Guide for Preparation of Adaptive Management Plans

Prepared for:

Fisheries and Oceans Canada
Fish Habitat Management, Western Arctic Area
Central and Arctic Region
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18 March, 2008

Citation:

Greig, L, D. Marmorek and C. Murray. 2008. Guideline for Preparation of Adaptive Management Plans. Prepared by ESSA Technologies Ltd., Richmond Hill, ON for Fisheries and Oceans Canada, Western Arctic Area, Central and Arctic Region, Yellowknife [NT] 8 pp.

Acknowledgement

Some of the material in this report has been adapted from support materials initially developed by ESSA for a course in Adaptive Management for the Forest Practices Branch, B.C. Ministry of Forests and Range.

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Adaptive Management

DEFINITION OF ADAPTIVE MANAGEMENT

Adaptive Management (AM) is a rigorous approach for learning through deliberately designing and applying management actions as experiments. It was first developed under the name "Adaptive Environmental Assessment and Management" in the 1970s by Dr. C.S. Holling and Dr. C.J. Walters and associates at the University of British Columbia and the International Institute for Applies Systems Analysis in Vienna (Holling 1978). It has since been applied to a wide range of resource and ecosystem management problems throughout North America and elsewhere (ESSA 1982, MacDonald et. al 1997, Bouris 1998). AM is an approach to management that involves synthesising existing knowledge, exploring alternative actions, making explicit predictions of their outcomes, selecting one or more actions to implement, monitoring to see if the actual outcomes match those predicted, and then using these results to learn and adjust future management plans and policy (Walters 1986, Taylor et. al 1997, Murray and Marmorek 2003, Williams et al. 2007). This sequence of steps can be summarized in terms of a 6-step process (Figure 1).

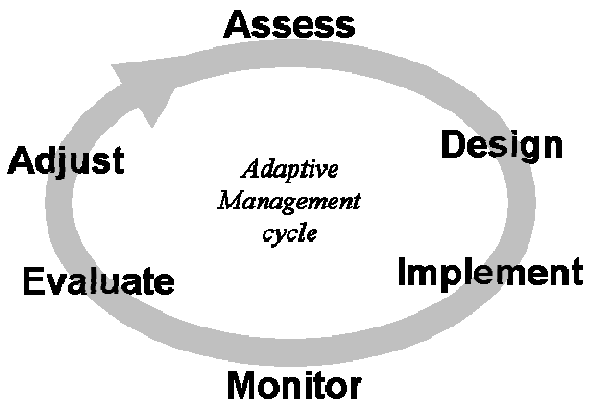


Figure 1 The Adaptive Management Cycle (Murray 2008).

Adaptive management may be essential for achieving sustainable use of natural resources, as it is often the only way to rigorously address scientific uncertainties in how management actions affect ecosystems. Small scale research experiments cannot be legitimately extrapolated to the scale of management; management itself must be conducted in a deliberately experimental manner.

Adaptive Management is sometimes referred to as "experimental management" (applying management activities as experiments to see which are most effective in achieving management goals) and since its initial inception in the 1970s various respected authors in this field have published slightly different definitions of AM (Table 1), but with important commonalities that include:

- *Learning* in order to reduce management *uncertainties*
- Using what is learned to change *policy* and *practice* (i.e. "closing the loop"; ensuring what is learned informs decisions)
- A focus on improving *management* (i.e. this is where the learning is applied)

- It is *formal, structured, systematic* (i.e. not ad-hoc, trail-and-error, or simply reactionary).

Table 1 Selected Definitions of Adaptive Management (adapted from Marmorek et. al., 2006).

Definitions	Source / Citation
Adaptive management (AM) is a formal process for continually improving management policies and practices by learning from their outcomes.	Taylor et al., 1997. Adaptive Forest Management in BC.
AM is a structured process of learning by doing that involves more than simply better ecological monitoring and response to unexpected management impacts. It should begin with a concerted effort to integrate existing interdisciplinary experience and scientific information into dynamic models that attempt to make predictions about the impacts of alternative policies.	Walters, 1997. Challenges in Adaptive Management of Riparian and Coastal Ecosystems.
AM is an approach to managing complex natural systems that builds on learning – based on common sense, experience, experimenting, and monitoring – by adjusting practices based on what was learned.	Bormann et al., 1999. Adaptive management. In: Ecological Stewardship: A common reference for ecosystem management.
AM is a systematic process for addressing the uncertainties of resource management policies by implementing the policies experimentally and documenting the results.	MacDonald et al., 1999. AM Forum: Linking Management and Science to Achieve Ecological Sustainability.
AM is a structured method for "learning by doing" that includes establishing clear goals, defining practices to achieve those goals, implementing the practices, monitoring the outcome of the practices, assessing how those practices are succeeding relative to the goals, and adjusting management in response to the assessments. It is designed to address questions such as: Where do we want to go? How do we get there? How do we know if we're there? If we're not there, how do we change to improve?	Kremsater, Perry and Dunsworth. 2002.
AM treats actions and policies as experiments that yield learning (it mimics the scientific method: specifies hypotheses, highlights uncertainties, structures actions to expose hypotheses to field tests, processes and evaluates results, and adjusts subsequent actions in light of those results), and embraces risk and uncertainty as opportunities for building understanding that might ultimately reduce their occurrence.	Stankey et al., 2003. Adaptive Management and the Northwest Forest Plan: Rhetoric and Reality.
AM is “learning by doing” with the addition of an explicit, deliberate and formal dimension to framing questions and problems, undertaking experimentation and testing, critically processing results, and reassessing the policy context that originally triggered investigation in light of the newly acquired knowledge. The concept of learning is central to AM. It is a process to accelerate and enhance learning based on the results of policy implementation that mimics the scientific method: experimentation is the core of adaptive management, involving hypotheses, controls and replication. It is also irreducibly socio-political in nature.	Stankey, Clark and Bormann, 2005. Adaptive Management of Natural Resources: Theory, Concepts, and Management Institutions.
AM is a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. It’s most effective form – "active" AM – employs management programs that are designed to experimentally compare selected policies or practices, by evaluating alternative hypotheses about the system being managed.	BC Ministry of Forests and Range Adaptive Management web page
AM is a formal process for continually improving management practices by learning from the outcomes of operational and experimental approaches. Four elements of this definition are key to its utility. First, it is adaptive, and intended to be self-improving. Second, it is a well-designed, formal approach that connects the power of science to the practicality of management. Third, it is an on-going process for continually improving management, so the design must connect directly to the actions it is intended to improve. Fourth, although experimental approaches can be incorporated into adaptive management effectively, operational approaches and scales are emphasized to permit direct connection to the efforts of managers	Bunnell et al., 2007. Forestry and biodiversity - learning how to sustain biodiversity in managed forests.

ELEMENTS IN THE STEPS OF THE AM CYCLE

Table 2 lists the basic elements in each of the six steps in the AM cycle. Inclusion of the elements in each step in the cycle depends on the specific context of an AM initiative and consequently not all elements are employed in every AM initiative. However, each element has an important function and there are consequences for leaving any out. As elements are dropped, the application of AM becomes less rigorous and begins to move out of the domain of AM into a less rigorous, and potentially much less effective learning paradigm.

Table 2 Elements within each step in the Adaptive Management cycle.

AM Steps	Ideal Elements within each Step
Step 1. Assess and define the problem	a. Clearly state management goals and objectives b. ID key uncertainties (what are the management questions?) c. Explore alternative management actions (experimental "treatments") d. ID measurable indicators e. ID spatial / temporal bounds f. Build conceptual models g. Articulate hypotheses to be tested h. Explicitly state assumptions i. State up front how what's learned will be used j. Involve stakeholders k. Involve scientists l. Involve managers
Step 2. Design	a. Use active AM b. Include contrasts, replications, controls c. Get statistical advice d. Predict outcomes e. Consider next steps under alternative outcomes f. Develop a data management plan g. Develop a monitoring plan h. Develop a formal AM plan (for all of the remaining steps) i. Get the design peer-reviewed j. Obtain multi-year budget commitments k. Involve stakeholders
Step 3. Implementation	a. Implement contrasting treatments b. Implement as designed (or document unavoidable changes) c. Monitor the implementation
Step 4. Monitoring	a. Implement the Monitoring Plan as it was designed b. Undertake baseline ("before") monitoring c. Undertake effectiveness monitoring
Step 5. Evaluation of results	a. Compare monitoring results against objectives b. Compare monitoring results against assumptions, uncertainties, hypotheses c. Compare actual results against model predictions d. Receive statistical or analysis advice e. Have data analysis keep up with data generation from monitoring activities

AM Steps	Ideal Elements within each Step
Step 6. Adjustment / Revision of Hypotheses & Management	a. Meaningful learning occurred (and was documented!) b. Communicate this to decision makers c. Communicated to others d. Actions or instruments changed based on what was learned

ITERATION WITHIN THE AM CYCLE

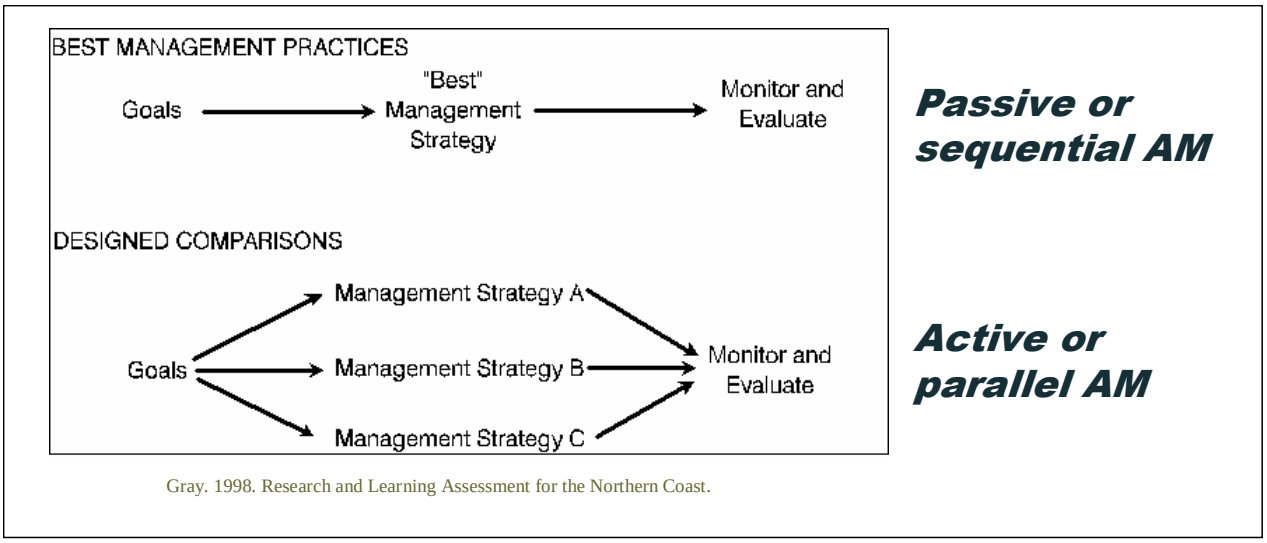
The AM process is intended to be iterative. After management experiments are completed and assessed, the knowledge gained should be applied to improve the next round of management. However, it is often not possible to resolve all uncertainties in a single management experiment. Also, the influence of external drivers of the ecosystem should be expected to change over time, and as they do, they may influence the effectiveness of management strategies. Consequently, subsequent rounds of management should also be treated as management experiments leading to subsequent iterations of the AM cycle.

Iteration also occurs within the cycle itself. For example, if dealing with a first iteration of the cycle, especially if there is no preexisting baseline data, it may be necessary to conduct baseline monitoring prior to completing Step 1 (Assessment) or Step 2 (Design). However, baseline monitoring is different from post-implementation monitoring (Step 4). A common occurrence is that the first year or two of post-implementation monitoring and evaluation (Steps 4 and 5) suggests changes to the design of either the management action or the monitoring itself, requiring a return to Step 2.

ACTIVE AND PASSIVE AM

AM experiments can be conducted in either an Active or Passive mode. In Active AM alternative management strategies are deliberately applied in different treatment areas and/or times with statistical designs that provide for strong contrasts (e.g. different levels of actions, treatments vs. controls). Active AM enables more powerful learning over shorter time periods than Passive AM (Figure 2). Assigning treatments randomly to locations and/or times improves the statistical reliability of conclusions.

Passive AM is the application of one management strategy that is believed to be the best or most effective (e.g. a Best Management Practice), rather than several as is done in active AM. While there would not be active experimentation with alternative treatments, passive AM can still incorporate the six steps and most of the elements in each. Passive AM may be necessary when the management problem at hand does not provide suitable opportunities for Active AM (e.g. it is not feasible or is too risky to implement alternative management strategies), or if there is a need to verify that a best management practice (BMP) is indeed the best practice (e.g. learning that a BMP does not actually achieve the desired outcomes may suggest a subsequent need for more probing using active AM). If it turns out that the assumed BMP is not producing the expected results, the passive approach significantly lengthens the time needed for learning which practices are in fact “best”.



Gray. 1998. Research and Learning Assessment for the Northern Coast.

Figure 2 Comparison of Active and Passive Adaptive Management**.**

Using Adaptive Management in the Context of Development Projects

A common misconception about AM is emerging in the field of environmental impact assessment. Some regulatory agencies and proponents mistakenly believe that AM is a good tool for resolving uncertainty at the EA stage regarding the potential impacts from development projects, and can be relied upon to ensure that significant impacts will not occur, or to ensure that significant impacts can be successfully mitigated after they have arisen.

As the name implies, AM is about *environmental management*: taking an experimental approach in order to learn which *management* actions, among some set of alternatives, will best meet environmental goals/objectives. Most projects undergoing an EA review are neither an environmental management action nor an experiment among alternatives: they are development projects. The project is not something designed to meet environmental management objectives; it is typically the construction and operation of something that is likely to *cause* impacts. While there is uncertainty regarding what the significant environmental impacts will be, and whether they can be adequately mitigated, experimental management in this context cannot ensure that significant effects can be avoided or successfully mitigated. While some elements of an AM approach can be helpful in this type of situation (for example, elements of the Assessment step can help predict impacts, characterize the uncertainties behind these predictions, and provide information useful in designing *monitoring* programs to track actual impacts), it is erroneous to expect that AM is a tool that will prevent unwanted ecosystem changes from development projects. Even in the right management context, AM is not appropriate in situations where impacts are likely to be unacceptable or irreversible (i.e. when a "safe-fail" experiment is not possible). Management actions that are to be subject to AM should be reversible (i.e. if the management action does not achieve the desired result) and practical irreversibility is a characteristic of most development projects.

Adaptive Management *may* be useful for trying to find the most effective mitigation measures for impacts that do occur, but it must be remembered that AM is a tool for learning how the system responds to our actions – and we may learn that none of the feasible mitigation measures will be sufficient to render impacts insignificant.

Guideline – Contents of Adaptive Management Plans

Adaptive Management plans are developed as part of Step 2 in the AM cycle (element h in Table 2). While there may be iteration between some of the elements in Steps 1 and 2 in the cycle as the design is refined, the AM plan should be prepared and filed when there is a complete draft of the design of the management experiment suitable for peer review. In some cases, where additional baseline information is needed, it may be desirable to conduct the peer review in two phases: 1) an initial review when there is a well developed conceptual outline of the AM experimental approach together with a design for collection of additional baseline information, and 2) a final review when the design has been finalized in light of the baseline information collected during the design phase.

Adaptive Management plans must describe the results of Steps 1 and 2 in the AM cycle in sufficient detail to permit a thorough peer review of the intended experimental design. This description should include not only the design for the management strategies and monitoring to be carried out in Steps 3 and 4 of the AM cycle, but should also include a description of the anticipated analysis to be used in Step 5 and the expected management response in Step 6 of the AM cycle based on what is learned (e.g. what changes in policy or practice would be expected if the outcomes that are *predicted* in Step 2 do indeed occur). The plan should describe the AM initiative (AMI) in sufficient detail that it can be used to guide implementation of the subsequent steps in the cycle. In this regard an AM plan (AMP) should include each of the components listed below.

1. A clear statement of the management goals and objectives for the AMI, in measurable terms.
2. A list of the key uncertainties (management questions) to be addressed by the AMI
3. A description of the alternative management actions (experimental "treatments") to be employed in the AMI, and how they relate to the uncertainties listed above. Management actions considered during the assessment stage but which are not included in the AMI, if any, should also be identified and the reasons for their elimination from the AMI should be documented. In the event that the AMI will employ a Passive AM approach, the plan should indicate the initial management action to be explored, the duration of monitoring required to evaluate that action, and the likely sequence of alternative management actions thereafter depending on the outcome of the monitoring and evaluation steps (i.e. a series of if…then statements). If the sequence of alternatives is not specified, then the criteria for selecting alternatives for subsequent investigation should be described.
4. A graphic (map based) and textual description of the spatial / temporal bounds of the AMI.
5. Conceptual models which describe the hypotheses to be tested, and which thus underlie the design, should be clearly documented. Such models are best presented in terms of diagrams that illustrate the pathways through which the effects of alternative management actions are thought to occur, accompanied by descriptive text to explain the meaning of the linkages in the pathway diagrams. As appropriate to the context of the AMI such models should clearly illustrate the specific spatial / temporal boundaries, and spatial / temporal dynamics of the pathways. The discussion / presentation of the models should clearly state the assumptions made in developing the AMI design.
6. A description of the indicators that will be measured to assess the effects of management treatment(s) (effectiveness indicators).
7. A description of the sampling design (locations, timing / frequency of sampling for each indicator) employed in collecting any baseline data used to develop or inform the AMI, and a presentation of the results of the baseline monitoring (this may be incorporated in the presentation of the conceptual models which describe the hypotheses to be tested).

8. A description of how what is learned from the AMI will be used to change management policy or practice.
9. A description of the involvement of stakeholders, scientists, and managers in the development of the design of the AMI (who was involved, the methods of involvement, and their contributions).
10. If the AMI will employ an active AM approach (preferred) then the AM plan should include a description of the contrasts, replications, controls to be employed in the AMI.
11. Predicted outcomes of the management treatments. This should include not just the most likely expectation, but the possible range of expected outcomes. The next steps to be taken in response to each of the alternative outcomes should be also be described. This is especially important for any designs that may employ a tiered approach (e.g. one in which the initial level of monitoring is designed to detect a problem which if detected would necessitate a subsequent management response – either the implementation of corrective management actions, or increased monitoring to further identify the cause of the problem.
12. Develop a data management plan:
    - data formats, locations, backup security,
    - planned design of the statistical / data analysis of the AMI results,
    - planned timing of analysis and reporting
    - planned reporting formats
    - planned methods for data sharing and review

13. Develop a monitoring plan, that should include:
    - A description of *implementation* monitoring to be done (where, how, by who, how often, for how long) including and reporting formats, in order to track and document the implementation of the prescribed management treatment(s), and any deviations from the intended implementation.
    - A description of the *effectiveness* monitoring to be done (sampling locations, timing / frequency / duration by indicator, methods of data collection, methods for securing, transporting and analyzing samples, etc).
14. A description of the plan for implementation of the treatment(s) to be explored in the AMI. This description should be provided in sufficient detail that persons responsible for implementation of the management action(s) can successfully implement it/them as intended by the architects of the design. This would for example include a sufficiently detailed description of the management methods to be employed, their location and timing (and clear instructions to document any deviations that might be unavoidable; although implementation monitoring as described in the monitoring plan should also be sufficient to catch this).
15. A description of the plan for data analysis, evaluation and reporting (i.e. how will you go from data to decisions?)

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