest problem in implementing Adaptive Management was the lack of feedback integrated into collective learning and	a. Mechanisms need to be put into place that essentially requires feedback to be reviewed policy makers, managers and affected parties. In the early years of the Everglades Restoration, Governor Bob Graham required annual report cards. Graham would announce a date for a public meeting where managers

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	adjustment of subsequent policy and action. b. Monitoring is just a technical exercise unless it is organized into information that can be effectively communicated to others and serve as a basis for changing behavior. c. The goal is effective action either by individuals or communities. People need large-scale system models in order to make informed decisions. d. Credible information and ways of structuring that information are necessary to make sense of the world around us. This cannot be accomplished in a mass setting like consumer marketing.	would report, policy makers would respond and leaders of the interest groups would react in a series of panels. b. This event proved so successful that after Graham was elected to the US Senate, the Everglades Coalition, mainly composed of environmental groups, would began scheduling a 3 day conference to review progress on the plan. c. Another forum that proved extremely vital to the restoration was the Governor's Commission on a Sustainable South Florida. The Commission provided an ongoing forum for dialogue on a wide range of issues – economic, ecological and community level. The restoration was the centerpiece but in the context of the whole future of south Florida d. These are just two examples of very powerful "attractors" of the best feedback available to inform everyone and to provide a Reson d'etre forming elements of a feedback policy. Feedback policy is not formed in a vacuum, it needs a reason or being, or else monitoring and feedback loose focus and relevance.
10. Institution al Memory	a. Data sets from years of monitoring are lost due to constant changes in hardware and software that render old information unreadable. Employees with 30+ years of rich experience and deep understanding are walking out the door with no thought given to the loss of institutional memory. b. One of the most indispensable people in MN Division of Fisheries whose first job on	a. Agencies need to develop systematic plan for learning, including the identification of uncertainties, methods of resolving uncertainties and how to evaluate existing actions and mechanisms for retaining lessons learned in institutional memory. This is the stuff that integrative science and management are made of. b. Files, reports, computerized databases and people's minds are all incredible sources of decision relevant knowledge.

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	staff was to manage the monthly newsletter that the division put out to its constituencies. The job was not challenges but the opportunity to read over 60 years of newsletters, reports, memoranda, made him an invaluable resource to the division for knowing the lessons learned and being able to apply them in new decision making settings. c. An active institutional memory eliminates or discourages people from burying mistakes instead of using them as sources of learning. Institutional memory has been ignored because policy makers and managers would just as soon bury their mistakes.	Jim Lane was the last surviving engineer in the early 1990s that knew how all the modifications to the original Corps project that is the plumbing systems for South Florida. He knew what problems he regional original design and operations created and what actions, operational or structural were taken to make necessary adjustments. If Jim would have retired before the history of the regional plumbing system had been written, the lose of this information to those charged with redesigning the system for restoration would have been "driving blind" the lessons learned from past mistakes and corrective action would have been lost.
11. Analytic v. Integrative Inquiry	a. Scientific methods that are incapable of merging data from different sources present another challenge. This includes the inability to incorporate human experience as part of the knowledge base upon which decisions are made. b. The most fundamental challenges facing integrative approaches to scientific management is the methodological battle that is ragging in the natural sciences particularly at the applied level. c. The bottom line is that when scientists move from small-scale experiments to large-scale restoration the same methods on inquiry do not always apply. d. Three hundred years ago arguments raged between	a. In essence traditional science creates independent strands of evidence that require alternative methods to make sense of the multiple strands that independently only yield very limited views on relational reality. Induction uses these individual strands of evidence as building blocks, pieces of larger, landscape and ecosystem level puzzles. Integrative science must understand the value of induction and master inductive techniques. b. Strong inference means accelerated learning by testing more than one hypothesis at a time. Strong inference provides managers and scientists to weed out hypotheses that demonstrate less explanatory power when tested. c. For integrative science to be effective it needs to be more

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	Bacon, and Kant on one side and Descartes and his followers on the other. The issue was the legitimacy of inductive versus deductive reasoning as a basis for inquiry. The debate was resolved as the fruits of deductive reasoning and reductionist research fostered an age of incredible growth in technological innovation and advances in just about every discipline. e. Today, the strengths of the deduction in the scientific method continues to yield tremendous fruit, however, its weaknesses in being unable to knit together multiple lines of evidence based on differing modes of inquiry is a major methodological stumbling block to integrative science. f. Further, the use of null-hypothesis testing has drawbacks that hamstring integrative inquiry – cross-disciplinary discovery of new understandings – consilience. g. Inductive reasoning has been rediscovered as a fundamental tool for understanding complex adaptive systems and the perpetual emergence of novelty that is integral part of their behavior. Inductive reasoning is not a tool in most resource scientists "took kit" its main purpose as a minor actor in the accretion of theory based on null-hypothesis testing. h. Bayesian Statistics and Strong Inference are being haled as the "new science," despite their deep intellectual roots in decision theoretics. Both of	closely linked methodologically with decision theory. This helps scientists overcome the myth and reality that managers manipulate scientific findings. Well, that phenomenon happens sometimes because they need to convert it into decision relevant framework that science has not provided them. Business schools teach and corporations routinely employ Bayesian statistics and decision theoretics. Frequentist statistics still dominate natural sciences. d. Analytic inquiry needs to refocused on filling gaps in understanding ecosystem function by conducting studies and research that will yield insights into subsystem mechanisms that can inform modeling and be paired with and enhance of the value of monitoring programs.

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	these methods make science more relevant to decision making in large scale restoration initiatives	
12. Requisite Diversity and Functionality	a. There are some fundamental truths about the management of complex adaptive systems that have been largely overlooked, but there implications manifest themselves constantly in the approaches to large-scale restoration efforts. b. The key to why this profound understanding is absent at present is that since WWII when the law was discovered, management has been occupied with various forms and manifestations of social Darwinism – survival of the fittest. So decisions were "one and done" solutions that dominated the landscape and harnesses nature accordingly. An alternative view again is reemerging that it is not the most "fit" that survive but the most "fitting." There are ample instances of this phenomenon in nature, even in "predator-prey" relationships. c. The most fitting response is based on the Law of Requisite Variety discovered my Lord Ashby in England while Turing was working on developing the computer during and just after WWII. d. The Law of Requisite Variety simply states that the challenges from multiple influences and interactions that living organisms face external to them, continually eclipse their extant response capacity, creating a gap; if the gap persists and an	a. The implications for integrative scientific management are clear. The age of "dominant" "most fit" solutions that continually exceed the limits of sustainability are over. b. The new paradigm for management is adaptive – why, because managers and policy makers; social and ecological systems are constantly being acted upon by external forces that exceed their capacity to respond. c. The need for large-scale restoration was inevitable as a societal response under the social Darwinian model of human domination and nature as victim. d. Integrative science for adaptive management of large-scale restoration is a fundamentally new response (requiring new methods and ways of taking action) to a class of challenges whose speed, scale and asperity exceed past response capacity. e. Integrative and adaptive science needs new methods to match the relational reality that of necessity requires more fitting responses. The implication is that management functions like navigation cannot be separated from consideration of protection and restoration. All of these major functions have to be integrated into the management calculus – this is requisite functionally – what are the functions that have to be integrated into a durable solutions?

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	appropriate response is not found or mobilized, the organism's capacity to survive is diminished as lack of responses created a cumulative deficit.	f. Requisite diversity means that diversity mirrors complexity so those who have endured past failed policies have experience and knowledge requisite to developing more fitting responses to calamities like Katrina and Rita. Diversity in perspectives are integral to how complex problems/challenges must be framed and how appropriate or fitting responses must be designed
13. Options Analysis	a. Planning approaches to selecting alternatives were based on a tradition of thinking that largely ignored requisite functionality and diversity. The evaluation of alternatives was iterations of accommodating existing means with ends. b. Preferred alternatives did not depart non-incrementally from the past. Solutions were traditionally projects of the past. This logic supported the findings of two federal reconnaissance studies that said that the benefits did not exceed the costs of Kissimmee River Restoration (KRR). c. The KRR would never have succeeded as the first large scale river restoration, unless major departures from traditional planning practices were not developed – new methods (options analysis) that defined the legitimacy of restoration problems and the credibility of composite solutions that embraced all the requisite functions of	a. Monitoring schemes at large scale must become more imaginative, cost-effective and less bound by scientific precision that unnecessarily sacrifices realism that could influence anticipated decisions. b. Alternatives such as data mining, backcasting, use of informed citizen (avid fly fishermen) who can be trained in scientific protocols for monitoring of trout streams c. Managers will be forced to hold monitoring more accountable; demonstrating that existing resources have been redirected to highest priority needs, that extant data sets are not lost to shifts in technology, that sophistication in protocols are matched with management needs, that indicator schemes are appropriately sized and that the basis for choice of indicator is carefully considered relative to their function of measuring stressors versus effects. d. Monitoring programs also need to be fitted to the needs

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	the river (flood control, water supply, commodity production, commercial sports fisheries, etcetera.) and meaningfully engaged the requisite diversity of perspectives and interests that would have to be swaged into embracing a composite solution that “left no one behind” “produced no regrets.”	of others engaged in research and modeling as well as the requirements of monitoring effectiveness. e. Technological advances in monitoring remotely are coming online rapidly. Monitoring program managers need to anticipate these changes and call them to the attention of decision makers so that cost-effective decisions can be made about what monitoring configuration will best fit anticipated needs and resources.
14. Monitoring	a. Monitoring efforts have fallen into many traps that have questioned their legitimacy and credibility. Their lack of relevance to answering management questions, there lack of monitoring indicators that would trigger management response, the development of exorbitant monitoring designs and protocols and fine resolution that contain irresponsible gaps in spatial coverage from a management perspective, their development in isolation of other monitoring efforts, and the perpetuation of monitoring efforts whose relevance and purpose are predicated on “pet projects” serve as examples of the types of problems monitoring programs have face. b. Nonetheless, systems level and sub-systems monitoring are essential. Past mistakes can be accepted as inevitable growing pains and a valuable tool preoccupied with its own	a. Monitoring schemes at large scale must become more imaginative, cost-effective and less bound by scientific precision that unnecessarily sacrifices realism that could influence anticipated decisions. b. Alternatives such as data mining, backcasting, use of informed citizen (avid fly fishermen) who can be trained in scientific protocols for monitoring of trout streams c. Managers will be forced to hold monitoring more accountable; demonstrating that existing resources have been redirected to highest priority needs, that extant data sets are not lost to shifts in technology, that sophistication in protocols are matched with management needs, that indicator schemes are appropriately sized and that the basis for choice of indicator is carefully considered relative to their function of measuring stressors versus effects. d. Monitoring programs also need

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	internal development at the expense of its informing management of the influences and changes that require their attention and consideration in decision-making. c. Monitoring programs need to be adaptive. As needs for more systems level monitoring become apparent, changes in monitoring schemes will follow. As management and operational adjustments are made, monitoring programs need to be undated accordingly. d. "Sentinel sites" – geographically fixed but relatively isolated monitoring stations may be provide valuable information in management "hot spots" where more extensive and experimental designs are impractical.	to be fitted to the needs of others engaged in research and modeling as well as the requirements of monitoring effectiveness. e. Technological advances in monitoring remotely are coming online rapidly. Monitoring program managers need to anticipate these changes and call them to the attention of decision makers so that cost-effective decisions can be made about what monitoring configuration will best fit anticipated needs and resources
15. Measuring Performance	a. Performance management builds from the ground up in the sense that conceptual ecological models establish parameters and their associations. Performance is the difference between projected and actual response of parameters to management interventions. b. Performance is also measured from the bottom up. Ecological structure and function begin with physical parameters and build chemical and biological understanding from there up. The Kissimmee River Restoration is an excellent case in point, where the	a. There is a growing body of literature and experience that is beginning to take into account that degraded systems often represent new stability domains that resist change. b. Further, the expected response may not resemble the expected response for three reasons: (1) resistance to change of existing relationships; the system may have reached an irreversible state; (2) the new trajectory of a more preferred state of nature may not resemble the past. c. Other key associations may during response to management perturbation assume a novel and new stable configuration; and (3) individual performance measures

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	understanding of the physics of hydrology and sedimentation had to be understood, so that biological responses were not false or transient indicators of long-term performance. c. Revisionist history is one problem associated with the interpretation of monitoring results as pertains to performance. Scientists and managers alike must be patient and not just to conclusions that revise their understanding of the past to fit the results obtained from indicators over short periods of time.	may be entrained by other relationships such as trophic triangles that constrain response do to management action. d. Regardless, the trap of "constant improvement" is a major trap in the monitoring game where management expectations are involved.

Final Remarks

The task order laid some context and hopes within which this work was being conducted. It also eluded to some of the forces shaping the social and political reality that the restoration of Coastal Louisiana and the Office of Coastal Resource Management face. These final remarks attempt to offer a perspective on these topics based on the findings and implications summarized above and discussed in detailed matrices of Tasks 1 and 2.

1. Advocating for greater system-wide planning and operations of ecological restoration

a. Advocating for greater system-wide restoration will require the reframing of existing ways of doing business – restoration is about not only managing change but projecting a new social reality – on a local to planetary scale civilization is losing ground to climate change, oil peaking and population growth.
b. Challenge/Response
   i. Restoration and its science and management need to be reframed in terms of "challenge and response."
   ii. New more complex challenges require more sophisticated responses.
   iii. The speed, scale and complexity of the response must match that of the challenges faced – failures to address the challenges at larger than local scales in the past are necessitating larger more systems level responses.

iv. This challenge/response dynamic is far removed from traditional thinking that served as the basis for the Corps Principles and Guidelines.
    1. Challenge/response is framed as effective action based on changing external conditions. As external forces and feedback change, so do the next round of responses.
    2. Challenges are now growing at exponential rates while societal responses are still sorting themselves out. The Everglades Restoration has still not produced an adequate scientific basis for "getting the water right." That may be do to its preoccupation with building water supply reservoirs at the state level and the federal governments incapacity to act.

c. Planning versus Design
    1. The mentality associated with planning has outlived its usefulness. The challenges we face are too fundamentally complex for planning paradigms to work.
    2. Planning is getting to a decision; a case can be made that planning has contributed to paralysis, by assuming that there is one solution that eventually everyone will agree to that will not require serious adjustment or modification following the record of decision.
    3. Design assumes the biggest challenge to decision making is how the problem is framed and that there is no "perfect" solutions, there are multiple policies that need testing and modification or replacement.
        a. In design, there is no "effective knowledge" there is only effective action; action that has been survived the crucible that only relational reality can provide.
        b. The distinction between planning and design is so important to the US Army that their new manual on counterinsurgency is based on this new paradigm.

ii. There are terms that are bandied about for many different reasons – to distract attention, to project an image of change, to mix metaphors, which allow wolves to appear in sheep's clothing. The advocacy of design over planning is not window dressing, it is a profound change that will enable agencies to respond more rapidly and provide excuses for jettisoning obsolete tools and approaches.

d. Blind Spots – Societal, Technical and Scientific

i. The completion of Tasks 1&2 revealed a number of "blind spots" that are worthy of consideration as rationale for advocating change toward more large-scale ecosystem approaches to restoration and scientific management.

ii. First and foremost, humans cannot detect temporal discontinuities. The Max Plank institution in Germany spent a decade documenting this problem and produced a book entitled the "logic of failure."
    1. GIS is used to demonstrate changes in spatial terms
    2. Numerical models of ecosystems are able to tract temporal discontinuities, lags, thresholds, and limits that are extremely important to large-scale scientific management of natural resources.

iii. "Blind Faith" is accepting predictions about the unpredictable. John Kenneth Galbraith, a professor emeritus from Harvard and national economic advisor to several presidents wrote a small treatise about how financial institutions perpetuate this myth with great regulatory and profit from it. Scientific management assumes ignorance surfaces our knowledge and that predictions are fine as long as you use them to learn why you were predictions failed when tested

iv. The legacy and drag that creates on the initiation of new large scale scientific management efforts is still being underestimated.

e. Lessons learned from other efforts

i. The cases reviewed, the interviews conducted and the reports read have given greater hope to those who are eager to find ways to overcome apparent roadblocks.

1. Ingenuity and taking advantage of informal opportunities to "re-wire" procedures to expedite work and to circumvent normal agency conventions are working.
2. The message is out, that realigning internal procedures to meet external demands needs to take priority.
   a. But how this message is being interpreted varies, but the "seams" are showing so managers seem more inclined to look the other way and allow modifications of procedures to pass.
   b. The endorsement of the Secretary of the Department of Interior of Adaptive Management is emboldening managers and field staff to "experiment."
3. Some senior managers in new positions, under the cover of "new broom sweeps clean" or "the honeymoon period," or "first however many days of a new administration" are not waiting for permission but creating change and not waiting for approval.
4. "Scientific management" is still a very hard pill for some agencies and managers to swallow. They perceive it only as a threat and are not looking for how to make it an opportunity. For example, Mike George senior project management for MO River Recovery said "Why not invite Fish and Wildlife Service in as a partner; they are going to be sitting next to me on every decision anyway"

2. Consideration social and political realities that will help shape the future of science and engineering for restoration and protection.

a. The implications of climate change have not hit the mid-continent region as it has the states west of the 100^{th} Meridian. There is a "tsunami" that has just about overturned all boats in the West.

i. By that, I mean that climate change and oil peaking is triggering a fundamental rethinking of the relationships between Energy, Water, Growth, Infrastructure and the Environment.

ii. A new social reality that begins with "ecological footprints" and carbon credits based on rating of various methods of sequestration, and follows through to "interruptible water rights," and the recognition by the governors that natural capital not human capital is becoming the limiting factor in growth and development.

1. In the past, the West pumped water to where the people wanted to be; in the future that trend will be reversed. Major demographic shifts are being

anticipated.

2. The cost of wheeling water around California consumes close to 20% of all the state's energy needs. This must change.

b. The other dynamic that coincides with climate change is the realization that the nation's infrastructure is beyond its design life and economic life.

   i. Foreign policy commitments have been putting off the re-capitalization of the nation's infrastructure for decades.

   ii. Now that bridges are starting to collapse, levees are sloughing into canals or collapsing due to a combination of accretion and subsidence; the time may be ripe for a reprioritization of national objectives.

The completion of Tasks 1&2 were done with a thought to the fact that they might complement organizational and institutional analyses; however, more attention is the summary was paid to informing subsequent scientific and technical meeting(s) and/or workshop(s) about the lack of alignment between major components of the Adaptive Process and standard or proven practices in the field. It is apparent that moving to large scale ecological restoration will require more scientific innovation along the lines of Conceptual Ecological Modeling as a major new tool for effectively communicating scientific information.

Task 1
Technical and Scientific Criteria
for Analyzing Coastal Programs and Functions

Task 1, Product: With support from OCRM staff, Dr. Light will be responsible for preparing a matrix that analyzes technical and scientific functions and programs. Budget: $14,593. Develop background understanding of CWPPRA, WRDA, LCA, CIAP, and OCS, as well as CPRA and LACPR, through attendance at in-person meetings and conference calls and review of background information.

Process Components of the Adaptive Management Program	Commentary	Technical and Scientific Functions and Programs (T&SF/P)	Questions	Design Criteria
The Adaptive Learning Phase				
➢ Inputs (from Policy Design Phase)				
o **Feedback policy**	• Where are the links that close the loop with policy and condition subsequent actions? • Adaptive Management (AM) is learning in action. However, rarely if ever, is a systematic feedback policy developed and formally adopted to link vital sources with feedback recipients. • Sometimes there are no biophysical monitoring schemes or repositories. When they do exist, the information is deposited and never interpreted, dis-tilled, or	• T&SF/P are first and foremost centered on management problems and intended to confront hypotheses with data. • Therefore it is imperative that a clear and routinely updated set of conceptual models to systems level be developed to determine which hypotheses are in most need of testing and why, and what data are	• What opportunities do T&S monitoring and feedback from projects and programs offer institutional learning? o Who learns? o What needs to be learned? o How do they learn? • What are the novel distinctions signaled by unique events or emerging	Design criteria: • Whatever systems, programmatic, project, and operations levels and linkages are considered important. • Methods to incorporate qualitative data and experience into quantitative analyses and interpretations. • Updates of conceptual and

	distributed to predetermined audiences for specific purposes. • Institutional memory is usually ignored and systematically destroyed for lack of attention or ignorance of its value. T&S data are turned over to administrative staff that has little regard for information.	needed to inform our understanding of extant hypotheses and models. • The data allow the T&SF/P to tie together the salient, necessary, and sufficient features of a systems-level understanding.	patterns? Are systems always changing? • How do we separate signal from noise? • How are research results integrated into feedback assessments and updates of monitoring process? • How do you get feedback from project implementation fed back into updating understanding? • More information on implementation and operations, not just monitoring, is needed.	numerical models. • Goals and objectives that evolve with increased understanding based on experience, and ends and means that are constantly being challenged to improve effectiveness • Established protocols related to sources of, access to, and needs for institutional memory. • Clearly defined relationships between science and scientific management that clarify roles and establish their relevancy to short- and long-term management priorities.
o **Subsystem monitoring**	• Subsystem monitoring involves data collected from management experiments and project operations. • Usually, project monitoring is done only to fulfill regulatory requirements and is rarely based on management initiative to resolve uncertainties. • If managers expect AM to a viable alternative to the EIS	• T&SF/Ps in many cases are insufficiently staffed to anticipate and address management needs. • Science practitioners must realize that they do not function within a context that is conducive to role clarity when working in a management	• Are monitoring schemes designed for determining statistical or biological significance? Which is more relevant to management decisions? • T&SF/P must develop the	Design criteria: • Subsystem monitoring designs that not only looks inward to determine project or study needs but also looks outward to the audiences or other T&SF/Ps the data will serve. • Monitoring schemes

	process and overly prescriptive allocation and regulatory policy, management must take the initiative in designing tests to improve its effectiveness. • This cannot be accomplished without collaboration with the policy, scientific, and citizen communities.	context. • How are monitoring schemes redirected or shut down over time? What are the criteria? How often are schemes for monitoring subsystems reviewed? • How is subsystem monitoring coupled with systems-level monitoring, scientific research, and field tests and surveys? • Target-defined project level: Are project-level goals and objectives established with specific performance metrics and targets to guide project evaluation and facilitate assessment along their trajectory relative to expected performance?	capacity to facilitate management experiments that solve problems by helping them develop monitoring and feedback schemes. • T&SF/P must provide the framework for rolling up monitoring at the project operations level into larger scales. • The "firewall" between management and T&SF/P is in judging trade-offs between risk and reward for management monitoring. Managers are in the business of coping with risks that solve their problems.	specifically designed to deal with high levels of uncertainty. T&S representatives involved with monitoring need to be engaged with project development teams from project inception. • Incorporating compliance monitoring requirements into the project design phase. • A method for using monitoring results to develop annual report cards for policy review.
o **Hypotheses** (e.g., management experiments, field tests, and environmental	• The guiding principle in AM is that policy and management actions are hypotheses masquerading as answers. • An axiom for working in large-scale social and ecological systems: If you are not confused, you don't know anything.	• No two sets of T&SF/Ps are the same. How and under what conditions will hypotheses be tested as management attempts to solve the problem? • Successful management	• Hypotheses development will be part and parcel of conceptual ecological modeling, in which associations and assumptions are used to create	Design criteria: • The two principal tools for hypotheses testing are control and inference. Variants and gradations of these must be considered when moving from

studies)	• These types of "wicked" problems are truly complex all the way through. They have no definitive formulation, no stopping rule, and no test for a solution. There will likely never be a final resolution of any of them. • Wicked problems don't lend themselves to one signal hypothesis. • Typically, wicked problems require multiple ways of framing the problem and multiple modes of inquiry. • AM adheres to the notion of "strong inference" testing of several plausible hypotheses, eliminating the weakest and building on those considered more robust. • Decision makers may be unfamiliar with concepts such as risk taking and with policies that are not "once and for all" pronouncements.	experiments have been few and far between, because most managers are still trapped in a naïve and obsolete concept of "scientific management" in which they view themselves primarily as arbitrators and administrators of activities, not as solvers of complex problems accountable for performance. This is a legacy from the "progressive" era now some 100 years ago. • T&S science practitioners must help managers, policy makers, colleagues, and citizens understand the new set of roles and relationships.	hypotheses. o What are the drives at various temporal and spatial scales that will influence hypotheses? o Based on conceptual modeling, what is the likelihood of alternative hypotheses being invalidated? • As they contemplate hypotheses testing, S&T practitioners must ask two questions: o Which problems are most in need of attention? o What is ripe for action? • What works in one region of the country will not necessarily work in another. o At what level, institutionally and biophysically, are people ready for	basic processes of observation to the use of replications. • Hypotheses can only be invalidated, never validated, given the uncertainty inherent in complex adaptive systems. • Other choices include the use of frequentist statistics (null and alternative hypothesis testing) or the new science of strong inference (examination of multiple hypotheses simultaneously to accelerate learning and rapidly separate stronger from weaker policy options using Bayesian statistics. • Hypotheses articulation, modeling, screening, and testing form the central pivot around which all else in the AM process revolves. • Hypotheses are the centerpiece because uncertainty is our constant companion and surprise is the "wild card" that is always waiting to be played. • Multiple hypotheses

			management treatments? o What will be required to prepare policy makers and managers for treatments for which there may be no alternative? o Is there freedom to experiment? How can flexibility be increased? o What field studies might be conducted to achieve the "bite" size needed for hypothesis testing?	are becoming more necessary because surprises are becoming more synergistic as forces converge in a "perfect storm." • What is the "bite" size into which management treatments must be broken down so that we can separate signal from noise?
➢ **Thruputs**				
o **Analytic inquiry** (in the context of social learning)	Analytic inquiry is the traditional form of scientific investigation that is focused on logically decomposing questions into detailed subprocesses that are amenable to experimental design. This type of experimental method has been very successful in a number of fields and has yielded incredible advances in knowledge and development of technologies. Obviously, its place in the biological sciences is secure.	• From a T&SF&P perspective, redirecting or developing new analytic inquiry to address the gaps in our systems-level knowledge must be a priority. • It is imperative that agency-driven research be redirected to filling in gaps exposed by	• Much of university training is based on reductionist approaches to scientific inquiry. What influences can be brought to bear to encourage more training in integrative science? • T&SF/Ps need training in the principles and	Design criteria: • Establish a process for identifying gaps in existing research based on numerical and conceptual modeling and develop mechanisms to close those gaps. • Provide outreach to the research community to explain to them the function

	However, from an ecological perspective, this approach is a “science of parts.” The sum of the parts does not reveal the whole of ecosystem patterns, behavior, and change, or the discontinuities, limits, and thresholds inherent in ecosystem behavior. As a result, ecosystems are greater than the sum of their parts and different from them. Moreover, when a given set of analytical studies is integrated for the purpose of ecological study, the process inevitably reveals gaps in understanding, because some necessary subprocesses will have been well studied whereas others remain unexplored. To study ecosystem-level phenomena, we must learn how to integrate the parts. We have no alternative. This is sometimes referred to as “new” science that brings a different sort of logic, i.e., induction rather than deduction, to investigative inquiries. Inductive modes, which put more emphasis on experience, use different tools and methods. Without them, science will fall further and further behind in its understanding of the dynamics of climate change and its related phenomena. Consequently, analytic research under a science regime intended to solve management problems	conceptual ecological modeling. • Federal- and state-funded university research should also be given incentives to focus on filling in these gaps. • The fundamental role of S&TF/Ps must be in conducting, funding, or facilitating the integrative science needed for systems-level understanding. • The advent of climate change effects is only exacerbated the demand for mesoscale inquiry. • Integrative science has implications for the design of projects and management strategies that cannot be overestimated at this point in time. • Feedback from subsystem tests at field level or management experiments must be used to update numerical and conceptual models so that policy options and predictions can be improved. • Under integrative science, the emphasis shifts from finding the	methods of integrative science to learn how to interpret the results of traditional science in terms of system-level behavior. How can this be accomplished? • T&SF/Ps in support of management decision making must confront the tradition of null hypothesis research with an alternative approach in which managers co-design and test multiple hypotheses with T&S units. Is there the willingness and capacity to support such technical and scientific activities? • To accelerate learning and eliminate weak hypotheses in the context of complex problem solving, researchers must use strong inference in which biological significance is not equivalent to statistical significance and experience must be	of integrative and inductive science that is designed specifically to address management problems. • Ensure that science presentations to constituents are conducted in ways that facilitate, rather than obscure, social learning. Effective communication of scientific issues is one of the most important functions that S&T units can perform.

	must also focus on filling in the gaps in our knowledge. This is essential if we are going to manage ecosystems that are changing faster than our understanding of them.	"right" answers to adequately framing the questions that management needs to address. • T&SF/P efforts must help engineers involved in planning understand the implications of what they intend. Planning implies that problems are readily identifiable and that following a predetermined set of logical steps can derive solutions. In an integrative approach, the structure of decision-making is to some extent unknown, especially when dealing with high levels of uncertainty. • T&SF/P units must also foster the skills necessary to develop creative and innovative solutions. Ecological needs must be reconciled with viable This does not imply any sacrifice of ecological resilience or integrity but means that objectives must be adapted to achieve more with less.	integrated into the research design and its execution. How do T&S units plan to effectively link managers and scientists accustomed to using analytic methods to achieve this objective?	
o **Modeling**	Conceptual models used at the	• T&SF/Ps need to	• Many numerical	Design criteria:

	system level: Are conceptual models created and used at the program level to make it easier to detect and clarify ecosystem-scale problems by identifying keystone species and relationships and data gaps and to enhance the focus of performance standards and metrics?	become familiar with AEA modeling as a shared learning tool and a way of updating existing understanding with new information from feedback and results from analytic inquiries. • T&S units are the nexus at which science and communication meet. • Considerable attention should be given to how to effectively communicate science. • Science must also be made accessible. Developing effective Web sites that are intelligible to the casual observer as well as the seasoned technical expert is essential. • Linkages among monitoring, modeling and research: Is there an explicit description in the program documents of the ways in which predictive modeling, pre- and post-construction monitoring, and relevant research efforts provide feedback to one another?	models fail to address management concerns in a timely fashion. What will it take to make numerical modeling more responsive? • Modeling can provide a way to herd cats in the sense that it can help to put many scientists from diverse backgrounds on the same page. How can AEA modeling help work through disagreements and stimulate the interest of scientists who are unaccustomed to working with others to develop a system-wide understanding? • Are we capable of understanding the nature of the problems we face in a way that allows us to comprehend project goals, features, and performance metrics?	• Great detail in conceptual and numerical modeling for collective learning is not necessary. There is a point at which there are diminishing returns to learning with more detail. • Coarse- vs. fine-grain models: With the advent of micro chips with enormous computing power and storage capacity, more detail is readily available. However, too much detail can obscure learning during this phase. • The important design criterion is the ability to identify the point at which the models make the most sense at the strategic level. • The goal in the collective learning phase of the adaptive process is to make the models as transparent and manageable as possible for strategic purposes. It is important to determine if and how new data from analytic inquiries and

				feedback change the dynamics of the models to reveal a new understanding. • Conceptual and numerical models should be updated at the same time. • T&SF/Ps should integrate diverse modes of inquiry and lines of evidence into the learning phase. • Complex problems are moving targets that incorporate data mining, heuristics, and "toy models" as well as results from field and environmental studies. Physical models of hydraulics and sedimentation, the drivers of aquatic systems, are particularly useful when studying floodplains.
o **Shared understanding**	One of the most under-rated and frequently ignored aspects of the adaptive process is shared understanding. Modeling in the shared learning phase helps to increase and expand the base of this understanding. During the development of the Kissimmee River Restoration design, having policy makers, managers, and	• S&TF/Ps must realize that they are the pivot around which much of the adaptive process revolves. • How can T&S units encourage researchers to take shared risks, challenge constraints, understand	• How are conceptual and numerical modeling used to help the requisite diversity of resource functions and interests learn what is known and not known about ecosystem	Design criteria: o The first and only rule in developing a shared understanding among a requisite diversity of interests is to keep everyone at the table and in the game.

	project teams visit the future land- and waterscape in miniature engendered more support for landscape-level restoration that any other single learning tool. Much of the same value can be achieved if constituents are exposed to the logic of how the ecosystems functions visually and mechanically. Visualization in particular aids comprehension. All too frequently, the visuals developed by science practitioners are geared for the eyes and comprehension level of the end-user, who is not the scientist. All the stakeholders in the decision making process must be able to understand the visuals. One of the lost arts of adaptive management is the capacity of shared learning to accelerate the development of trust, generate relationships among diverse interests, and increase their willingness to commit to shared risk taking. Most attempts at this component of the overall process are feeble. All too often, scientists turn to process consultants who have no background in resource science and take a dispute resolution approach collaborative problem solving. This is tragic because of the opportunities lost and the time wasted. Shared understanding not only	uncertainties, and resolve conflicts through collaborative problem solving? • T&SF/Ps waste their potential when they fail to address these issues. • These four functions lay the groundwork for all subsequent phases of the process. Waiting until the policy design phase to address them severely limits the sense making required for adaptive policy design. • T&S units are responsible for bringing the requisite variety of perspectives and resource functions to the table to begin the process of developing a shared understanding. • Is there evidence that science is being integrated across multiple scales and multiple disciplines to assess complex multivariate interactions? • One of the key functions of the shared understanding component of the shared learning phase	functions, processes, and structure? • How are the results of analytic inquiry into the socioeconomic aspects coupled conceptually and numerically into the modeling effort? • Modelers are prone to ignore socioeconomic links and concentrate only on biophysical parameters. How durable are policies if they do not provide opportunities to see how coupled ecological and social systems function together? • How can T&SF/Ps prepare themselves for doing the deep spadework required to bring risks, conflicts, constraints, and uncertainty to the surface? • In addition, how can such activities also be used to explore options that all stakeholders can buy into?	o All other rules are malleable, at least temporarily, to ensure the continuation of a meaningful dialogue. o Despite the common belief that all it takes is to get everyone to the table, the reality is that some stakeholders simply may not have to ability to comprehend complex issues. o Process consultants' claims to the contrary, 30-35 people are all that a science-based dialogue can accommodate, based on three decades of experimentation. o Complementary means need to be developed if more people seek to be engaged in the process. The fact is that, when it comes to comprehension, there are limits to the number of different perspectives that humans can have and the types of functions they can perform. Beyond that limit, dialog devolves into

	provides an opportunity to articulate the biophysical nature of the management problem but also helps to bring the larger picture into focus, including its socioeconomic parameters. Modeling serves as a reality check on individual desires and interests. Models are designed to be value variable in the sense that, during initial development and screening of options, all participates are given the chance to test their pet ideas. These tests not only reveal adverse impacts on other stakeholders and the natural system but also encourage radical ideas that, although they themselves cannot provide a solution, may inspire innovative thoughts in other participants.	is to pinpoint the performance measures that all constituencies consider essential. • The function of shared understanding in the AEA sense is to elicit new ideas and to explore untested options in a microworld environment as a principal means of accelerating collective learning.		noise. o How long should these sessions of shared learning be? o Starting from scratch may require 3-4 workshops over the course of a year. o Follow-up workshops should be based on the availability of new data that reveal novel patterns, traumatic events, and possibly the entrance of a new cast of characters representing various interests and functions stemming from an election. o The output from shared understanding activities should be the creative synthesis and exploration of new policy options.
o Systems monitoring (Output)	This component of shared understanding is incorporated as a guard against myopia. All too frequently, discussions among science practitioners and affected parties devolve into analyses of	• T&SF/P must realize that systems-level monitoring is usually the lowest priority during budget allocations. However,	• How is project-centric monitoring related to systems-centric monitoring? o Start with what people are most	Design criteria: • As the modeling process evolves, strategic decision-making should be emphasized, and the

	specific projects and stakeholder perceptions of them. Unfortunately, moving from a project-centric orientation to some semblance of a shared perspective usually results in an understanding of the parts but not the whole. One key aspect of the whole landscape or large-scale ecosystems is that they function differently from the sum of the parts. As a result, rolling up performance measures across scales is challenging. The affected parties need to be exposed to this logic so that they can develop an appreciation for systems-level monitoring and its benefits. For example, once the ranchers and wilderness proponents in northwest Colorado realized that systems-level monitoring would improve the overall quality of the landscape, particularly its biophysical aspects, they became enthusiastic supporters of this approach.	an understanding of landscape-level dynamics is crucial for changing peoples' perspective of landscape integrity. • TS&S units need to be prepared to prime the pump when it comes to explaining what systems- level monitoring entails. Analogies from other applications, e.g., from computer runs, can help reinforce the concept. • Monitoring must be understood in the context of performance and the ways in which the results of systems-level monitoring can inform decision makers.	familiar with, i.e., the project scale, and then move to the operations and subcomponents of the system, such as how the sloughs fit into the landscape. o Scale dependency must also be explained to constituents, who need to understand why an indicator that makes sense at the project scale may not be useful at the systems scale. • How does systems level monitoring tie into other levels and functions associated with performance management? • Also, why do systems not respond immediately to corrective actions? There are many reasons for delays that can be explained through	scales that require effective monitoring should be identified. • Systems-level monitoring must grow out of shared understanding, not out of pet projects and new technologies. o Frequently, different monitoring schemes are being implemented at the same time, and no single agency knows what is being done, or why, or how it fits into an integrated understanding of overall systems performance. o This is not to suggest that, like the budgeting process, everything should come to a standstill until authorization to spend money is given. o However, those involved in monitoring need to be aware of the

			models, but it may be necessary to explain why degraded systems may resist recovery.	TS&F/P responsibility to oversee systems-level monitoring by various agencies so that all their efforts are coordinated and integrated.
The Adaptive Assessment Phase				
➢ Inputs				
o Modeling	The coarse-grain modeling work conducted during the adaptive learning phase forms a gestalt, i.e., a sense of the whole that becomes the basis for assessment. The assessment phase uses this modeling input as “base conditions” based on feedback and analytic inquiry designed to fill in modeling gaps. As the managers, policy makers, and stakeholders re-engage during the options analysis, the assessment team will be responsible for updating the basic understanding coming out of the learning phase. Conceptual and numerical modeling serves as a bridge between adaptive learning and adaptive assessment (input). All of the understanding developed during the previous learning phase should inform assessment. This includes not only the ways in which initial policy options are informing assessment but also errors in understanding that will	• T&S units must ensure that the results of the shared understanding component help clarify assumptions, hypotheses, and key associations among parameters. • T&S units must help all participants clarify goals and objectives as much as possible. Goals and objectives are not always clear and unambiguous, possibly because of a lack of understanding of the current or desired system states. • There may be some overlap between those conducting the modeling during the learning phase and the assessment phase. What is important is that the functions remain distinct.	• Why does shared learning occur before the assessment phase? o There is no argument that could not be countered by others. o The process is structured based on years of testing and evaluating results. o It places the emphasis on filling in gaps in existing understanding based on feedback from previous actions. This is a very powerful and overlooked means of	Design criteria: • The assessment team must be briefed on new “baseline” conditions of shared understanding, and the points at which conflicts, constraints, uncertainties and risks seem to be barriers to “unwrapping” bolder policy options. • The separation between shared understanding and assessment also acts like a firewall, so that scientists can test out new concepts during the assessment phase without having to justify this to stakeholders. • Modeling is our best attempt to give a composite shape to what is currently intelligible.

	have to be part of the update when options analysis commences.	Learning involves the consolidation of existing information to enhance comprehension. Assessment is an expansion of knowledge in the most fruitful areas. • The learning phase is centered around constituents; the assessment phase is centered around integrative inquiry and synthesis for the purpose of options analysis.	gaining increased momentum for future management treatments, testing, and experiments. o A basic level of shared understanding makes it easier to determine where assessment efforts can be most beneficially applied. o Assessment results may help to overcome barriers to pursuing policies with greater risks and rewards.	
➢ Thruputs				
o Systems monitoring	Assessment of systems monitoring is an ongoing and iterative process that is punctuated by policy review and budgetary processes. Systems monitoring is an important piece of systems-level operations and the management component, which will be discussed later in the assessment phase.	T&SF/Ps usually have to design, justify, and advocate for systems-level monitoring. Increasingly, land and water resource managers are coming to understand the value of such data, but progress is slow. Take, for instance, the need for a regional-scale drought information	Should the data be made available to all stakeholders? • In the past, T&S units have produced "status and trend" reports that have very limited value in decision-making. How should T&SF/Ps intend to	Design criteria: • T&S units must be responsible for helping to create the synergy needed to unite various monitoring schemes. Typically, systems-monitoring teams inherit a legacy of patchwork stations

	Systems monitoring must not only consider applications to biophysical systems but links to social and economic systems as well. Both natural and social systems must be monitored at multiple scales, and both direct and indirect means of monitoring must be considered on a cost-effective basis. In conceptual models, the major forces outside the focal system will be called “drivers.” These drivers, which some policy makers would just as soon leave out of the assessment process to condition their prerogatives, must be justified based on scenarios that show how pronounced an influence they can have on policy options and design. To continue the metaphor, drivers have “passengers,” and it is very important that the assessment team ensure that drivers are connected to appropriate passenger parameters when representing them in conceptual and numerical models. As mentioned before, resource programs tend to be project-centric and ignore the fact that the whole as more than and different from the parts. It is incumbent upon T&S units to develop a blueprint of monitoring that illustrates and explains key relationships and justifies the	system in the states west of the 100th meridian. Without the unanimous political support of western state governors, nothing would have been done despite the scientific justification. The point is that scientists should not be shy about advocating good science based on evidence. On the other hand, systems monitoring has been criticized for being self-referential and not engaged in informing decision making. T&S units are responsible for seeing that standards of practice for sighting, instrumentation, measuring, calibration, and proper maintenance of recorders are maintained.	redirect such efforts to assess effective performance? • How can future monitoring systems overcome the lack of even a minimal foundation in theory or empiricism? o Is there a logical justification for the selection of indicators? o Can we identify the monitoring indicators that would trigger a management response? o How do we secure funding?	that are small in scale, poorly planned, and incompatible. Making sense of and optimizing existing monitoring schemes is the best way to justify new funding, identify key gaps, and avoid unnecessary duplication in the overall system. • Based on new scientific understanding, the scales at which legacy monitoring schemes were designed may be obsolete. • In summary, optimizing existing monitoring systems and linking them to decision-making should be the number-one priority. • Conceptual models should help guide both the optimization of existing systems and the development of blueprints for future monitoring capacity that would target key assumptions and hypotheses. • The development of indicators and their justification is

	value added by each major element in the monitoring system. Sometimes these justifications need to be cast in the negative while noting the potential for vulnerability and catastrophe associated with the lack of systems monitoring, as was the case in levee failure during Hurricane Katrina. Systems-level data management, including sampling, collection, measurement, analysis, interpretation, and storage, must be scrutinized and subject to peer review to ensure that acceptable standards of practice are maintained.			another area of monitoring system design that needs to demonstrate synergy. • To some extent, systems monitoring must anticipate and not just react to policy mandates. Technology is changing rapidly, and new techniques are rendering whole systems obsolete. • Technology assessments are necessary to avoid getting locked in to traps from which it is expensive to extricate the monitoring system. • The use of independent peer review panels should be standard practice to ensure that the existing system is measured against present and future best available practices.
Levels of monitoring • N+1 • N • N-1	Systems monitoring must focus on management problems at whatever the boundaries of the focal scale (N) happen to be. Furthermore, the bounding of the problem must be understood to be arbitrary and subject to change	T&S units must be responsive to the future. This means that one of the key functions of systems monitoring is anticipating changes in policy, programs, and projects	• How do T&SF/Ps keep pace with the ever-changing lattice of monitoring schemes in a way that makes sense in terms of both the	Design criteria: • Systems monitoring must be adaptive to accommodate the lattice of projects and operational needs for monitoring change.

	over time. Reframing the problem may involve changes in objectives and in monitoring requirements. Problem solving in systems requires feedback not only at the focal scale but also from crucial subprocesses (N-1) and from patterns and processes operating at higher system scales as well. Monitoring systems must be adaptive, and policy makers, managers, scientists, and citizens must all be cognizant of this fact. This raises the issue that the data you need is not the data you have, but the data you have provides continuity that reveals changes, or the lack of changes, in trends and patterns over longer temporal and spatial scales. Both are instructive. However, limited resources condition monitoring systems. Furthermore, abandoned monitoring sites may look very promising 10-20 years later when it comes to resolving new management problems. However, the data are often not accessible, have not been updated to new software systems, or may even have been jettisoned. The preservation of institutional memory must be made a priority despite shifts in management problems and frames of reference.	that will influence monitoring. T&S must provide oversight of proposed projects to ensure that monitoring and performance measures are considered early in the design process and throughout as the design evolves. Monitoring must be in "conversation" with proposed management actions and used to assess adjustments that will have to be made in the architecture of the monitoring system.	project and the system? • Every system will manifest different needs. Would an appropriate response be to incorporate some redundancy into systems monitoring on the grounds of the continuous change in the lattice of management problems and responses? • How are monitoring and research linked from a management standpoint? For example, the ways in which flow in the Everglades influenced historical ridge and slough morphology is a research question that has not been adequately addressed. It might be worthwhile to investigate the mechanics of periphyton, an important subprocess that is thought to be involved in the structuring process of the ridges,	• The architecture of systems monitoring schemes must be robust to the ever-changing needs of management and shifts in both the biophysical and socioeconomic systems as they interact with each other. o This will require foresight and the ability to anticipate shifts in policy and programs. • Monitoring systems as part of the larger technological revolution that is, according to some experts, still in its infancy places an added burden on those managing monitoring systems. Technology assessments may be necessary to avoid getting locked in to a form of technology that may rapidly become obsolete. • T&S units must rely increasingly on independent science and technology panels to help them respond effectively and efficiently to

			sloughs, and tree islands. Research could be very helpful in filling one of the important gaps in the N-1 level of the problem flow regime. • This research could potentially reduce the need for monitoring over time if the mechanics of the periphyton process were understood and predictable.	monitoring needs.
o Integrative inquiry and synthesis	Integrative inquiry and synthesis is the keystone of all assessment components. Earlier in the adaptive learning phase, analytic inquiry was discussed as one important way to fill gaps in management problem solving. Analytic inquiry is the science of parts. Integrative inquiry and synthesis is the continuing effort to piece together the management and ecological puzzles to inform policy design. Integrative inquiry requires the engagement of those with the deep experience and understanding needed to make the intuitive leaps by which integrative inquiry and synthesis go about their business. The notion that the observer can be	Experience strongly suggests that the bias injected by disparate disciplines and their respective methods makes integrative and adaptive assessment extremely difficult, yet it must be accomplished. When TS&SF/Ps are faced with well entrenched scientific and agency positions, real cross-fertilization of thinking and open-minded exploration of alternatives may be considered impossible. However, opting for a separate unit to do the integration is a far less effective option,	It is important to guard against scientists overselling their targets and creating false expectations. Performance metrics must be used for evaluation, feedback, and updating. • T&SF/Ps must be prepared to see that integrative science is incorporated into traditional engineering and land management planning. What strategy can be devised to bring this about?	Design criteria: • First, science practitioners do not have the training in integrative science and inductive reasoning that is required to lead T&S units. • Second, science practitioners are not trained to assume leadership roles in the same way that engineers and managers are. Again, adequate training is required. • Institutional structures still tend to put science in a supporting role, and

	totally separated from the observed is no longer viable. Institutional memory, native understanding, and deep experiential understanding have all proven to be valuable to the assessment process. Some scholars would argue that "consilience" occurs only in the accretion of knowledge from differing modes of inquiry. Others would say that sparks of insight can dramatically change the whole frame of reference and generate scientific revolutions; these are considered grand intuitive leaps. Both arguments are probably correct, but the days of using the results of micro-level experiments to extrapolate to larger scales are over. Given our new understanding of cross-scale dynamics, this type of extrapolation is not only inappropriate but dangerous. At the level of integrative inquiry and synthesis, the strategy for applied science is housed. For example, it is here where the feedback from management treatments, monitoring, research, and operations is reviewed to determine if hypotheses, assumptions, or aspects of the assessment structure should be changed. Integrative inquiry and synthesis is where multiple modes of	because the thinking and behavior of the larger community of scientists involved has not been challenged in a way that elicits new responses. T&S units are usually limited in their scope of authority and must rely on the good will or dictates of higher authorities to achieve their objectives when it comes to integrated inquiry and synthesis. T&S units may have to use formal or informal outside forces to oversee how well the integrative inquiry and synthesis is performing. These evaluations would then be passed on to the appropriate powers so that corrective action can be taken. As a last resort, it may to necessary to appeal to policy makers to mandate support for the activities set forth in the applied science strategy, which needs policy-level endorsement. Targets defined at the system level: Are program-level goals and objectives established with specific	• Conventional approaches to T&S integration has been cast in more passive roles such as activity coordinators or clearinghouses, but the image of T&S as purely supportive is fading. • Once the sciences were lucky to receive scraps thrown from the tables of engineering, management, and operations. Now policy makers are increasingly requiring consultation, if not leadership, from science on key decisions that involve setting directions and spending literally billions of dollars. • How do managers of T&SF/P units intend to assert this new leadership position? With great temerity, one would expect. Resource science practitioners are not used to being at	this must be changed. • Being the regional or area-level repository of integrative science does not mean being a library. • Process techniques in which scientists confront their own data in the face of competing perspectives and modes of inquiry are essential. This should not take place in a hostile environment but in one that is robust to exposing the limits of knowledge and competency and allows the participants to embrace uncertainty and error. • Policy makers must be made aware of this new dynamic. The National Academy of Sciences is becoming increasingly responsive to demands for science review as a basis for leading policy. Peer review is also filling part of the void, but institutional changes must be made to empower resource

	inquiry and their requisite lines of evidence are brought together to see where they converge and where they diverge. The targets of assessment emerge from the adaptive learning phase seasoned by the stakeholders is also framed by new discoveries from ongoing assessment work as well as other sources, including analogs found in science articles from other places.	performance metrics and targets to guide the collective evaluation of the program and to facilitate program assessment along a trajectory relative to expected performance?	center stage. • Science is no longer safe from all the unnerving responsibilities associated with playing the roles of pilot and partner with engineering, management, and operations. o Science practitioners have been stepping up to the plate for decades (e.g., Art Marshall in the Everglades), but many scientists would prefer to remain embedded in the herd. o At present, there is a gap in the leadership ranks of science practitioners. How should it be filled? o New scientists coming out of our university systems are not prepared for these types of jobs. How and where will their	science as never before. • The age of policy makers relying on technology to fix relationships is over. Therefore, science is in the midst of a dynamic that is reframing institutional relationships that have been in existence for more than a century.

			training needs be met? • Non-scientists have been thrust into the role of science management, which makes many people uncomfortable. Will professors with comfortable life-styles and research grants be willing to take painfully political jobs in positions that scientists have not traditionally held?	
o Options analysis	Options analysis is not a trade-off of alternatives, although this is how the engineering and management planning procedures most evident in federal agencies view it. Options analysis differs in a number of ways. 1. Options analysis is an integral part of the design process. It is not a planning process. Planning processes assume the preeminence of experts who are the best equipped to define problems, goals, and objectives and conduct diagnoses. Consulting firms or internal planning staffs carry out these kinds of planning efforts. It is a form of social engineering in which experts are hired to solve the problems that people	T&SF/Ps as assessment specialists are responsible for setting the table for options analysis. Before policy design is taken over by policy analysts, the science practitioners from assessment are called upon to reconfigure the models developed and/or updated during the learning phase and to further develop and screen options. At this stage, the lead science practitioners upgrade the models based on the best available science and prepare scenarios that will be used to confront alternative policies with potential	• Alternative tradeoff analysis and benefit cost analysis still dominate agency thinking and OMB evaluation criteria. How are agencies going to integrate Options Analysis into their decision making processes? • T&S units are not prepared to get this close to decision-making processes. Modelers are used to being totally separate from the policy process, only called upon to	Options Analysis is a new generation of tools designed to make decision making more robust; to more meaningfully engage representatives of all distinctive parties in the Options formation and screening process. Participants are encouraged to explore creative and innovative designs for policies that eliminate barriers to agreement, overcome constraints, and make risk taking more palatable, and uncertainties more reducible and

	cause. 2. Options analysis assumes that diversity mirrors complexity and invites diverse perspectives to share in the design of options for the future. Stakeholders are not relegated to “hearing” status. 3. Efficiency criteria as defined in the *Corps Principles and Guidelines* do not dominate trade-off analysis. Options analysis uses a variety of criteria, including robustness of design to contingencies. 4. Whereas trade-off analysis attempts to quickly eliminate suboptimal management measures, options analysis develops composite solutions that attempt to keep management measures in play as long as they are deemed useful. 5. Composite solutions, another trademark of options analysis, attempt to keep resource functions separate so that their values and interests are not masked by aggregates of utility that have lost all semblance to tangible values and functions. 6. Composite solutions attempt to do more with less. Options analysis looks for solutions that move beyond conventional trade-off frontiers and explore new alternatives that are mutually beneficial or do no harm to other resource functions and their interests. It	vulnerabilities, uncertainties, and calamities. Policy makers, managers, and stakeholders are responsible for refining the policy options based on updated models and new information from a variety of reputable sources. The scenarios in which policy options will be tested are not shared with those designing the options, although synopses of the information used to develop the scenarios are made available to them. T&S functions cease at this point. Policy makers, managers, and affected parties are positioned to test and modify the policy options and screen those composites identified as outliers based on scenario testing. At the conclusion of the policy screening, the scientists may be consulted again to review the policy responses and provide their personal perspectives. From that time, T&S shifts to its traditional role as a support for decision-making. Are there clearly	explain graphs and explanations of science and engineering based results. • T&S units are being asked to challenge policy options. How will scientists respond to this challenge? Instead of tripped into advocating a policy or having the policy maker abdicate responsibility for decision making, the science practitioner is given the chance to poke holes in policy options by developing scenarios that intended to test the robustness of alternatives. • Who decides what the program metrics are and how they are evaluated?	manageable by working together. The “firewall” between policy and science is maintained. Science provides its best available information, does its best to challenge policy options and then functions as support. The actually policy design, and alteration, objectives, risks perceived outcomes are artifacts of non-scientists involved in the assessment. Options Analysis will require sensitivity analyses to be conducted to determine • the model resemblance with the process under study • The quality of model definition • Factors that mostly contribute to the output variability • The region in the space of input factors for which the model variation is maximum • Optimal - or instability - regions within the space of factors for use in a subsequent calibration study • Interactions between

	does not discount ecological values but actually attempts to find ways in which society can live with and profit from the dynamics inherent in healthy ecosystems.	defined performance measures to evaluating the effectiveness of the program?		factors
o Systems-level management and operations	The current generation of land and water managers is working with legacy polices, programs, regulations, and prescriptions and with projects that are in some cases more than 100 years old and well beyond their design and economic life. The failure to plan for obsolescence and the lack of renewal capacity, as manifested in everything from collapsed levees and obsolete pumps to oil and gas exploration leasing procedures, grazing, fees and allotments, are sapping our nation's productive and, more importantly, response capacity to future contingencies. As the emphasis shifts from extensive *ex ante* analysis based on "guestimates" to *post hoc* monitoring and assessment based on feedback (i.e., actual data and observation), institutional functions must respond accordingly. Whether housed in a separate unit or functioning in an *ad hoc* manner, a systems-level management and operations (SLMO) capacity in whatever form is necessary to ensure that the connections between implementation functions are in	The question comes down to who has systems-level authority and responsibility. Or does it? Frankly, in every large-scale system, the nature of complexity, cross-scale dynamics, and wicked problems defies authoritative answers or ultimate authorities. At this stage in the evolution of systems management, T&SF/Ps with system-level integration and coordination responsibilities need to assume a leadership role "until relieved." Agencies have been passing the buck on this issue for decades, and the problems just keep mounting. Often, implementation functions are overlooked because of budgetary considerations. New responsibilities, activities, and projects are always to be preferred over	o What contributions can T&SF/P units make to overcome the bias in land and water agencies that favors projects and activities? • Can T&SF/P units offer an "outward-looking matrix" to help everyone understand the system-level implications, contributions, and limits? • M&O relationships are constantly changing. Repair, replacement, upgrading, and rewiring are all actions needed to ensure that overall quality and performance are not sacrificed. • What	Design criteria: • The first goal of a systems-level management and operations capacity is to optimize the performance of the existing combination of authorities, plans, prescriptions, regulations, activities, and projects. o Efforts must be made to heighten awareness of and focus attention on overall system performance. o Creating and maintaining synergy at the systems level is essential as the lattice of projects and programs shifts and evolves over time. o Answers must be found to the following questions: • Specifically, how are legacy projects modified

	good working order. SLMO fills the institutional gap in implementing adaptive management by performing a essential "supervisory" function that may involve differences among agencies, disciplines, authorities, plan prescriptions, regulations, court stipulations, budget constraints, and project sequencing. Its purpose is to deal with unintended, dysfunctional, and seemingly unavoidable interstices and pileups in a dynamic policy domain. The system-level cost of poorly performing operations and management can magnify over time, igniting defense systems and posturing that can be quite costly in time and money, not to mention the resulting entrenchment of positions that can have a cumulative consequence. The problems outlined above identify a clear void in systems management that results in a lack of overall responsiveness and performance that will only become more pronounced and inescapable as the awareness of the implications of climate change become more pronounced. This lack of alignment among what is coming on line, what is already "in the ground" and operational, and what is in the process of	"operation and maintenance." The image of O&M has traditionally been one of tasks such as mowing the grass and cleaning the spillways, i.e., routine, boring activities that can be checked off at the end of the year. A new rationale for operations and *management* might spring partly from domestic security and the re-capitalization of the nation's infrastructure. However, more fundamentally there must be a shift from the administration of activities to managing for systems-level performance. The role of resource science is to confront managers and engineers with data as a basis for making decisions. The argument could be made that these are institutional issues and should be the function of policy analysts or others. The flaw in that argument is that policy analysts have not shown any acumen for the effective oversight of systems-level performance. Policy analysts might be	contribution can T&S units make to this goal? • Who is best positioned to play a leadership role? • Is the answer more power and control, or are there softer forms of persuasion that would be just as effective? • What are the greatest barriers to systems-level optimization of operations? o Are there methods to justify the cost-effectiveness of proposals for optimizing operations? • Could the quantification of benefits forgone as a result of sub-optimization of ecological performance be a means of justifying	so as not to diminish benefits from new projects? • How can T&S units help show the linkages between various levels (activity, project, program, systems) of attention and action and the associated cross-scale ecological and social dynamics (functions, processes). • Who is responsible for anticipating the inevitable gaffs that occur when operations and new activities and construction that are not coordinated interrupt schedules and create localized ecological damage? • Often the relationships between land and water management are overlooked. To

	being taken off line cannot be underestimated. Typically, new activities and programs are most concerned with their internal coherence and justification. The "inward-looking matrix" of associations usually consists of activities and functions directly related to input-thruput-output functions. This project- or activity-centric orientation tends to ignore the external and indirect effects and influences associated with a system-centric perspective. For decades, the operations of Lake Okeechobee (LOK) in the Greater Everglades system created problems for the health of the St. Lucie and Caloosahatchee estuaries, flood protection and water supply in the Everglades Agricultural Area, and the water quality of the lake itself. LOK operations were tied to a rigid rule curve initially established in the 1950s for water supply and flood control. It dictated when releases would be made based on water levels, season of the year, trends, and rainfall projections. For decades, the environmental and water quality functions of systems operations were ignored. In recent years, the rule curve has been relaxed, and in its place an "on-line" interdisciplinary team of engineers and scientists meets at	able to point to where the "edges of the scientific patchwork pieces" are, but it takes an deep understanding of science and technology involved and their historical context to fit the pieces together into the patterns that make sense ecologically. T&S units must be responsible for the oversight of system optimization in ecological restoration, possibly by serving as conveners of the requisite managers and engineers. In pool-stage manipulation in the Upper Mississippi River, state and federal scientists and engineers and their coordinating committee were involved. Policy-level involvement is necessary when provisions for making mid-course corrections need legislative authority.	recovery projects? • How can the culture of agencies be changed to see the value and raise the stature of systems operations from an afterthought to "forethought" in overall policy and management?	achieve the desired levels of system-level performance, the interface between land and water is everyone's responsibility. How can T&S units contribute to this culture change?

	least weekly to fine-tune releases from the lake. This team includes specialists in all the functions of LOK operations (e.g., flood control navigation, water supply, water quality, and ecosystem restoration), and their decisions take all these functions into account.			
o Communication	First and foremost, science practitioners must realize that resource science is a vehicle for establishing and sustaining a dialogue between nature and society. The foundational nature of this fact is not well understood. This dialogue between resource science and society is what has been missing in past approaches to "scientific management" as defined at the turn of the 20th century as part of the progressive era. Instead of relying on "experts," as Theodore Roosevelt and Gifford Pinchot did, the new model of scientific management views diversity as a mirror of complexity. Consequently, the engagement of all affected parties or stakeholders adds value to policy design and improves options for decision-making, although there is a point of diminishing returns. Determining that point is inevitably a judgment call for which T&S units must assume at least partial	T&SF/Ps have a major role in overall communication of scientific and technical information. Building on the commentary in the communication section, T&S units must work with communication specialists to establish the basis for reframing the dialogue between social and scientific communities as new scientific understandings and influences emerge. T&S units are a major force in bringing about social change. T&S units must realize that, to the vast majority of stakeholders, the world is flat and static. History, which is a basis for ecology, is not even on their radar. A flat world assumes a landscape of largely intelligible objects. GIS forms of communication reinforce	• T&S units face their most challenging responsibility in figuring out how to communicate science effectively. There is no "one size fits all" solution. Further, communication strategies must be as adaptive as the science itself. Because, without wide-based public support, durable changes in policy and practices will not stand the test of time. • Where does the foundation for effective science communication begin? In the adaptive learning phase, in which sufficient time is spent reviewing	Design criteria; • T&S units must be configured in a way that gives them direct access to key stakeholders and top decision makers so that critical lines of communication can be established. If such connections are absent, they must be created. Middle management, with its concerns about accountability and span of control, has failed to realize the urgency and the scope of the change needed for the effective communication of scientific information. Although there are exceptions, the rule has been that, in state and federal agencies,

	responsibility. According to the traditional, and, to some extent, the current view of scientific management, agency managers are the best qualified to make final decisions because of their incontrovertible understanding of the issues. Nevertheless, the days are over when land managers and water resource engineers made all the decisions without at least consulting all the affected parties. The fact is that the world is now too complex and the uncertainties too profound to even contemplate the manager's role as that of final arbiter. There are no authoritative solutions even when a final decision is required. The precipitous rise in the use of independent scientific peer-review panels, not just for technical purposes but also to advise policy and courts, is the harbinger of a major reconfiguration in how technical and scientific decisions are informed. Effective scientific communication means that the overall goal is to be responsive to changing needs and new understandings based on feedback from monitoring and evaluation, not just of policy but of the efficacy of technical and scientific messages. Far too often	this popular image. However, the world is not static; it is emergent and constantly changing in novel and unexpected ways. It is incumbent upon T&S units to address society's fundamental understanding of how the world works. T&S units must find ways to make social and ecological history a basis for understanding the dynamics of complex adaptive systems. The structure, processes, and functions of ecosystems are evident when there is visual evidence of them. However, they are invisible to humans when temporal discontinuities are involved; this is a cognitive blind spot that is not shared by members of the animal kingdom that are attuned to pending temporal discontinuities such as earthquakes, rapid shifts in weather conditions, anticipation of seasonal shifts, and winter food requirements. Trust in government, particularly the federal government, is at an all-time low. Agency	feedback, updating understanding regarding hypotheses and assumptions, and adjusting initial policy considerations. If the adaptive learning function is ignored, there is no chance that science will be effectively communicated to all parties over any extended period of time. • How are T&S units to anticipate and prepare for changes in budgetary matters and political agendas caused by elections or natural and/or society calamities? Far too frequently, adversity is not anticipated. Unwittingly, staff tends to favor the best-case scenario in which everyone is assumed to get along. • How can T&S units make their communication processes with key stakeholders more	middle managers are intolerant of T&S units that have direct access to the top without going through channels or the chain of command. • Platforms for science and democracy are the essential "docking station" for coupling all the affected parties. T&S units are the bridges to bypass communication barriers. Their major role is to help others make sense of the fast-moving and unpredictable world around them. • T&S units must be organized around science practitioners with deep craft. These practitioners command the respect of others because of the depth of their experience and understanding and their relentless focus on the ever-changing face of the problem. It is primarily the science practitioner of deep craft who has not only mastered his or her own craft but

	communication strategies are reactive and not anticipatory and responsive to real, rather than perceived or preferred, needs or wants. Communications specialists must be cognizant of the fact that they are in the business of helping society reframe legitimate problems based on new scientific understanding. They must then communicate credible solutions based on new understandings and findings. It is essential to test assumptions. During the 1980s, the Everglades were the number-one news story in the regional media, including half a dozen television stations and three major newspapers. Despite this exposure, plus occasional national nightly news coverage, Penn and Schön, a nationally recognized polling firm, found that most people in South Florida did not know what the responsibilities were of the major regional water management institution paid by their tax dollars to deal with Everglades issues. The implications of this phenomenon may challenge the assumptions held of those who report on land and water resources and those who are the subject of reporting. Staff must challenge there perceptions of what people are capable of	communication is perceived as propaganda. However, the public does trust the results from "good" science. Unfortunately, during the past several years, science and intelligence, particularly when it originates from federal sources, have been intentionally doctored to serve political ends. The NRC has documented the ways in which the economic benefits were inflated to justify the expansion of navigation capacity on the Upper Mississippi River. To the extent practicable, T&S units must work to establish firewalls between their results and potential sources of corruption. Effective communication of science is essential to legitimize the new class of cross-scale problems and the design of credible solutions that serve the pubic interest. Instead of allowing congressional representatives and corporations to dictate to federal agencies, it is imperative to establish platforms for science and	robust? Hiding behind a set of graphs, tables, and projections is not the answer. Many scientists will admit that they did not get their advanced degrees to be turned into agents of social change. They assume that they were hired to fill a disciplinary niche in an agency organizational chart and to practice their craft in relative solitude. • The nature of our times would suggest otherwise; scientists are being called upon to justify billions of dollars in public funds. This transition has occurred within a single generation. Scientists are no longer just in the business of producing peer-reviewed papers. • What is the appropriate response for a T&S unit as society literally passes through an historic	can help others distinguish signals from noise as patterns in social-ecological systems begin to shift. • T&S units are independent of organizational units charged with the responsibility of the major phases of the adaptive process. Their role resides at the interface of all three phases. o During the adaptive learning phase, T&S units are most active in developing the shared understanding that informs assessment. o The assessment phase conducts integrative inquiry and synthesis for temporal and spatial scales that span 3-5 years. T&S units are designed for a more rapid response to emerging problems and reach into their agencies and

	understanding; generating fact sheets for the sake of fulfilling a performance requirement without determining the effectiveness of the effort is a waste of money and effort, but more importantly, the failure to communicate effectively is a deprecation of the public trust.	democracy, because the only cure for the shortcomings of these platforms is more science and democracy. Public demands for greater involvement justify the formation of platforms for dialogue. If the public lacks informed science-based discretion for making decisions, T&S units working in conjunction with others must establish dialogues to accomplish that end. It is the responsibility of T&S units to use these platforms to build capacity for social change through shared understanding. Only integrative science based on inductive reasoning, not on the deductive logic of most scientific inquiry, can knit together the various strands of scientific results together so that both citizens and scientists can make sense of the world around them from an ecological perspective. Some people believe that the only thing need to make sense of science is to bring everyone to the table. This belief is based on two	bottleneck in which nature's and society's responses to each other are magnified as the stakes for both grow exponentially? We have arrived at the point of deflexion at which the scale of human actions has reached regional and planetary scales that jeopardize the persistence of both society and nature, i.e., hypothetically, the ultimate pathology. • From climatologists to local government officials to organizations like the Western Governors' Association and The Nature Conservancy, the principal gap in adaptive capacity and "sense making" is at the mesoscale. That is where the resolution of climate change models is the weakest and resource science the most under-funded. It is also the scale at which society is	across the nation for access to the best and brightest when justified. The pulse of T&S units is dictated by two questions: (1) What is in need of immediate attention? (2) What is ripe for action within our purview? o In the policy design phase, T&S units provide a support function by serving as a technical secretariat for policy formation and policy making. • In many respects, T&S units are the keepers of the flame, in the sense that they are responsible for making sure that the management problem is fittingly framed and confronted with the best available data available, so that communication of this understanding and information can

		essential fallacies: (1) that science will reveal the “truth” if only we can get all the stakeholders to listen and (2) that the more affected parities there are at the table, the better. The first assumption is false because just bringing everyone to the table does not automatically create the sort of integrated science and shared understanding that we are seeking. The second assumption does not take into account the fact that, the larger the group, the more difficult it is to achieve a shared understanding even when you go about it properly. This is because “sense making” requires real change in how people think and structure the world around them. That means helping people create new associations while replacing outdated ones. It is true that diversity mirrors complexity, so it is important to have the requisite diversity of perspectives deeply involved in restructuring the social “sense” of how the world works. But the reality is that there is a law of diminishing returns	least prepared to respond to major discontinuities and perturbations involving water, energy, growth management, and ecological systems. • T&S units from regions all over the country complain of “stove pipes,” i.e., the lack of interagency cooperation, turf wars, and independently designed projects, and their inability to work around or through them. How should T&S units respond to these challenges? Decades of waiting for change to occur or for a new generation of agency leadership or more enlightened policy makers	be as useful and useable as possible.

		when it comes to communicating and understanding complex problems. Sharing truly integrative science initially with large groups creates a shared understanding that is a mile wide and an inch deep. By nesting communications as understanding grows, the circle of dialogue can be gradually expanded.	to emerge have cost us precious time. • T&S units are on point for bringing these issues to the attention of top managers and policy makers. Where else will the leadership come from? These issues are largely invisible to the public and are downplayed by agency leadership. Although no one wants to point fingers, everyone eventually becomes part of the problem. • How is integrative science achieved? T&S units will never be able to force the integration of disparate lines of evidence from	

			independent sources. Second, such units will never be given the staff to do the integration themselves. Third, any integration done by T&S staff without the engagement of their peers simply forestalls the irreplaceable need for scientists to integrate the understanding of others into their tightly reasoned but brittle models of how the world works.	
➢ Outputs	Commentary	Technical and Scientific Functions and Programs	Questions	Design Criteria
o Policy formation (output	Policy formation benefits most directly from the results of the options analysis. The framing,	T&S units should begin to work with policy formation staff to ensure that the	• What techniques do T&SF/P units anticipate using to	Design criteria: • Formal linkages between T&S

from assessment)	screening, evaluation, and testing of alternative policies are the basis for policy action and experimentation. Systems operations and management also inform policy formation by putting proposed actions into a larger implementation context. System operations and management and proposed policy actions must be adjusted to one another. Accommodations will need to be made on both sides. What contributions or demands will proposed projects and actions make with regard to overall system performance? What adjustments in projects may be necessary to maintain overall system performance? The results of the integrative inquiry and synthesis should inform those involved in policy formation as to the presence of external forces or drivers that could surface within the policy environment as decisions are in the process of being made. Forewarned is forearmed.	latter integrate monitoring and feedback into the adaptive action and/or experiment. T&S units should be prepared to assist policy staff in understanding how proposed actions contribute to answering key questions posed by conceptual ecological models. T&S units must also anticipate the need to organize a feedback policy to ensure that the results of policy actions are coalesced into intelligible communication packages for predetermined audiences and especially for those managers and policy makers charged with designing subsequent actions.	"roll up" monitoring results into measures of performance at the systems level based on established goals? • What outreach capacity is needed by T&S units to adequately assist those charged with policy formation?	units and policy formation staff should be in place. • Technical guides should be developed to assist policy formation staff to adequately address monitoring and feedback issues • Conceptual ecological models (CEM) should be made available so that policy formation staff understand how their actions will draw from and contribute to the shared understanding encapsulated in the CEMs.
o Field tests (output from assessment)	Field tests: Are small-scale, highly reversible demonstration projects or field tests used to address uncertainties and answer questions prior to large-scale implementation? As science makes more vigorous efforts to adapt society to nature, more tentative and precautionary steps	T&SF/Ps will help to identify hypotheses that need further testing before they are incorporated into policy design. T&S units may be in a position to provide valuable input into the	• Where are field tests most useful in advancing the overall adaptive process? • How are the results of field tests incorporated into	Design criteria: • T&S units need to monitor communications during field tests to help facilitate the distribution of results and their

	may need to be taken. Where flexibility is limited because of threatened and endangered species and uncertainty is high, scientific field tests and environmental studies at various scales with limited controls and inference will become the norm, just as more reliance will be placed on peer review processes to increase levels of confidence. In engineering, actions of this type are referred to as quality engineering, testing of construction methods, pilot studies, demonstration projects, physical models, and phased implementation.	design of field tests in terms of how controls and inference are structured. T&S units will need to track such field tests, consider the implication of their results, and see that their results are committed to institutional memory.	the adaptive learning process?	implications for the adaptive process.
o Hypotheses (output from assessment)	Hypotheses are the pivot around which the entirety of the adaptive process revolves. Through policy options analysis, only the best alternative hypotheses are forwarded to managers and policy makers in the policy design phase. N.B.: Policies are hypotheses masquerading as answers.	By the time hypotheses reach the adaptive policy design phase, the major contributions of the T&SF/Ps should have been completed. Their main function then becomes one of policy design support to ensure that the policy design process follows through with what was developed during the assessment process, keeping in mind that policy options are hypotheses. T&S units are the keepers of the conceptual ecological models as an encapsulation of	• Do the policy options adequately frame testable hypotheses? If not, why not? • Hypotheses are the basis for learning: o Who is learning? o What is being learned? o How will that be communicated to others? • If hypothesis testing and learning are not explicit aspects of	Design criteria: • Multiple agencies will be involved in various aspects of policy design. All of them should be on the same page of conceptual ecological models or be able to justify their departure from the hierarchy of hypotheses and assumptions that have been developed. • T&S units may be consulted during the policy formation component of the design phase, and

		integrative scientific thinking. These models should be the basis for adaptive policy design.	the proposed action, what is its justification?	should be prepared to provide support in this area.
Adaptive Policy Design Phase:				
➢ Inputs				
o New policy mandates	Policy mandates emanate from higher institutional levels in the executive, legislative, and judicial branches of government. They are the policy instruments from which authority is derived, direction given, and procedures outlined. At the central office level of agencies, such policy mandates are often developed into implementation plans. The Louisiana Coastal Protection and Restoration Master Plan is the type of framework document that is best suited to the adaptive design process. Framework documents present policy as a set of commandments but stop short of developing detailed narratives and prescriptions, procedures, and projects for implementation. .	The role of T&SF/Ps is to work with others to interpret the new policy mandate and determine its implications for the future actions of others or their own responsibilities. New policy mandates rarely eliminate prior legislation. Typically, new policy is layered on the preexisting lattice of mandates, which do not necessarily fit well together. The legacy of prior policy mandates is most perplexing to those charged with interpretation. Fitting the new with the old and attempting to reconcile apparent conflicts is a major challenge. Top-level policy makers	• Rather than point fingers and waste more time by fixing attention on what is not working, how can T&S units contribute to making sense of the labyrinth of existing policy mandates? These policies have not only caused delays and confusion but have been distractions resulting in a significant loss of focus on critical management problems. • The preponderance of unresolved issues created by the lack of attention to legacy mandates is symptomatic of a policy process that lacks adequate feedback mechanisms so that	Design criteria: • T&S units need to create or support forums that attempt to interpret and determine how new mandates can be reconciled with existing ones. • Within T&S units, new policy mandates may create new functions or expand responsibility in existing functions. Instead of looking to add more staff in such situations, T&S units

		have neglected the increasingly congested and confused maze of mandates that confront and retard actions to be taken. T&S units may be one of the few systems-level "sense making" capacities at hand to sort through the profusion of authorities, prescriptions, and operating criteria. Hopefully they can reconcile and optimize what exists, jettison that which is within their discretion, and recommend policy changes for aspects of legacy mandates that are simply an unnecessary drag on necessary action.	corrective action can be taken. How can T&S units structure feedback mechanisms so that legacy-related messages for streamlining policy are conveyed to policy makers?	should explore ways to partner effectively with others to achieve the desired results from new mandates. • T&S units through their respective chains of command should consider how incentives could be structured through new policy mandates to bring other agencies starved for resource scientists to the table. Instead of funding projects, T&S units could fund science practitioners in other agencies to do integrative science and analyze systems-level policy and

				management in terms of their effectiveness.
o Communication (input)	Communication input from the assessment phase to policy design should be structured around report cards, investments, and policy options. Through the learning and assessment phases, all the related "workshoping" with policy makers, managers, science practitioners, and citizens should have taken place. Policy design is for structuring the decision-making package. The report cards should include assessments of system- level performance and compliance. The final set of policy options are also reported along with their respective performance in terms of vulnerability, uncertainty, and potential calamities.	T&SF/Ps support agency-based assessment phases that are responsible for delivering report cards on performance and compliance. T&S units are directly responsible for ensuring that the systems-level perspective is not lost in the transition. The shift from assessment to action invariably entails a narrowing of focus in temporal and spatial scales. Hypotheses as implemented through management action are scale dependent, but the ecological processes those actions encounter are cross-scale by nature. T&S units should be prepared to communicate this understanding and discuss the implications with policy design staff.	To preclude the taking of actions to solve management problems that do not exceed systems-level operations and management (O&M) capacity: • How are O&M concerns communicated to the policy design phase? T&S units should understand that they "have a dog in this fight" in the sense that systems-level O&M functions are separate from those of T&S units but have serious implications for T&S functions. Action-related O&M concerns involving investments in or recommendations regarding monitoring, analytic inquiry, the size of management experiments, etc. influence T&S functions and programs. • What is there is no systems-level management and operations capacity? • What role can T&S units play in	Design criteria: • Systems-level technical and science units review and comment on agency-level report cards and provide support to action agencies in their final review of options for decision makers. • In the absence of systems-level operations and management capacity, T&S units must be prepared to at least raise the questions that fall under their purview (see the section on Systems Operation and Management above). • T&S units perform "staff"

			articulating O&M concerns without overreaching their purview and damaging relationships, which may take considerable effort and time to repair?	rather than "line" functions, and communications is a staff function. However, communications are not always handled by technical staff, nor are they usually centralized and screened for consistency or accuracy. Agencies have the prerogative to interpret T&S results to suit their own ends, but within accepted standards of practice. T&S units would be well served to explore ways of creating incentives for communications functions to be consolidated or at least coordinated with T&S

				units. Such an effort should be marketed as a staff-to-staff effort to improve the effectiveness of science communicatio n.
o Systems 0peration and management (input)	Given the scarcity of resources, the various components of the adaptive assessment phase must be viewed in the context of systems operation and management to understand their implications and investment requirements. The development of testable and credible hypotheses is one thing, but the operational implications, particularly those associated with project construction involving high levels of uncertainty, management experiments, field tests, and environmental studies, require an analysis costs, benefits, risks, and trade-offs. The design of elaborate monitoring schemes and replicates for control and inference associated with large-scale experiments are not formed in a vacuum. There are trade-offs among precision, hypothesis testing, learning, and relational realism. Integrative inquiry and synthesis and options analysis must be	T&SF/Ps complement systems operations and management (SOM). T&S units can provide the conceptual ecological models that are an exceptionally powerful tool when building a framework for analyzing the priorities and trade-offs that SOM must make. However, T&S units should not attempt to replace the functions and decisions that rightfully belong to managers. In the context of "mixed scanning," the T&S units are in effect helping operations and management units focus their attention on high-priority needs from a systems-level scientific and technical perspective. They can assign priorites at large	• What is "mixed scanning," and how does it pertain to relationships between systems-level operation and management units on the one hand, and science and technical units on the other? • Land and waterscape levels of understanding are the least understood. • What is needed is: o a range of defensible hypotheses that are cross-scale in nature, and a set of techniques to concentrate on credible possibilities and structure their evaluation. • What do managers and operators	Design criteria: Managers live in the "twilight of uncertainty." No set of models, suite of statistical tools, or results from process studies will solve the wickedly complex problems that managers, policy makers, and society face. T&S units serve systems-level operations and management best by contributing conceptual ecological models, scale-constrained numerical models, scale-unconstrained process knowledge, and deep experiential

	screened by systems-level management's consideration of their requirements. Investments in monitoring, analytic inquiry, and imaginative research, management, and operations must all fit together. Institutional arrangements and capacities must also be factored into the equation. Precision and realism are the toughest trade-offs for science practitioners to make. However, the priority is always to inform the management problem. The onus is on science to stretch the limits of technology and conceive of new methods to capture data and consolidate monitoring efforts in support of management objectives.	spatial and temporal scales from the standpoint of addressing the legacy of uncertainty and the value of information for management. Typically, the attention of management and operations is captured by small-scale, fast variables, events, and patterns. S&T units can help M&O understand the value of scanning the larger temporal and spatial horizons. Through this lens the need for large-scale management experiments becomes more apparent. It is important to find alternatives to intensive sampling technique that are time and labor intensive. Possibilities include satellite imaging and digital particulate counting.	overlook that T&S units can help bring clarity to? o Hypotheses relevant to changes in external context or environment and key parameters of ecological structure and functioning of managed ecosystems are often neglected. o These changes are the real source of the surprises and crises that pace learning.	understanding of the natural history of the regional system. This blend of qualitative and quantitative tools and understanding pave the way for active adaptive management that provides useful information, reduces uncertainties, and gives direction to both scientists and managers of regional renewable resource systems
o Options analysis (input)	The results of options analysis never provide credible evidence in support of a single explanation.	At this juncture, the T&SF/Ps have done their job. The process of options analysis conducted during the assessment phase goes through one more round		Design criteria: At this stage, whatever hold the T&S units had on the development, screening, and

		of evaluation as policy is defined.		evaluation of options is loosened. The baton is passed to the policy analysts who must prepare the decision tables, however uncertain the perceived outcome.
➢ Thruputs				
o Policy formation	Policy designers at the scale of decision making and implementation must be flexible enough to create policy framing documents from elements in the policy environment. Their flexibility is derived from the actual situations of policy practice, which tend to be more muddied, fuzzy, and mixed than in the assessment phase, in which the policy environment is restrained by rules pertaining to platforms for science and democracy. As a result, settings for institutional action tend to be hybrids of natural system conditions derived from politics, society, and science. True to the relatively general character of institutional action settings, individual policy actors are at greater liberty to select particular combinations of elements of policy options on which to act. This discretionary freedom is what	How should T&SF/Ps position themselves in terms of the relationship between the scientifically framed and stakeholder-engaged options analysis vs. the policy environment of specific decision settings? In particular, T&S units must avoid falling into the trap of allowing their attempts to salvage the scientific basis for decision making to lure them into a position of either advocating policy alternatives or standing alone defending the results of what was truly a policy and science dialogue during the assessment phase. When faced with having to make potentially	• It has not always been easy to provide technical and scientific information to decision makers. Roles and relationships have been unclear and expectations at times ambiguous or nonexistent. • What is the new relationship between decision making and systems-level T&S capacity? • What are the processes that will ensure that the information provided by the T&S unit is incorporated into report cards for policy-level review, and that regulatory reports include information on systems-level or	Design criteria: All attempts to frame scientific and technical issues are diagnostic and prescriptive. The challenge that a T&SF/PS face is to ensure that the diagnoses and prescriptions forwarded to decision makers are based on systems-level understanding, not just project based.

	makes it possible to reconcile divergent views and unresolved conflicts. In the last stage of the policy design process, decision makers have the flexibility to explore convergent themes that do not violate the norms of the interests or agencies they represent. At this stage, the results of the options analysis are most vulnerable. If left unattended and unstructured, all the hard work and shared understanding held by the participants in the preceding policy forums and dialogues may have little influence on shaping the patterns of action in the final policy design. Unless explicit tables are developed to transfer the results of options analysis into a simple matrix that sets forth policy alternatives with their respective likelihoods, risks, and projected outcomes, however uncertain, the policy environment will create a “garbage can” that policy makers will rummage through before taking final action.	unpopular decisions that involve high levels of uncertainty and conceivably costly short-term results, decision makers have been known to pass the buck to scientists or to balk and ask for further studies. T&S units must resist the temptation to get involved in policy environments in which decision makers are attempting to abdicate their responsibilities or find scapegoats. The role of T&SF/Ps is to reflect on the work that has gone into the development of policy options and to provide feedback relevant to policy formation and design based on prior implementation, assessment, or results from field tests or environmental studies	cumulative effects and are filed in timely manner?	
o Policy action and experimentation	Policy action is not monolithic. It can be carried out through (1) goals articulated by political leaders; (2) points of view expressed by representatives of government agencies; (3) formal	The role of T&SF/Ps in the policy action and experimentation component of the policy design phase is minimal. If the scientific and	• How can T&S units help anticipate and address management’s reluctance to carry out actions as	Design criteria: • As part of developing their systems-level perspective,

	statutes, rules, or regulations; and (4) the practices of the administrative agencies and courts charged with implementing or overseeing programs. In the context of the adaptive process, policy action and experimentation is a deliberate effort to use actions as a way of learning about uncertainties that cannot be reduced or eliminated by any other means. Decision makers must learn to confront management problems with data obtained through deliberate action. As far as possible, large-scale experiments must be conducted with scientific rigor in the areas of control and inference. In some cases, the necessary flexibility does not exist to implement management experiments. Where this situation exists, decision makers need to embark on avenues of inquiry that explore policy space in which it is “safe” to fail.	technological basis for management action and experimentation has not been incorporated prior to the point of decision making, the T&S unit should turn its attention to the next effort that is ripe for action and can benefit from T&S capacity.	experiments? • Could T&S units use their systems-level perspective to help identify potential field tests and environmental studies that could be conducted to increase management flexibility and options?	T&S units should identify potential reference sites and locations for field tests and environmental studies that could help management become more flexible in its actions.
o Implementation	All important distinctions are initially ambiguous; moreover, complex adaptive systems are changing faster than humans can mobilize appropriate responses. Unrestrained growth fueled by blind faith in progress may have created the conditions for the ultimate pathology in which human influences are so dominant	Clear goals and objectives are possible only when problems are simple and concise and cause-and-effect relationships can be easily discerned. We are now facing wicked problems whose	The question is this: Is decision making by trial and error the best that humans can do? Adaptive management is learning by doing, but there is little if any evidence that human adaptive capacity has	Design criteria: T&S units must focus on how to close the gap between the recognition of management challenges and the development of

	that natural systems are being pushed to the brink of collapse. Instead of knee-jerk reactions or the passive acceptance of the environmental problems that managers now confront, a new approach to scientific management is needed that can accelerate learning in the face of increasing uncertainty.	multiple causes require lines of evidence that may not intersect or converge. Planning traditionally assumes that problems are relatively easy to define and therefore amenable to the establishment of clear goals and objectives. Consequently, the major task is following a logical sequence of steps that will ultimately reveal a clear, unambiguous solution. The challenge for T&S units is to help others frame and reframe questions in ways that bring greater clarity to problem definition and to project goals and objectives. As social-ecological systems continue to change, problems also evolve, and so must our technical and scientific understanding.	evolved as quickly as our challenges. Can technical and scientific functions and programs accelerate learning and help managers make more rapid progress in wrestling with what appear to be intractable problems and inept approaches to problem solving?	appropriate responses. T&S units must help management agencies shift from antiquated and arcane planning modes to design approaches that are much more suited to complex problem solving.
o Subsystem monitoring	The adaptive assessment phase is responsible for systems-level monitoring. In the adaptive design phase, monitoring is focused on responses to specific management actions.	T&SF/Ps are essential for coupling project-centric monitoring to system-centric monitoring. The rationale for subsystem monitoring should	Monitoring at different scales tends to focus on different objectives, indicators, and performance measures. T&S units can help coordinate efforts by	Design criteria: T&S units are most effective when they are not doing the monitoring work themselves but are

	The role of Technical and Scientific Units is to support line organizations in helping them determine What needs to be monitored and why? The projects need to fit into the overall conceptualization of the ecological systems as stress-response models. • Species to detect changes in population, e.g., presence/occupancy, demographics. • Habitat to detect changes in amounts and conditions, e.g., ground plots, satellite/photos, maps. • Ecosystems to detect changes in processes, e.g., applicable to management problem. • Threats -- detecting change in degree or type, e.g., testing the efficacy of management strategies.	comport with the conceptual ecological models that have been developed at the system and subsystem levels. T&S units can provide a valuable service to management units during the adaptive design phase by helping them determine how their indicators and performance measures not only address project-specific issues but how they fit in and contribute to a greater understanding of the conceptual modeling that has already been developed. • What hypotheses and assumptions are being tested? • What, if any, new associations between key parameters are going to be tested in the monitoring scheme?	local management units and serve the larger purpose of integrating subsystem monitoring into landscape-level schemes and conceptual models. Why do we need subsystem monitoring schemes? • To detect changes in species abundance, condition, and population structure; • To support management needs (the primary reason); • To provide early warning; • To measure species response to management efforts or other factors; • To provide a basis for adjusting/modifying subsequent actions; and • To expand the information base (the most commonly used reason).	facilitating the work of others. This helps to keep T&S units focused on the bigger picture and how all the puzzle pieces fit together while educating managers and developing greater adaptive implementation capacity within management units. • T&S units must have the capacity to support and influence the development of project- or subsystem-level monitoring efforts. Without such capacity, their effectiveness is seriously hampered, if not irreparably damaged. • T&S units must be skilled in helping action agencies

				understand the whys, not just the hows and the whats, of monitoring and feedback.
➢ Outputs				
o Feedback policy	Closing the loop: One principal goal of the adaptive process is to have management agencies learn from actions taken. The traditional planning model assumed that, if a sequence of steps was followed, the most appropriate alternative would be selected, the problem would be solved, and managers could move on to the next issue. This approach has had tragic results and catastrophic consequences for both society and nature because feedback was not part of the traditional planning model. It was assumed that, if the *ex ante* analyses were conducted accurately and objectively, the solution would be obvious and implementation would proceed unquestioned. Over the past 60 years, this planning approach has unsuccessfully attempted to decouple society and nature by isolating society from nature and turning nature itself into an "enemy" or a "victim." Implicit in the notion of feedback is that management decisions are being	T&SF/Ps have evolved for the express purpose of recoupling social and natural systems in generative ways that are mutually beneficial and reinforcing and that view natural systems as "allies" and "partners." The relationship between humans and nature must change. There is no alternative. Nature has always provided essential ecological services that have benefited and sustained humans. T&S units are a principal agent in reestablishing a relationship in which humans can learn to live with and profit from the dynamics that generate and renew natural capital and provide essential services to mankind. This role for T&S units	• How can T&S units reinforce the message that management actions are not once-and-done affairs, but are sequential in nature? As a result, managers must pay as much attention to monitoring and feedback as they do to planning. • What are the existing policy levers that T&S units can use to influence, cajole, and guide managers to adopt effective feedback policies as part of their way of doing business?	Design criteria: • Feedback policies must answer the following questions: o Which management problem are the monitoring and feedback components intended to address? o How can the monitoring scheme be structured to not only address scientific questions but also provide feedback

	conducted in a closed-loop system. External social, economic, and ecological forces are acting upon institutions. These forces require fitting responses, or ultimately such institutions become irrelevant and obsolete.	has been articulated not at the level of a series of activities to pursue or a set of steps to be taken, but at a deeper level that attempts to frame the challenge at the scale at which it must be understood. The prevailing logic of the system in which nature and society interact must change within the span of current professional careers. Once this understanding has been incorporated into the mental models that each of us uses to take effective action, the principles, procedures, and practices inherent in a feedback policy will be apparent.		to inform subsequent policy and management actions? o Who is responsible for distilling and synthesizing the results of monitoring into a form that effectively communicates the scientific and technical information they contain? o How can the communication of feedback be turned into learning opportunities in which shared understanding can be

				updated, reframed, and integrated into the conceptual models and analyses that form the basis for ongoing assessment activities?

Task 2
Challenges Faced and Lessons Learned:
From other efforts in large-scale restoration and recovery efforts around the Nation

Task 2 Product: Dr. Light will be responsible for drafting a report describing other technical/scientific programs from regional restoration programs around the nation.

The Adaptive Process Challenges & Lessons	Large Scale Recovery & Restoration Efforts		Integrative Science For Adaptive Management	
	Challenges Faced	Findings	Lessons Learned	Implications
The Adaptive Learning Phase				
➢ **Inputs** (From Previous Policy Design Phase)				
o Feedback Policy Case Examples: ➢ Missouri Dept. of Conservation (MDC) ➢ Columbia Basin Fish and Wildlife Authority (CBFWA) ➢ Upper Mississippi River Basin, US Geological Service Environmental Science Center Missouri River	➢ MDC is in the process of converting its whole agency approach to scientific management to align with Adaptive Management principles and practices. Projects have to manage experiments – biggest challenge is getting feedback from experiments to inform subsequent actions. ➢ CBFWA was intended to be the "third pillar" of the institutional framework for governance of the Columbia River Basin, along side Bonneville Power and the NW Power Planning Council. CBFWA was intended to provide technical and scientific support for the Basin; however,	➢ Formal feedback policies to inform subsequent management action in many cases do not exist. ➢ Informal relationships such as the Corps have developed with the Fish and Wildlife Service on the Missouri River Recovery are working; as is the case in the Everglades. ➢ The Everglades with their Applied Science Strategy have developed an excellent monitoring and assessment	➢ The old planning model of "once and done" decision-making is a persistent habit that is hard to break. ➢ Changing the way people work is more important than changing institutional boxes. Good working relationships	➢ Integrating science alone is not sufficient; science, policy and management must be integrated before Adaptive Management has a chance of working. ➢ Incentive structures are more flexible than institutional structures. Where managers are providing

Recovery, Corps of Engineers and Fish and Wildlife Service Partnership	the institutions are stove piped with CBFWA unable to convince either of the other two that it should be providing feedback on the policies and programs. ➢ Systems level monitoring carried out by the US Geological Survey and its state cooperators is not used to inform US Army Corps of Engineers management decision-making. There is no working feedback relationship between the two outside of minor issues pertaining to potential sites for dredge-spoil material. State and federal cooperators in monitoring and restoration have not been apprised of a recent management services contract to assist the Corps with projects pertaining to new congressional authority for navigation expansion and ecological restoration ➢ To close the gap between the developments of Corps projects for river recovery of threatened and endangered species and the meeting of species and habitat goals, the Corps of Engineers has contracted with the Fish and Wildlife Service to provide scientific and technical services on meeting recovery targets. This same relationship has evolved in the Everglades	program i.e., "Box 2." However, "Box 3" in their Adaptive Management Strategy where monitoring and assessment is integrated into decision-making is not functioning. ➢ In Minnesota DNR, the work relationships were changed, the organizational relationships followed suit during the 1990s but political backsliding influenced by fin and feather group agendas dismantled ecosystem management in past 7 years.	between science & management developed on relatively informal basis seems to be closing the gap between action and feedback. Formal multi-institutional arrangements are relatively inflexible and tend to thwart feedback efforts.	incentives to science, the feedback and integration is more likely to be achieved. ➢ Management without feedback upon which to base subsequent decisions cannot be considered "adaptive." ➢ State-level efforts like MDC may prove to be an excellent model for Louisiana to follow.
o Subsystem monitoring Case Examples: ➢ Comprehensive Everglades Restoration Plan ➢ South Florida Water Management	➢ In many instances, subsystem monitoring at the project level is not conducted; if required, rarely evaluated and integrated into subsequent decision-making. Primary reasons – monitoring is too expensive; not enough manpower, lack of capacity to develop databases, scrub them and develop analytic tools to integrate monitoring at larger-than-project levels. o For water projects, once plans and	➢ Precision v. Accuracy Scientists are trained in precision and theory building at the expense of being able to account for exogenous influences that effect indicators monitored in real time. As a result, scientific monitoring at project scales is often narrow but thoroughgoing in number of reliable	➢ Scientists charged with developing and implementing sub-system monitoring systems must become more imaginative methodologically to improve capacity to inform	➢ For science to be truly integrative, science must come to terms with how to integrate experiential understanding into its monitoring schemes. ➢ More training in

District system level evaluation of wetland permitting ➢ Minnesota DNR Citizen Science Program ➢ Northwest Colorado Range Management Plan ➢ Sage Steppe Restoration Strategy ➢ Fisheries research findings by Carl Walters and Jim Wilson ➢ Upper Mississippi River Ecological Restoration and Navigation Expansion	specs are approved, construction and operation permits are issued with special conditions to handle contingencies. Periodic monitoring reports are sometimes required but under routine circumstances are not evaluated. Increasingly, project monitoring in highly sensitive (a.k.a., reduced threshold) areas are receiving greater scrutiny. o For land projects, instead of monitoring, stipulations or prescriptions are attached to project approval. Crude indicators like "stubble height" are used as non-degradation standard for grazing allotments. ➢ For some human uses in highly sensitive land and water areas, agencies are turning to methods of self-monitoring and policing. If agency field observations of an area detect excessive soil erosion, compaction or degradation of the resource, permitting is stopped until user groups form their own methods of monitoring overall conditions and regulation. Permits are issued, citizens monitor conditions use accordingly; agencies oversee. ➢ In a growing number of cases since mid-1990s, citizens are augmenting agency capacity for science-based subsystem monitoring with self-knowledge complemented with training on record keeping. For example, in Southeastern Minnesota, Trout Unlimited members are trained in sampling techniques for macrophyte invertebrates used to determine the health of trout streams. Studies of the use of these protocols by citizen	recordings; inference is limited but reliable. ➢ On the other hand extensive experiential understanding from persons of deep craft lack the precision of science but may actually be able to surpass technical monitoring by drawing from rich observations made over diverse condition that reveal relationships and system level dynamics that are beyond the capacity of monitoring systems. ➢ Use of non-degradation standards (NDS) as a way of monitoring and <u>adjustment</u> at local projects scales can be effectively employed. However, there are drawbacks. Such standards may be used to "trigger" remedial action, but are implicitly self-limiting, establishing minimal acceptable conditions andfundamentally recuperative not restorative in nature. ➢ On the flip side, NDSs are at least tied to management action where sub-system monitoring may not. ➢ One of the most persistent and debilitating problems in land and water management agencies and the communities they serve is	management actions. ➢ The use of remote sensing capability is one tech-based avenue that is developing rapidly. ➢ Basically monitoring is a form of intelligence gathering, & just like the CIA discovered; there are limits to the intel. that "monitors and keyboards" can produce. Science assumes objectivity and universality, but subjective and authentic experience may be reliable and accurate as well. Is one better at separating signal from noise? ➢ Actually both are necessary. Increasingly, Bayesian statistics that incorporates both is gaining favor and credibility in terms of percent of journal articles	Bayesian statistics and decision theoretics is needed. ➢ How education and outreach dollars are spent needs to be revisited. In addition to school teachers educating children who then pass learning on to parents; science practitioners responsible for monitoring and assessment need to think of how citizens as scientists can be effectively engaged as well. The benefits are not only reduced costs of monitoring but more informed citizenry and strong advocates for monitoring programs. ➢ Due to increasingly scarce resources and bourgeoning demand for additional

	scientists have proven to be effective in development of agency databases.
	➢ Extensive review of research literature was beyond the scope of this effort, however it is worth noting that the questions of alternative methods of subsystems monitoring is being researched. Wilson has shown success in lobster fishermen being capable of self-monitoring and regulating lobster take. Walters in analyzing the plight of the cod industry in the North Atlantic recommends developing incentive structures for employing the fishing fleet to regulate themselves; being trained not only to self-monitor but also trained in proper use of legal fishing rigs and gear to cut down on by-catch and over-harvesting of certain age classes.
	➢ For large-scale water projects, monitoring is typically tied to rule-curves that regulate water levels for human purposes (e.g., navigation, flood control, water supply, etc). Instead of subsystem monitoring for the environment, mitigation is required. All manner of problems arise with mitigation.
	  ➢ First, mitigation is usually designed at inconsequential scales, usually smaller than that which the natural system requires to define it. As a result, many of the mitigation structures are ineffectual.
	  ➢ Second, the mitigation treats the symptom and not the cause. Implicitly, nature is assumed to be the "victim" and as victim, will never be made whole.
		the lack of institutional memory based on monitoring and related observations. Without memory, there is no data mining; no learning from the past, without learning there is no improvement in management. Examples of this problem are multifold
		o In water projects, reasons for changes in construction and operations are not documented which can confound monitoring efforts.
		o Monitoring data based are developed, shelved; software architecture and programs are changed and the capacity to integrate long term monitoring records is lost.
		o Frequentist(?) statistics also hamper the capacity to draw from multiple data sets as a basis for decision-making; decision theory approaches have developed techniques for addressing this problem.
			published.
			➢ Less sophisticated but effective methods of incorporating experiential information into monitoring schemes is the use of citizen scientists and field workers in resource industries. With training in observation, and record keeping valuable contributions to institutional memory can be made.
			➢ Institutional memory is one of the biggest gaps in integrative science and must be systematically addressed.
			➢ Again, human understanding, not just banks of monitoring data need developing.
				monitoring capacity, technical and scientific units will be pressured to supply evidence that existing monitoring data is being fully employed before submittals for new monitoring schemes are recommmended for budget approval.
				➢ The demands for monitoring capacity are growing exponentially with the advent of national and international policy domains legitimizing climate change as serious societal problem.
				➢ Increased scrutiny of monitoring schemes will require greater adherence to management specific objectives. There exists a legacy of monitoring

	➢ Alternatives to mitigation are being attempted in the Upper Mississippi River. For a season, rule curves are being modified, channel depth for navigation receives extra attention, but pool levels are being lowered and the interannual response by submerged vegetation has exceeded expectations. The management experiment has been intensely monitored from an ecologicaland economic impact perspective. Such monitoring has paved the way for more experiments to follow.			activities that have been in existence for decades that have been perpetuated as pet projects not because of their value as decision relevant information or their capacity to reduce key uncertainties. These efforts will undoubtedly be given closer review and subject to redirection. ➢ Proposed projects and actions will increasingly be reviewed to determine how uncertain their results might be and how much risk is requisite to their implementation. New criteria pertaining to the “value of new information” and the capacity to reduce the “legacy of uncertainty” will be added to project evaluation. ➢ Peer review of

				monitoring for integrative science and management will become more common and required by policy makers
o Hypotheses ➢ Salton Sea Restoration ➢ Kissimmee River Restoration ➢ Glen Canyon Dam ➢ Comprehensive Everglades Restoration Program ➢ Missouri Department of Conservation ➢ Chesapeake Bay ➢ Bay/Delta, Sacramento River ➢ Research Literature by C. S. Holling, Carl Walters, Don Ludwig, and Ray Hilborn ➢ Bernard Borman, lead scientist with PNW Forest Plan (a.k.a., FEMAT)	Ecosystems are complex. This complexity is compounded by the fact that they are managed systems with arbitrary boundaries imposed by administrative jurisdictions with dissimilar missions, objectives and targets. Moreover, managed ecosystems are dominated by human systems that are largely ignorant of their properties, inherent trajectories and dynamics of renewal. Policy has been dominated by images and myths of nature that present challenges to management. These images and myths form the deepest human orientation toward nature and define the fundamental relationship. Images of the relationship include nature as "enemy," "victim," "ally," and "partner" of man. Myths of nature's behavior include "infinitely forgiving," "ephemeral," "practical joker," "resilient," and "mystery." All of these images implicitly guided human policy and actions for millennia. Ironically, all of these images and myths that guide policy are really assumptions, and policy is hypothesis. Adaptive Management strikes a fundamentally new position based on scientific management that has as its challenge the surfacing of these images and myths, making them explicit and testing their veracity by	o The evolution of Conceptual Ecological Modeling (CEM) as a tool for making hypotheses and assumptions explicit has proven to be a breakthrough in effective communication of scientific principles, methods and thinking as a basis for action. o The practice of not developing multiple and competing hypotheses has wasted time and hindered learning. For example, in the Chesapeake Bay, the decline of the fisheries and habitat was largely blamed on water quality. The Environmental Protection Agency was the lead federal agency and their policies in water were largely quality based clean up of point and non-point sources (Clean Water Act), not really ecological process driven but looking instead at constituents (physical, chemical and biological). Beginning in 1988, research started to	o In the vast majority of cases the science of testing hypotheses is not being used to steer management action. o Experimental designs require controls and inference to be taken into account. Decompartment alization of the Water Conservation Areas and restoration of flows to the Everglades National Park have been thwarted due to the lack of will and determination by policy makers. The most crucial aspect of the	o Until management action as inquiry using hypothesis is taken seriously by the agencies, integrative science will not be seen as important. o With the advent of climate change effects coupled with the precipitous decline in biodiversity due to the alternation and collapse of biophysical structures (coral reefs, river deltas, major fisheries, migratory flyways) that support life, humans have reached the point of deflection referred to as hypotheticality where man induced actions

	confronting images and myths with data. Action as inquiry. Much of the forgoing is based on the pioneering work of the authors acknowledged in the column to the left based on literally hundreds of case examples. The challenges to science practitioners inherent in surfacing assumptions and testing hypotheses are exacerbated by the personal agendas and constituency based interests the decision maker takes into account, and topped off by the fact that they are by nature risk averse. It is little wonder that this new age of scientific management has had problem getting a firm footing when decision environments resemble "garbage can" politics and disjointed incrementalism. How have these challenges been overcome? In the case of the Kissimmee River Restoration, engineering and policy had to rely on science and the scientific method because no one had ever attempted to restore a river. Second, teamwork developed between science, engineering, management and policy. Extensive public engagement was initiated and all the reasons why the restoration would not succeed were surfaced. Third, they used the feedback from all affected parties as a tool for advancing restoration. The feedback were prioritized and tested. Analogs were also used to justify field tests. A process emerged of separating what was known from what was unknown. The goal was to eliminate as many of the uncertainties as possible through different modes of	emerge regarding the potential role of oysters in water quality. Further research revealed that 99% of the oysters had disappeared over 100-year span and the habitat for oysters had also been damaged or lost. The growth in population around the Bay continues creating potentially new sources of water quality problems. But the role of oysters continues to be investigated and heightened by recent discovery that a myriad of streams and tributaries to the Chesapeake were dammed during colonial days, trapping sediment that hypothetically could have had a derogatory effect of oyster beds and island building in the Bay. (So the decline occurs as these dams are removed, releasing the sediment? Just trying to understand.) o The Salton Sea is a salt-water body artificially created down stream of California's central valley irrigation canals. With the loss of almost all the inland wetland and brackish water coastal areas, the Salton Sea has become an integral part of the Pacific Flyway and the	Everglades Restoration is "getting the water right" and the only effort to design a test of flow restoration was cancelled after a year of concerted effort by an interdisciplinary and interagency group of scientists and engineers. Scientifically it is undisputed that virtually no large scale flow-response hypothesis testing has been conducted in the past 50 years. The restoration is estimated at $8B and the test could coast $10M over 4 years. (.01% of money over 10% of time for program). o The mantra used to be that in Adaptive Management, the science was easy, dealing with the social-	have reached a stage beyond which safe-to- fail policy (hypotheses) cannot be tested; the risk of adverse synergistic effects may be greater than social-ecological systems are prepared to assimilate. o Considerable attention needs to be given to risk management, not risk analysis, to determine under what conditions collective risk taking supported by hypothesis testing and integrative science can work. o Risk aversion has created a positive feedback where the unwillingness to embrace action as inquiry has actually increased potential magnitude of future risk-taking due to the lack of precaution and deliberate management of risk(?) hypothesis

	hypothesis testing – physical, numerical, and conceptual modeling. Testing hypothesis is the cornerstone of adaptive action based on integrative science. In fact, Adaptive Management advocates the testing of multiple hypotheses simultaneously through management actions to accelerate learning by eliminated alternative hypotheses that don't yield significant biological results when tested. This process is referred to as "strong inference" and departs from traditional science that relies only on a null hypothesis and an alternative hypothesis. Interviews with Dale Humburg and Bernard Borman have substantiated the benefits of testing multiple hypotheses simultaneously. Humburg required project managers to develop alternative hypotheses and testing methods as part of project proposal writing for budgeting purposes. Borman used a nested approach to testing hypotheses. Developing hypotheses at different spatial and temporal scales in hierarchical fashion. The Glen Canyon Dam operations have been turned into a rigorous laboratory for testing alternative hypotheses in attempting to recover native warm water fish (e.g., Humpback Chub) and river dynamics (e.g., recovery of sediment dynamics and accretion of sediment in the form of sand bars a highly altered and regulated system. The US Geological Survey is now in the process of developing a long term testing program spanning two decades.	home or refuge for over 300 species of birds. Due to the rush created by available Congressional funding to improve habitat, a levee separating the discharge from the irrigation to help clean up the western portion of the sea was approved and construction began. No real hypotheses developed nor tested. The levee was constructed on a fault line and has failed to achieve its intended purpose.(hah!) o Uses of integrative science and adaptive management are receiving increased attention and challenges to the efficacy of scientific management strategies are being mounted. A quick survey of federal district court cases revealed 60 challenges involving Adaptive Management. Of those approximately 16 appeared to be substantive. The Institute for Environmental Conflict Resolution is currently conducting a detailed review of these cases. One case of considerable note was the challenge brought by Natural Resources Defense Council and other parties against the CALfed Bay/Delta science	political dynamics was challenging. Thirty years of experience would suggest that neither the science of hypothesis testing nor the institutions are working to any great extent, yet. o The vast majority of the scientists is rained only in null-hypothesis testing and lack training and application of more decision relevant Bayesian statistics.	based action taking.

	A serious challenge to testing hypotheses is the lack of patience by policy makers and the burgeoning demand for human uses of the river.	program. It was challenged based on the lack of methodological rigor and experimental scheme to support its claim of scientific management. This finding reinforces the call for more hypothesis testing where controls and inference are taken into account during design and implementation.		
➢ **Thruputs**	**Challenges**	**Findings**	**Lessons Learned**	**Implications**
o Analytic Inquiry Case Examples ➢ Middle Rio Grande Recovery of Silvery Minnow ➢ Development of Flow-Response Test In Everglades ➢ Minnesota Department of Natural Resources; Forest and Fisheries Research ➢ Missouri Department of Conservation ➢ US Forest Service, US Geological	In April 2007 a 3-day workshop was conducted on Adaptive Management (AM) by a local non-profit organization, Save Our Bosque Task Force. Notably absent from the workshop were research representatives from the University of New Mexico. Upon inquiry, a senior scientist from a principal water agency stated that research scientists were not interested in AM on the grounds that they were only interested in efforts that advanced their "null hypothesis research agendas." They assumed correctly that the workshop would focus on need for multiple working hypotheses being tested simultaneously using management experiments. This anecdote points up one of the major scientific clashes in implementing integrative science to support action as inquiry; one that is widespread but only talked about in sidebar conversations; rarely talked about explicitly.	• Traditional analytic inquiry dominated by null-hypothesis testing has resisted integrative science that requires dealing with other disciplinary modes of inquiry and limes of evidence. • Instead of being driven first and foremost by simple cause and effect theory building, integrative science is inquiry in support of management action, and is developing its own body of theory and methods. • Working in realistic settings in which management and nature define inquiry, is not conducive to issues pertaining to inference can research controls. In	• Management agencies must be more aggressive in working with academic institutions, to remedy the deficiencies in course work (e.g., Bayesian statistics, induction, strong inference, large scale experimental designs, interdisciplina ry training (multiple modes of inquiry and evidence), decision	• Until managers and policy makers understand the value of analytic inquiry in the context of integrative science for decision-making, management problems will be hamstrung. • Systems level integrative monitoring, assessment and management depends on traditional science and applied analytic science to provide the building blocks for problem solving.

Survey, ➢ South Florida Water Management District ➢ AM Research by Gunderson, Carpenter, Holling, and Walters, and Hilborn	The genesis of this rift between traditional science and what has been termed the “new” science or post-modern science (integrative and management problem centered by design) goes back to the 1960s when a group of scientists lead by Ken Watt, CS Holling, Paul Erhlich, HT Odum developed the basis for systems ecology. This move was opposed by both nationally respected natural historians and researchers who had grown up in the tradition of small scale experimental research that advanced discipline-bound, precision, and theory building that revealed simple cause and effect relationships. The systems ecologists challenged conventional thinking by arguing in a series of journal articles that realism had to be factored into the scientific design equation along with precision and theory building. Systems ecologists argued that: 1. Systems ecology complemented traditional science and pointed to the need for integrative science to respond to the growing number environmental problems manifesting themselves at larger-than plot size experiments. 2. Systems ecology were discovering that analysis of subsystems like predator-prey relationships could be generalized into a set of known behaviors and that those behaviors could then be linked to larger scale processes that influenced behavior, such as natural or human induced changes such as forest fires, changes in lake trophic status of	biological responses do not always equate to >0.05 level of significance. New methods dealing with issues of reliability and validity are needed. • For example, scientists working on monitoring schemes for Everglades’s restoration are still attempting to “validate” results, when in reality hypotheses can only be disproven, not validated. • Researchers are uncomfortable with efforts to accelerate learning over the slow accretion of evidence by using “strong inference;” the testing of multiple hypotheses simultaneously, to quickly weed out the “weaker” alternatives. • The gap between reductionism and integrative science is not being closed fast enough. There are legitimate methodological concerns, but scientists are usually given a tool bag of methods during their doctoral studies, so they are ill prepared developing methods to pursue more integrative questions. • Moreover, new faculty for fear of not being granted tenure avoids any research	theoretics) that stymie integrative science. Incentive work but they take time to take hold. • Over the years, agencies have attempted to create internal research sections and these have yielded mixed results. Even large-scale operations supported by agencies like the US Forest Service and the US Geological Survey experience goal drift. • Incentive structures work within agencies when management and policy are persistent in their demands analytic inquiry that is centered on filling gaps in	• Incentive and reward structures, intergovernmental and university institutional design must be realigned and the roles of traditional analytic and integrative science clarified. • The stigma and legacy of Environmental Impact Assessment needs to be studied and the implications for analytic and integrative inquiry need to be explored. For example, the process has encouraged “boiler plate” science, the growth of “biostitutes” and an “industrial strength” science that really does not deserve to be called “science.”

	lakes, forest cutting regimes, standards like "maximum sustained yield." 3. Sensing the need to respond more rapidly to societal problems, the systems ecologists saw the need for relying on inductive reasoning that searched for rapid breakthroughs in thinking at management scales as opposed the reductionist research that adhered to slower accretion of knowledge. 4. Systems ecologists saw a world that was multi-causal and required multiple modes of inquiry that yielded multiple lines of evidence. To address more realistic societal level problems where management could be applied, system ecologists had to develop new methods that addressed issues like precision and theory building. Numerical modeling, with the advent of personal computers and computing capacity facilitated the growth of these new integrative methods that also included decision theory, optimization, Bayesian statistics, likelihood, policy exercises involving game theory.	or publishing that does not demonstrate their individual prowess. • With support from the National Science Foundation with programs in biocomplexity and integrative studies, coupled with agency-based funds, research faculty are becoming entrepreneurial, and university development offices see the value of creating non-tenure tract institutes and centers that boost research revenues and prestige. • Agencies like the Missouri Department of Conservation are striking out on a new path. They require their science practitioners and managers to work together to develop management experiments using integrative science or their studies don't get funded. And it is working!	management problem. All to often, managers don't know how to harness research in analytic or integrative ways and how they need to work together to fill gaps in understanding as a basis for decision making; • Science programs lack problem-centered focus, creating reams of data that make for good conference papers and journal articles but do little to support management decision making.	
o Modeling __________ Case Examples ➢ Everglades Restoration ➢ Kissimmee River	Modeling for management of natural resource has proven to be powerful technique; however, it is still in search of its fundamental roles in management problem solving. ATLSS and ELM are two examples of large-scale modeling efforts in the Everglades, ecological models that	o What have evolved in natural resource management are the adaptation of engineering models to ecological settings for water management and the	o Modeling for natural resource management has enormous potential that has not	o Modeling in general (with the exception of conceptual ecological modeling) will be limited in its

Restoration ➢ Flow-Response field test in Water Conservation Areas in southern Everglades ➢ Upper Mississippi River Adaptive Environmental Assessment ➢ Northern Hardwood Conifer Forest	have failed to produce reliable results; results that are trusted as much at the Natural Systems Model developed in early 1990s and updated ever since then and the primary model used to testing alternatives for restoration. A requiem was even predicted for large-scale ecological modeling due to their resemblance to Rube Goldberg Machines. Caveat: There are exceptions, other smaller models have been developed like the one used by the Everglades National Park that has had impressive results in predicting biological impacts of flows regimes from culverts south of Tamiami Trail. Large-scale site-specific hydrologic modeling has been in place since the early 1980s, but the problem with them is the lack of data on sediment dynamics that would help considerably in predicting biological responses. Modeling has been plagued by criticisms that they lack precision. The response has been – add detail. Computer speed and capacity have dramatically improved so this is not a problem. What remains a problem is that ecosystems are remarkably diverse. What has happened is the loss of the simplicity of coarse grain models the strategic value. Detail obscures vision and the emergence of counter-intuitive results when not tailored to specific contexts. As CS Holling, a pioneer in the use of modeling of ecological systems pointed out in 1966 – “Although computers and their languages are remarkably well suited to cope with the magnitude and kind of complexity inherent in ecology, their great	development of multi-layered GIS models for land management. Hydrologic models with the exception of in-land lake management modeling (e.g., Lake Mendota in Madison WI, and Precambrian Shield lakes in Canada) has had limited success in coupling ecological dynamics with hydrologic dynamics. From the standpoint of GIS systems, they are superb at visualization of spatial complexity but lack temporal complexity. Advances in coupling temporal and spatial dynamics are improving daily, witness the explosion of video games and the science based “SIM” capacity. o The gaps that remains is the ones cited by Holling and Walters decades ago – modeling as a tool for communication among diverse constituencies and the lack of transparency which sometimes inhibits the building of trust and commitment. In fact, in the aborted Two Forks Dam project modeling by the lead government agency was proven to be seriously flawed by intent.	reached its potential. There are many types of modeling that are useful that scientists and managers seem to have trouble sorting through and appropriately matching their capacity with management needs. Examples are manifold and are discussed in the first column dealing with cases. o For some reason numerical models have been preoccupied with prediction at the expense of communicatio n scientific understanding . o GIS modeling has been very effective tool	effectiveness for communicating understanding to decision makers and stakeholders until it is embraced as a way of simulating a dialogue between humans and nature. Human capacity to comprehend nature’s dynamics can only be understand in the rear view mirror, in the past tense. But based on past experience, humans can become more future responsive through greater understanding, and not just prediction. In fact, prediction can mask the deeper logic of the problem that could reveal the reasons why humans keep creating path dependencies that foreclose options for the future. o Modeling can be more effectively be used as a way

	promise can paradoxically, inhibit rather than enhance understanding." The Adaptive Management school of modeling emphasized modeling as a tool for communication as well as prediction. The predisposition toward using modeling as a communication device was highlighted in the early prodigiously cited works (Holling ed, 1978 and Walters, 1986). Yet, much of their modeling recommendations are ignored. Examples of lack of use or ignorance of modeling capacity for solving management problems. The relationship between hydrology and sediment dynamics is fundamental to understanding flow regimes put physical modeling as used so successfully as a scientific and communication tools is largely ignored. Numerical modeling for strategic purposes that are relatively transparent, user friendly that expand the bounds of rationality for decision makers are largely overlooked or dismissed our of hand. The Forest Stewardship Council in Minnesota ignored the modeling of John Pastor that demonstrated that state policy and industry practices were creating a relative monocultures of aspen and birch, simplifying the forest structure, eliminating key processes essential for forest resilience. His model was barred from the forest council's deliberations. Pastor is internationally recognized for his scholarship, a member of the National Academy of Science and an annual recipient of NSF grants.	On the Upper Mississippi the chief economist for the navigation expansion study finally turned whistle blower because of the Corps hierarchy had "jerry rigged" the economic forecasts for the barge industry. o The Adaptive Environmental Assessment process actually constructs a coarse grain model combining science and experiential knowledge in the presence of policy makers, managers, scientists and stakeholders. Relationships are made explicit, everyone understands what is going into the model and why. Also where gaps in science exist and where experiential knowledge, local or indigenous knowledge is being incorporated. The result is a powerful tool for developing shared understanding with the capacity to develop policy scenarios and test them. o At smaller scales, ecological models developed for the hardwood conifer forests	for communicating spatial patterns but does not adequately address human's cognitive blind spot – temporal discontinuity. o Precision is worthless if it does not accurately frame the questions managers have to confront. o In complex adaptive systems involving coupled ecological and social systems being influenced by forces at multiple scales, is prediction really possible more most important. It would seem that framing and reframing	of developing credible scenarios that can be tested and identify potential instability domains that decision makers and policy should avoid.

	In the Everglades, a heuristic or "toy" model intended to replicate the physical dynamics of ridge and slough formation was ignored, despite the fact that it revealed patterns similar to those found in the Everglades. The tool could have been used for hypothesis development but was not at the time.	of Minnesota and Wisconsin have proved remarkably useful when used to reveal the larger-scale landscape mosaic. Different cutting regimes can be tested to show the effects on forest composition and structure.	the question and context might be at least as useful to decision makers faced with wicked problems.	
➢ Shared Understand -ing ___________ Case Examples ➢ Adaptive Environmental Assessment in Everglades and Upper Mississippi River ➢ National Riparian Stream Team ➢ Southern Everglades Flow-Response Test	Modeling is a component of the Shared Learning Phase of the Adaptive Process because of its capacity to communicate understanding to create real dialogue among affected parties and decision makers and to simulate the dialogue with nature. Shared Understanding is in many ways the product of the Adaptive Learning Phase, but it is also an integral process component; a component that is oft time omitted from integrative science and Adaptive Management. People do not understand the dynamics of change. Humans form cognitive models of how they think the world works or should work. Conflicts arise when interests and position diverge. It is presumed that one party does not share the values of the other. In most instances, such situations are defined as conflicts requiring conflict mediators who attempt to find a common ground upon which the parties can agree. Our society trips into this situation almost by instinct because the its litigious nature. Collaboration and the creation of new	o Uncertainty is a two-edged sword. It can be used to perpetuate vicious cycles and feed the politics of fear, or uncertainty can actually bring people together to create new ways of working together. o Diversity mirrors complexity. People say, "if we could only get everyone to the table." That is a myopic and even dangerous myth. What is really needed is the requisite diversity of perspectives that also span the various resource management functions (grazing, oil and gas, navigation, flood control, community development, ecological services.). There is only one rule, keep everyone in the game, but there can be only so many seats at the table, so in effect a version of the Samoan Circle is employed over time.	o There is no substitute for establishing a shared understanding among diverse perspectives and associated management functions. Without this foundation, Adaptive Management is only a limited technical gambit. o Getting beneath the surface of things, exploring the root causes using science-based collaborative methods is key to unlocking social and political	o First, science practitioners must be willing to engage processes for developing shared understanding. This is the essence for integrative science. Without getting beneath the surface of things, integrative science is just another myth with little or no substance. o Developing a shared understanding among interdisciplinary and interagency scientists can only be "caught not taught." It is more an apprentice

	alternatives that move beyond existing tradeoffs that keep everyone whole or advances all interests becomes possible. Most facilitators or mediators that attempt to address these politically charged but potentially science based problem situations fail. Lack the skills and understanding to use science as a way to divert attention from interpersonal relationships and power dynamics and focus on the "physics" of the problem or is core dynamic as a way of working through diverse perspectives to discover new more durable solutions. Only a handful of scientists know that it was this collaborative process of developing shared understanding that was the basis for unlocking the doors to Everglades Restoration (should that ever be actually attempted). The process described above is the process developed over 15 years that has been so successful in improving riparian stream conditions in the west. And it was this process that eventually brought 80 policy makers to the table in the Everglades Colloquy that led to the Everglades restudy and broke the deadlock on the Everglades mediated settlement of the water quality lawsuit.	The core of a shared understanding must be uncovered as the group of people engaged expands the circle. But initially there is a law of diminishing returns. Getting beneath the surface of things starts with a few, going deep limits shear numbers but not the diversity of perspectives and management functions. o Focus on the "physics." Take the National Riparian Stream Team from the Bureau of Land Management process as an example. After a brief introduction into stream morphology, they qualitatively evaluate a stretch of stream with a diverse set of stakeholders. The evaluation gets people thinking about what are the changes in the stream corridor that would restore its functionality. Then, what are the biological parameters that would help maintain the functionality and associated human uses. By focusing on the physics, people move off their position and start to solve the management problem collaboratively.	stalemates, logjams, etc. o Modeling in support of developing this shared understanding can help make relationships explicit, surface assumptions, test relationships and associations; enhance effective communication of values, interests, and experiential and scientific knowledge. o Wicked problems by definition have no stopping point, so what is the "end game" – staying in the game!	relationship that is required involving fellow scientists with deep craft in Adaptive Environmental Assessment or a member of the National Riparian Stream Team. There are no shortcuts. o Technical and Scientific units charged with developing integrative science program in support of Adaptive Management need to think about how to restructure their program to accommodate shared learning and understanding.
➢ **Output**	Challenges Faced	Lessons Learned	Findings	Implications
o Systems	The biggest challenge that systems monitoring have is proving its relevance	The more wading bird surveys became associated with	Systems monitoring was	Integrative science requires processes

Monitoring (Output) ___________ Case Examples ➢ South Florida Water Management District ➢ Upper Mississippi River Environmental Science Center. ➢ National Research Council Panel on Missouri River Recovery	to management problems and decision makers. The value of the Adaptive Learning Phase is the justification of systems monitoring. During the model development component and shared understanding, constituents are exposed to the external ecological and social forces at multiple scales acting on the problems that management is facing. During a 10-year stint at the South Florida Water Management District from 1983 to 1992, every budget cycle would find the funding of system level monitoring of colonial wading birds on the "budget bubble." The staff had other priorities and the governing board was inclined to say that the wading birds were a federal problem not a state problem; despite the fact that wading bird collapse by 90% over 60 years was an internationally recognized indicator of the ecological problems in the Everglades. This problem began to abate when the scientists began to take a unified position on its value for not just monitoring but for research as well. As the rationale for restructuring the flood control system became more apparent, the wading bird counts became more important. Experience from other parts of the nation did not help make the case for systems level monitoring. The Upper Mississippi River Monitoring program is a good case in point. The program has been in existence since 1986 but has never been tied to management decision making by the Corps of Engineers. That does not mean that the data collected will not be of	research management decisions and policymaking, the concerns over funding evaporated. During the National Academy Panel deliberations regarding the future of science in the recovery of the Missouri River, the most endangered river in the nation, the issue of funding a system level monitoring program surfaced. It received little if any support among the committee members and was not part of the final recommendations. For one thing, the panel found that there were over 2,000 reports and studies pertaining to the river that had never been integrated into a synthesis of existing information. The panel felt that until the integration of existing science was taken seriously, why fund more data collection that may never be distilled in a way that could inform policy. Without a synthesis of existing information how could the effectiveness of existing or future monitoring be determined?	been fighting an uphill battle for years. The reasons include: minimal foundation of monitoring in ecological theory; lack of convincing rationale for selection of indicators; no hypotheses regarding link between signals and cause and effect; no answer to what was the "value of new information;" previous uses of monitoring information; linkages between monitoring and system level performance. The single most important finding is that the Adaptive Learning Phase forces the policy makers, managers, scientists and citizens to ask questions about what is important and why is it important? Answers to these questions lead to	that create a foundation for its vital role in management. The only way that can be accomplished is by engaging directly with the decision-makers and managers on how systems level monitoring helps solve management problems, helps determine effectiveness of actions taken and helps guide the direction of future actions. This is accomplished through building shared understanding on existing knowledge that has been synthesized.

	value in the future, but until the systems level monitoring demonstrates performance of the systems, effectiveness and not just status and trends, systems level monitoring faces an uphill climb.		the establishment of key cross-scale relationships that make obvious the need to monitoring of systems level performance to inform decision-makers	
The Adaptive Assessment Phase				
➢ **Inputs**	**Challenges Faced**	**Lessons Learned**	**Findings**	**Implications**
o Modeling ___________ Case Examples ➢ Everglades management and lead up to restoration ➢ Upper Mississippi River ➢ Synthesis of experience with over a dozen case examples.	The biggest challenge that assessment faces is figuring out how to organize the associations among ecological parameters that structure the systems through various processes and functions is to establish the system architecture through Conceptual Ecological Modeling. The model-based synthesis that facilitates the conceptualization of parameters, the quantitative development associations their associations based on clear articulation of scientific basis or experiential knowledge which surface hypotheses and assumptions is a rigorous way of beginning a system level conceptual modeling exercise.	▪ Conceptual ecological modeling is not an exercise unto itself. If it is intended to be integrative in nature then the conceptualization of the ecological systems must be an iterative process; informed by field tests, environmental studies, monitoring and management action. ▪ Science programs that rely only on numerical models developed by an handful of modeling experts, will never achieve integration and the collaboration among scientists that is necessary to back new formulations of legitimate problems and credible solutions that systems level assessment and management requires.	▪ Synthesis of existing scientific information through conceptual and numerical modeling is the first step toward integrative science. ▪ Finding the incentives to make that happen is an essential test of whether decision makers are serious about monitoring and assessment as a basis for decision making.	▪ No one action will bring integrative science into being or make it function properly. A set of factors that are mutually reinforcing are required. These factors include leadership, policy mandates, incentive structures, and institutional arrangements. ▪ Toughest of all is changing decades of enculturation that is invisible but immediately sensed.

➢ **Thruputs**				
➢ Systems Monitoring ___________ Case Examples ▪ PNW Forest Plan Implementation ▪ Upper Mississippi River Environmental Science Program ▪ Corps of Engineers Planning Associates Report 2003 ▪ Department of Interior Workshop on Field-level needs for Adaptive Management Guidance. ▪ Kissimmee River Restoration ▪ Northwest Colorado Range Management Plan	"Status and Trends reports" fall short of monitoring with some end in mind -- effectiveness. As stated previously systems' level monitoring must build a clientele that understanding and support such a program, not in the abstract but in a way that can convince others of its value. At an ecological restoration conference in Spokane WA several years ago, a series of panels on monitoring systems and their management implications were convened. Bottom line. Federal agency staff had developed elegant systems level monitoring schemes and sampling designs but few of if any of the presentations even mentioned the term "management implications" even in passing. It would appear based on experience in a handful of regional systems that systems level monitoring all too often begins as an "academic or abstract" exercise that is not grounded as in the Adaptive Learning Phase, in iron clad justifications based on broadly held perceived need. There are many reasons to develop systems level monitoring schemes; to detect changes in species abundance, condition, population structure, habitat amount, condition, but for what management purpose? Justification can be based on support management needs by providing: ▪ Provide early warning	More emphasis needs to be placed on establishing criteria for performance-based approaches to monitoring at both the project and systems level. At the meta-level, assessment units need to keep two questions in the back of their minds: • What is the value of information to be collected? • How does the information address the system-level legacy of scientific uncertainties? The project level provisions for monitoring consider the questions above, additional questions emerge – what decisions in management, operations, systems level assessment, regulatory compliance is this monitoring intended to inform? Criteria: • What are the list of the parameters to be monitored and for what management purpose are they serving; • What are the methods for monitoring each parameter, including monitoring frequency and the location of monitoring	This technical and scientific units charged with the responsibility of developing integrative science, need set the pace, lengthen the stride of others in exploring ways to incorporate quasi-experimental designs or simulations of experiments with management objectives based on anticipated opportunities in the field. The following list identifies the range of systems=level activities that action as inquiry might entail: • Determining the nature, magnitude, and interrelationship s of natural and social phenomena and processes based on conceptual models, field tests, and working	For integrative science at the systems level to work – the principle that the "whole is not only greater but qualitatively different from the sum of the parts" What emerged from the use of integrative science and engineering at the river systems level in the Kissimmee Restoration, was the clear understanding that requiring each of the river functions to take the other functions into consideration as scenarios were developed – navigation, sports fishing, flood control, water supply, grazing – resulted in composite solutions increased overall ecological benefits. In working with grazers in the high plains of the Rocky Mountains, when they realized that systems level

	▪ Measure species response to mgmt or other factors ▪ Provide basis for adjusting/modifying the action What gets monitored? ▪ Species – detect change in population e.g., presence/occupancy, demographics ▪ Habitat – detect change in amount, condition e.g., ground plots, satellite/photo, maps ▪ Ecosystem – detect change in processes e.g., applicable to target ▪ Threat – detect change in degree or type e.g., testing control strategies What is very distressing is when a staff report comes out from a major water resources management agency like the Corps of Engineers that the regulations only permit three years of post construction monitoring and adjustments. Further, no guidance is offered for what to monitor or how it is to be incorporated in decision making. In 2007 the Department of Interior developed a guidance document for implementing adaptive management. In a recent workshop, DOI staff, led by Bureau of Land Management has begun to formulate guidance for field staff to develop monitoring programs.	stations; • What is the rationale for monitoring each parameter in relation to stated goals, objectives, and performance standards; • What consideration has been given to the use of controls sites and opportunities to draw inferences? • How will the resulting data be analyzed? • At what scales and with what measures performance will effectiveness be determined? • What triggers have been identified for remediation or alteration in management and operations? • What schedule of activities for conducting monitoring program has been established and how do they align with management and operations needs -- data collection, data analysis, and reporting of results? • How the results of monitoring are going to be communicated, for what purposes, and in what forms to what audiences?	hypotheses that have limited experimental design control features; • Creating and developing theoretical or experimental means of investigating these phenomena or processes that are reconciled with operational needs and constraints; and • Developing the principles, criteria, and methods applicable to active adaptive management and creating a body of generally applicable data for use by others.	monitoring and management would increase the overall quality of the range for them and others – the "light bulbs" went off. No one had to convince them again that systems level monitoring was in their best interest. The grazers understood that what was good for monitoring and enhancing the quality of range was good for protecting the landscape they loved while providing them better foraging conditions.

o Levels of Analysis for Assessment Purposes • N+1 • N • N-1 ___________ Case Examples • Personal experience with over a dozen case examples and reflection on early contributions to literature on Adaptive Management • Greater Yellowstone Ecosystems Winter Range issue • Minnesota Lake Management Policy	Assessment should be providing guidance to management about what are the minimum conditions and spatial and temporal extent of land or water bodies that are ecologically sustainable. Time and again, this question and requisite issues go unnoticed, unaddressed and unchallenged. It is another indication that management and operations are not thinking in ecological terms and that ecologists are not thinking management terms. Ecologically based policy design is corrupted by this lack of understanding and integration of science with management and operations. There are numerous examples of this issue. Most glaring is the persistence of Yellowstone National Park policy to hold levels of elk and bison artificially high for tourist purposes, which puts added pressure on winter range. In Minnesota, the DNR had set up a policy of ecosystem management that would seek to sustain natural fish populations based on the physical, chemical and biological conditions (naturally occurring trophic levels) indigenous to a given lake based on historic records. The lake residence protested, they preferred artificial stocking of preferred species, which were unsustainable. One example from the Everglades Restoration comes from field observations over several years from biologists and engineers who began to see the threats to non-critical but indigenous species increase as restoration projects were designed and constructed. When a follow	Far too often restoration efforts zero in on a scale of a project for numerous reasons ranging from political, to economic, and sheer happenstance, none of which make ecological sense. Artificial bounds are placed on a management area or a restoration project and subsequent assessment just takes for granted that durable ecological benefits will emerge. This situation is analogous to the state that wetland mitigation programs found themselves in at the end of the 1980s and have been confirmed more recently by a GAO evaluation of Corps 404 permitting. Wetland mitigation projects were being designed to fail. An evaluation of permitted and constructed projects showed that only 10% of the projects had sustained wetland populations as intended over 3-5 year period. The lesson “learned” from wetland mitigation needs to be applied to ecological restoration. The wetland managers agreed that wetland mitigation had to be integrated into a systems framework. Replacing wetlands “on-site and in-kind” really made no ecological sense. Of site and out of kind was more likely to be at least successful if not more,	Many of the deficiencies noted here are evidence that assessment at scales above (N+1) and below (N-1) are not contributing to the design of policy and projects (N). As a result, poor decisions with long-term effects are either being made or endured. Clearly, this systematic and systemic problem needs to be a top priority for integrated science assessments at the systems level. These anecdotes are clear evidence that long -term performance is jeopardized if not completely sacrificed or written off.	Restoration projects may be unwittingly supporting approaches and projects that will create as many problems as they attempt to resolve. Landscape and basin level assessments can help identify the potential traps that restoration projects may fall into. These unworkable projects prop up failed policy and undermine public confidence in the efficacy of public investments in such projects. This is a very serious issue that integrative science and assessment can make a meaningful contribution to identifying and offering alternatives for resolution.

	up interview was conducted a year latter, the supervising engineer replied, "I have lost tract, since I was moved into my new position." Another example comes from the Kissimmee River when interest groups were willing to settle for solutions to restoration that would have had to remain on "life support systems" that entailed considerable maintenance requirements to prop up a failed restoration project.	given that design considered watershed and landscape level conditions and needs.		
o Integrative Inquiry and Synthesis ___________ Case Examples ➢ European Union ➢ South Florida Water Management District	In a management context, systems ecology and integrative science help identify gaps in understanding that need to be resolved through more non-traditional approaches to scientific inquiry. But saying it does not make it so. The cultures of institutions have much to "say" about even if intellectual resources and scientific capacity will be mobilized. A case in point. In the mid-1980s, the South Florida Water Management District approached the University of Florida President and Provost with this problem. Meetings were convened, dinners hosted, pledges made, but no response despite the lure of millions of dollars of agency monetary support for restoration science. The District, in desperation due to the lack of responses by universities in general, was forced to develop its own applied research capacity. Gradually, over the years, with increases in incentives, the universities have responded and the district dissolved its own research unit. Journals featuring more applied approaches to science for restoration and ecosystem management	• Synthesis of existing information is the foundation for integrative inquiry. • "We know more than we think, but less that we understand." This idiom is true. It is only when the results of differing lines of inquiry are cobbled together that areas of convergence and divergence are discovered – yielding greater understanding by all involved. • The problem is that most agency scientists are not practitioners but define their role as "purists" offering up disciplinary based science to the best of their ability and resources. • With the rise of disciplines like Conservation Biology, and interdisciplinary masters and PhD	▪ Creating a foundation for integrative science that can stand up to the challenges presented by large-scale investments in infrastructure, management and operations is a painstaking process at best. ▪ The incentives, political, budgetary or collegial must be set in place, otherwise integrative science consistently falls through the cracks. ▪ New models of institutional relationships	▪ Alternatives to self serving systems level monitoring are being driven by policy from the top down that demand more accountability and relevance and from the bottom up where performance is being required and synthesis and ongoing integrative assessment is the preferred alternative. ▪ No silver bullet exists for remedying the situation. There are too many factors in play. Ordaining a T&S unit without

	have emerged that provide an increased incentive for academics to participate. But the culture of university research is slow to change. This is not an isolated case, but illustrative of most agency and university experiences. • Tragically, some of the best and brightest integrative scientists continue to be penalized and their careers stunted because of the lack of university rewards and incentives for integrative science. • Science encourages and rewards scientists that develop one mode of inquiry and pursue theory building using one set of similar lines of evidence.	programs, academia is beginning to respond to the need for integrative science. The Fish and Wildlife Cooperating Units housed in universities but actually employed by the US Geological Survey have proven valuable in helping graduate students link up with agencies needing integrative work. • However, even with these improving conditions the focus on decision-relevant management problems is missing. • One avenue of linking science, management and policy that is working involves several regional cases where Fish and Wildlife Service (FWS) employees are being tapped to support Corps of Engineers management and operational decision-making. • In effect, FWS as an agency has traditional been refuge managers, so they understand decision-making. More recently NEPA and ESA involvement have given them experience in implementing policies that require changes in thinking and action. Finally, their service as	must be explored. The examples of US Geological Survey's Fish and Wildlife Coordinating Units and FWS contracts for ecological services show promise in setting up generative relationships for integrative science and coupling it with management decision-making. ▪ However, opportunities for scientists to remain self-referent, self-serving and indulgent persist. In many instances this is a product of their culture, disciplinary expectations and lack of accountability. ▪ Furthermore, the action agencies continue in	building on lesions learned an pursing a multi-pronged approach to implementing integrative inquiry, and synthesis will not succeed. ▪ Short-term solutions do not seem apparent. However, the need for synthesis of existing scientific information using approaches like Conceptual Ecological Modeling could not seem more appropriate as a place to start. ▪ Building strong interagency partnerships backed by memorandums of understanding seem to be a solid step in the right direction.

		ecological scientists is being contracted for by other agencies. • For the first time, one agency that is more ecologically driven than resource allocation based is providing the ingredients for integrating science and coupling it with management. The "marriage" between FWS and agencies like the Corps of Engineers is still in its infancy but evolving.	arrogance or ignorance to ignore the needs of system=level monitoring for effectiveness at the very least. The absence of this capacity permits agency practices to persist that would otherwise come under scrutiny if integrated assessment techniques were routinely integrated at the top levels of decision-making.	
o Options Analysis __________ Case Examples: ▪ Everglades Adaptive Environmental Assessment (AEA) ▪ Everglades Adaptive Management Strategy ▪ Upper Mississippi river AEA process ▪ Kissimmee River	Options Analysis is not a "module" or "process component" that is just plopped into the middle of the assessment process as a stand-alone. Moreover, Options Analysis is not what is perceived as the "evaluation of alternatives tradeoffs" that has become so prevalent in engineering planning processes. Options Analysis is an integral part of the Adaptive Process that basically confronts alternative composite policies with scenarios that reveal vulnerabilities, uncertainties, and potential for catastrophes. Prior to Options Analysis a diversity of affected parties are engaged in gaming process that screens initial policy	➢ The Kissimmee River Restoration stands as proof the principles embedded in options analysis. ➢ Unlike planning processes that look at a narrow range of alternatives that are defined to cover a limits set of objectives using only cost/benefit analysis, Options Analysis creates alternative composite solutions in which policy makers as well as invested and affected interests are meaningfully engaged.	▪ Major management decisions involving high levels of uncertainty that do not consider and attempt to align all the related management functions to a problem can never produce durable integrative	▪ The challenges of today's complex and seemingly intractable problems exceed the bounds of "social engineering" that agencies have perpetuated. ▪ New challenges require new responses. Multi-causal and level problems

Restoration	options and allow various interests to explore optimizations of their particular objectives. This process was used in development of the initial round of guidelines for Everglades's restoration and is part of the Adaptive Management Strategy for implementing restoration. It can be argued that one of the reasons why federal agencies did not want the AEA effort on the Upper Mississippi River to succeed was that it would reveal options that would threaten the status quo. Corps of Engineers support for the project was withdrawn, as the Phase I report was being drafted and adopted despite support by each of the governors that were members of Upper Mississippi River Basin Association and the Congressional Caucus. The development of experimental designs for implementing active adaptive management actions is very time consuming and needs to be developed in conjunction with the Options Analysis. The "degrees of freedom" for conducting management experiments and the potential for controls and inference need to be assessed and conveyed to those designing the options.	➢ The goal is determine the small set robust alternatives that can withstand the range of contingencies and surprises that can be anticipated and practically imagined. ➢ This step is to define precise measures of performance for evaluating impact of any policy choice – short and long term ➢ Developing measure of performance is an iterative process where analysts offer up their best and others tell them to go back to the drawing boards.	solutions. ▪ Optimizing one or two functions is accomplished at the expense of other functions. Mitigation and remedial measures perpetuate the fixes that backfire set of long-term consequences that most projects build and plans implemented by resource agencies in the past 60 years can not deny.	require composite approaches to problem solving. ▪ Management responses must be equal to the speed, scale and asperity of the wickedness of the problems facing society. ▪ The new configuration of problems spanning water, land use, energy, climate change, growth and the environment challenge us to reframing problems and considered greater number of forces acting upon management choices.
o Systems Level Management and Operations ___________ Case Examples: ▪ Everglades	Probably the biggest "aha" in the development of the Everglades Adaptive Management Strategy was the realization that with the volume of projects planned for implementation, the scale of the operation and the legacy of previous policies, projects and operating standards required the reframing of the role of management and operations at the	▪ Adaptive Management places more emphasis on managing risk through implementation process than on *ex ante* analysis of risks by "experts" prior to decisions of record. *Ex ante* analyses are "still born," risks are often endured for	▪ A new systems level function needs to be developed by all agencies serious about landscape and systems level management.	▪ Every situation will be different as to how systems level operation and management are addressed. ▪ This new capacity will

Restoration ▪ Review of Louisiana Master Plan Draft December 2006 ▪ Lake Okeechobee management.	systems level. Under traditional modes of management and operations, the system is broken down into compartments. In land management these are allocations of public resources for limited purposes, in water resources these are projects or a cluster of projects with linked operating criteria. But rarely short of catastrophic events is the system's level really under active management consideration. Under conditions of restoration and recovery the whole configuration of the system and allocation of various functions is being challenged. Even in cases like the Missouri River where most experts carve up the river into 2-3 major section or over a dozen reaches – optimization of the entire system's operations should be considered with all river functions under review.	generations. ▪ Ideas lead change. Legacy resists change and may actually stymie change. ▪ As new strategies, principles, practices, projects are brought on line, those pre-existing need actively to be dismantled, and because these restoration, recovery revitalization initiatives occur over time, the new must be integrated with the new. Benefits are lost, or foregone when system level consideration are not taken into account.	▪ For example, In the management of Lake Okeechobee a virtual interdisciplinary units has been created to handle the very delicate situation there – water quality, flood control, hurricane protection, water supply, estuary management and wetland restoration. New projects to act as surge tanks are being brought on line but as that is happening intensive integrated operation of the system is required. ▪ In addition, the operations must be synced with other programs to management risks.	enable managers to integrate science operations and management decision-making in real time. ▪ This new type of function may help reinforce the justification for integrative science.
o **Communic-**	Synthesis and integrative science assessment are extremely useful for	▪ People are prone to see parts and to focus narrowly	▪ There is an art and science of	▪ Communication of results of

ations _____________ **Case Examples:** o Experience o Chesapeake Bay – Bill Dennison o Martha Musgrove Miami Herald associate editor	helping people from policy makers to parents make sense of what is happening and to help them grasp the “big picture. “ Science Assessment is no longer “just the facts m’ame.” It is no longer just about changing the way people think and act. It is even deeper – changing what is perceived as social reality. Climate change put the ”last stake in the heart” of those who for whatever reason did not want to grasp the profound period of adjustment that civilization must endure. Integrative science and adaptive management is designed to support this type of transition. However, scientists themselves are conflicted about what their role or roles really are – “purist” “advocate” “arbiter” are just some of the optional functions that scientists may be called upon to perform. Clearly at the systems level, scientists have to come to terms with their role as change maker. Technical and Scientific units charged with responsibility of integrating science must take full advantage of the opportunities that their work creates for effective communication of scientific information.	on their interests. But challenging their preconceived notions of how the world is organized and works is a function that Adaptive Assessment Phase must respond to. ▪ Specific role that Technical and scientific units can play and the types of communication devices available to them are covered in Task 1 of this report. They are all based on lessons learned.	communicating scientific information in a way that helps people make sense of their world. ▪ Change occurs when people are challenged to think and act differently. ▪ The scale and duration of communications on integrated issues vary by how deeply embedded existing patterns of behavior are.	integrative science are not a once and done affair. Note the persistence with which the IPCC had to continue to provide people with opportunities to change their thinking based on results of integrative science. ▪ Scientists will increasingly be called upon to be “advocates” for change in the face of ominous signs of potential calamity.
Adaptive Policy Design Phase:				
➢ **Inputs**	**Challenges Faced**	**Lessons Learned**	**Findings**	**Implications**

o **New Policy Mandates** —————————— **Case Examples:** o Pinedale Anticline Resource Management Plan o Alturas Bureau of Land Management Office o South Florida Water Management District o Sage Steppe Restoration Strategy o Everglades Restoration o Kissimmee River Restoration	Policy comes in many levels and forms. Task 1 details the various sources of policy. Managers are now being faced with condoning and disguising wonton exploitation of our natural resources under the guise of "agency policy" and "Adaptive Management." This is the case in the oil and gas development in western mountain ranges of Wyoming. The pressure to approve oil and gas at the expense of the environment and lose of critical habitat is a very real challenge that can cost professional managers their careers. There are examples as well of near heroic stands that mangers have made in the face of White House and state legislative pressure to reverse decisions or agree to reduced standards. On the flip side, managers will be asked to rapidly change prevailing standards of practice and develop more systems level management strategies. One example is the Sage Steppe Restoration Strategy that covers 6.5 million acres of Northeast California. One of the challenges that face those attempting to implement integrative science and adaptive management is how to avoid the traps which various constituencies will push for and the court interpretations of its implementation may be backed into. It is in the science practitioners' best interest to see that integrative science and adaptive management do not get trapped. For example, a recent National Research Council report on Everglades restoration	▪ "Incrementalism" is not what Adaptive Management condones or advocates. Adaptive Management is developing the capacity to taking step-wise calculated risks at large scales that integrate resource and human functions. The Kissimmee River Restoration is an example of this principle of large-scale experimentation. ▪ National Academy Panel report on the Everglades restoration progress to the contrary, large bridge spans across ecologically significant water bodies is not new or difficult to justify ecologically or economically. ▪ As with the Principles and Guidelines, what was envisioned in the Water Resources Planning Act of 1965 is not what the Corps of Engineers has been implementing in the intervening years. The environmental quality and social wellbeing accounts have been eliminated by administrative fiat, not by major policy reforms. Under the Carter administration, EQ has actually made a co-equal objective with National Economic Development but was later reversed, for	▪ New policy mandates are already appearing in the form of federal departmental guidance for implementing Adaptive Management. After years of resistance with more to come, the Congress has finally asked that the Principles and Guidelines be revised. The National Academy of Science completed 5 separate reports on the problems with Corps planning and management over 3-5 years ago. ▪ Increasingly, new policy will be implemented in the field using programmatic EISs. More and more managers are	▪ New policy mandates are expected in the areas pertaining to mitigation and adjustments to climate change. Agencies can be expected to reduce their carbon footprint and explore ways to increase carbon sequestration. ▪ Under these new type of mandates and the potential decline in the nation's economy for the next 10 years, resources will be come even more scarce. Scientists management and decision makers will be called upon to do more with less. ▪ However, instead of cutting staff and programs more emphasis will be placed on cutting operating costs and finding ways

	progress proposed an incremental approach to implementation. In the past Adaptive Management has been able to avoid the paralysis of "incrementalism" that is inherent in what economists would prefer to see as the principal approach to ecological restoration. The Kissimmee River Restoration would never have been authorized if it had to be designed under the prevailing guidelines of "incremental economic analysis."	reasons not made explicit. ▪ The point is that what is proposed as policy and what gets "locked-in" as policy are two different things. Fortunately, the courts have been starting to take an active role in helping to ensure that Adaptive Management does not become "make it up as you go along." Or "whatever you want it to be," ▪ However, as Adaptive Management becomes further defined through policy and practice, the courts may not play such a beneficial role but lean more heavily on steering Adaptive Management into more prescriptive directions, which would undermine its intent. On the other hand, courts are increasingly using peer review panels to help inform and resolve complex and uncertain scientific disputes. This may bode well for what institutional path Adaptive Management will be pushed into.	seeing programmatic EISs required to address threatened and endangered species and critical habitat as a way to reform policy and procedures.	to accomplish more with less. For instance, water rights in the west, once thought "untouchable" will become interruptible, making more use of a diminishing and increasingly finite resource.
o **Thruputs**				
o **Policy Formation**	The Missouri Department of Conservation has taken the lead in developing new procedures for submitting projects for budgeting process – projects have to be	▪ Commitment and trust in the Active Adaptive Management is developed long before policy	▪ Scientists must resist attempts by policy makers to keep	▪ Monitoring and assessment procedures must be developed in

Case Examples: o Missouri Department of Conservation o Experiments conducted by Walters and Hilborn o 12 years experience as Policy Director for South Florida Water Management District.	justified as management experiments. Policy formation is a microcosm of what has transpired to date for the purpose of preparing the decision package and ensuring that all the necessary steps have been taken in getting to the point of taking action (i.e., options assessment document). ▪ Identify alternative hypotheses ▪ Assess o "Legacy of Uncertainty o "Value of Information" (expected value of perfect information) ▪ Develop "models" of key associations w/ alternative hypotheses for future learning ▪ Identify adaptive policy options ▪ Design of action experiments ▪ Develop performance criteria for comparing options ▪ Comparison of options using decision analysis By the time policy formation is complete the final step is a formal comparison of options, which are presented to the decision makers for action. In addition to the options assessment document an adaptive experiment design for each option must be available to scrutiny. The design will be a preliminary assessment that will be further refined as implementation begins.	formation begins. Constituents, policy makers, managers must be engaged throughout the learning and assessment phases. ▪ During the policy formation process, scientists are passing the "baton" to the analyst who are preparing the decision package, so briefing will be held and scientists must be prepared to demonstrate that all the bases have been covered; all the steps/activities listed on the left hand column. ▪ The results of the options analysis must be reduced to a set of the most robust composite options. These options must be converted into decision table with probabilities for risks and rewards and the back up the assessment.	asking for revisions in assessments to satisfy questions raised by various constituencies. Roles must be clarified. A firewall between assessment and decision-making must be maintained. ▪ The firewall is the assessment document that details all the work by interdisciplinary teams that have co-created the set of options with others involved in the decision-making process.	advance that outline assessment scientists' roles and responsibilities and the development of the final options assessment document. ▪ Effectively communicating the scientific basis for the assessment of options created , screened and tested through scenario simulation by a diversity of representatives from interests who speak on behalf of various resource management functions.
o **Policy Action & Experimentation**	The greatest challenge in decision-making involving Adaptive Management is integrating the discipline of decision theoretics into the process. All to frequently scientists are caught presenting	▪ Most decision processes lack sufficient rigor. Scientists are not trained in formal decision processes and should not be put in	▪ Without integrative science, management experiments	▪ More training will be needed to understand how field level interdisciplinary

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Case Examples:

- Everglades Flow-Response Field Test
- Glen Canyon Dam Experiments
- Kissimmee River Restoration

options and then being asked for their recommendations. At the point of acting action, the scientists should step aside and allow the policy analysts to present the options for the policy makers to accept responsibility for the risks, uncertainties and the likelihood of achieving desired results. The relationship between risks, consequences and rewards acting in the public interest

Formal Comparison of Options: Step 6

Basic format for evaluating policy options

Policies	Hypotheses			
	H_1	H_2	H_3	$H_{...n}$
Baseline				
AM $Policy_1$		V...n		
AM $Policy_{...n}$				

- The table shows how alternative policies will perform under differing hypotheses
- The entries for “v” in the table are the performance measure (s) for each pair of policies and hypotheses
- Included in each policy option is the action to be taken and the feedback to be obtained
- The table reveals the tensions between risk v. expected performance; options v. projected consequences.

that position. Scientists should be helping develop the information that goes into a decision table (e.g., risks, hypotheses, expected outcomes).

- Roles and responsibilities in decision making need to be clarified. The decision makers are accountable to the public and their constituencies, not the scientists or the analysts.
- We learn faster if we have spatial replicates and controls, but this is often not possible when making adaptive management decisions.
- In general passive adaptive policies are best if you don’t have lots of spatial replicates
- Lack of replicates, reference sites or controls means learning will be slower and not be able to achieve the same level of certainty we could with replicates and control; while delayed learning may have significant cost to the system – it may pose too high a risk
- When you do have spatial replicates then some can be designated as experimental units to accommodate larger perturbations that yield faster learning.
- Managers must consider

are not possible.

- Management experiments put much on the line for agency managers and scientists. They fear that unsubstantiated positions that agencies have maintained for years and lines of evidence will be brought into question.
- Science leaders must come to the fore from a number of disciplines to help lead management experiments from design through implementation. BUT not decision making. Walters relies on one leader, others have found that a small group of leaders is necessary.
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and interagency tests are designed, implemented and evaluated.

- The scientists are only called upon during decision making to clarify points in the options assessment document and questions pertaining to the bounding of the implementation of the adaptive experimental design.

		the temporal horizon and spatial extent of action in order to obtain yield and learning ▪		
o **Implementation** **__________** **Case Examples:** ▪ Kissimmee River Restoration ▪ Design of Everglades Flow-Response Field Test ▪ Works and notes from Carl Walters, Kent Loftin, Ray Hilborn, Steve Light	Implementation begins with a detailed design of the option(s) selected for management action. Detailed designs, Such experiments involve serious trade-off between the value of information and policies that are "tried and true" with the value of informative policies accruing to the future managers and stakeholders that are currently part of the "legacy of uncertainty" There are many practical questions that adaptive management experiments must consider in their implementation design ▪ How many hypotheses will this field test address simultaneously? ▪ What is the level of importance (priority) of the hypotheses addressed by this field test; what are the design implications based on priorities? ▪ What are the chances this field test will clearly prove or disprove its hypotheses? ▪ What are the chances the desired exogenous conditions (e.g., climatic) will occur or can be mimicked during the term of this test? ▪ How well (scientifically and lay-perception-wise) will the results of this test indicate "actual responses?" Injection of biases, and unintended design effects.	▪ Expect periodic backsliding and defections from constituents and other agencies and scientists. ▪ New Institutional Pathology – the change in top levels of management agencies – they are dominated by people with the traditional training who have to turn to younger people for help when there is no way to sidestep the difficult experimental and quantitative questions. ▪ Generally specify policy choices as rules of response to change rather than absolute degree of impact. ▪ We have generally made the same types of mistakes over and over again: (1) being preoccupied with adding spatial and biological detail, looking downward into the system structure rather than more broadly at factors (2) concentrating on variables and relationships for which we have the strongest data, rather than those likely to be most important to the policy problems at hand. ▪ We invite misunderstanding by using	▪ We should be encouraging designers to think in different ways. ▪ Often times we get trapped by our own disciplinary background and experience. ▪ Inviting peer review and a diversity of perspectives into the design process helps mirror the complexity. ▪ Multiple modes of inquiry and multiple lines of evidence should be encouraged. ▪ Ecosystems are moving targets – the truth is found at the intersection of competing explanations for behavior –it is a process of triangulation, using multiple	Scientists must be prepared for the surprises in test operations which are inevitable; be prepared to respond as accurately as possible to questions from major news companies that are raised when a storm turns into a down pour that triggers flood control that interrupt the experiment and cause massive fish kills. On the other hand, admit that surprises are inevitable and that we are always trying to anticipate and thinking about what we may have left out – these are part of being human. At least through intentional experimentation rather than "trial and error" we are accelerating out learning and attempting to reduce surprises and

	▪ How much of the total spatial extent a does this test represent – sample size of a landscape mosaic, for instance – what is left out of the design and why? ▪ What is the likely time required for "getting to launch" of this test and why? ▪ What is the period of operation required for this test? ▪ Are there conditions on or adjacent to the test site that will ultimately limit the success of the test? ▪ The chance of some "failure" occurring during this test is? ▪ If or more likely when there is a failure, what level of damage can be expected, anticipated, mediated, minimized; what are the opportunities for learning from failure?	the word "assumptions." "Enormous" numbers of assumptions are, in fact, needed whenever one derives proposed experimental scheme for making prediction about any natural dynamic systems whether or not one bothers to make these explicit. The point is we need to be prepared to embrace error: ▪ Some biological detail that we overlooked turns out to have an important large-scale effect. ▪ The change is driven by some factor "outside" the breath of factures considered in the model	methods, there will never be "one answer" because complexity is never about one thing, one cause and effect replationship!	unknowns in the future.

Appendix to Task 1 & 2

The LSU Task Order asked that Task 2 address critical questions of similar scope and scale to those of Coastal Louisiana; developing an analysis based largely on written reports, websites, email and phone interviews. Over two dozen science practitioners from a variety of disciplines, agencies and field sites were interviewed but their names will not be listed, their conversations with me were confidential.

Case Studies Reviewed:

Task 2 matrix incorporated material from the following examples of large-scale efforts in restoration or recovery:

1. California Marine Life Coastal Protection Act
2. Catskills Watershed Project – New York City Water Filtration Program
3. Chesapeake Bay
4. Columbia Basin Fish and Wildlife Authority
5. Everglades
    a. Experimental Water Deliveries
    b. Kissimmee River Restoration
    c. Comprehensive Everglades Restoration Plan
    d. Lake Okeechobee Management
    e. Nutrient Removal Project
6. Glen Canyon Dam Experiment in sediment dynamics and recovery of indigenous fish
7. Greater Yellowstone Ecosystem
8. Klamath River
9. Missouri River –
    a. Managers' Workshop March 2007
    b. Report NRC Report 2002, Panel Member,
10. Northwest Colorado Range Management Plan
11. Pacific Northwest Forest Plan
12. Pinedale Anticline Resource Management Plan
13. Red River of the North – case study funded by National Science Foundation.
14. Sage Steppe Restoration Strategy, Alturas, CA
15. Salton Sea Restoration
16. State Natural Resource Departments
    a. Minnesota Department of Natural Resources
    b. Missouri Department of Conservation
17. Upper Mississippi River – Adaptive Environmental Assessment of UMR funded by McKnight Foundation, The Northwest Area Foundation, Corps of Engineers and the State of Minnesota.
18. Western Governors Conference and Western States Water Council Proceedings, October 10-12, 2007

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