Available online at www.sciencedirect.com

SCIENCE DIRECT®

ELSEVIER

Ecological Economics 58 (2006) 434–447

ECOLOGICAL ECONOMICS

www.elsevier.com/locate/ecolecon

ANALYSIS

Adaptive management and environmental decision making: A case study application to water use planning

Robin Gregory [a,*], Lee Failing [b], Paul Higgins [c]

[a] *Decision Research, 1160 Devina Drive, Galiano, B.C., Canada V0N 1P0*
[b] *Compass Resource Management, Canada*
[c] *B.C. Hydro and Power Authority, Canada*

Received 9 November 2004; received in revised form 6 July 2005; accepted 22 July 2005
Available online 13 September 2005

Abstract

Adaptive management (AM) techniques are one of the principal tools proposed by environmental decision makers to provide flexible and responsive management approaches over time. However, the record of successful applications is surprisingly small. We believe that this in part reflects the lack of an intuitively plausible framework for evaluating AM initiatives. This paper outlines such a framework, based on the insights of decision analysis, for evaluating the use of AM as a technique to improve environmental management decisions. British Columbia's Water Use Plan (WUP) process, which has developed operating plans for more than 20 major hydroelectric facilities, is introduced as a case-study example. The discussion emphasizes that decisions to adopt adaptive management strategies involve judgments concerning tradeoffs across a variety of economic, environmental, and social objectives. As a result, adaptive management initiatives need to be carefully evaluated based on their merits relative to other alternatives. Within an AM framework, alternative experimental designs should be evaluated because the design of a preferred experiment involves choices among different levels of investment, the quality of available and desired future information, and different ecological, economic, and social risks.

Keywords: Adaptive management; Decision making; Evaluation; Water planning

1. Introduction: Adaptive management and environmental decisions

Adaptive management (AM) has become a widely suggested approach for reducing ecological uncertainty and improving the overall performance of many resource-based systems. The concept, developed by the ecologists Holling (1978), Walters (1986), and others (e.g., Gunderson et al., 1995) over the past 25 years, incorporates an explicitly experimental approach to learning as a way to reduce uncertainty. Rather than downplaying uncertainty and using existing knowledge to implement a single "best" plan for ecological management, AM approaches

* Corresponding author. Tel.: +1 250 539 5701; fax: +1 250 539 5709.
E-mail address: rgregory@interchange.ubc.ca (R. Gregory).

0921-8009/$ - see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.ecolecon.2005.07.020

explicitly recognize the existence of uncertainty and propose that a range of management alternatives be tested and refined over time based on a careful comparison of the results. The implementation of a scientifically defensible adaptive management approach requires probabilistic estimates of anticipated ecological responses under different management alternatives, the ability to discriminate among competing hypotheses about those responses, and the incorporation of explicit mechanisms for linking learning from the experimental trials to the management decision at hand.

Two general approaches to AM have been described in the environmental management literature (Walters and Holling, 1990). *Passive AM* typically involves developing hypotheses about system performance, implementing a management action based on the best available data, and then closely monitoring its effects to test (and refine) the underlying hypotheses. It is similar to effectiveness monitoring in that, by assessing system changes (e.g., involving different water flows or reservoir levels) over time, the goal is to create an improved management policy. It differs in having a clear set of testable hypotheses tied to an evaluative structure, which for passive AM should explicitly anticipate the extent to which management decisions would vary depending on the outcomes of the experiment. *Active AM*, on the other hand, involves planned manipulation of the physical environment through testing a range of alternative management actions or treatments, either simultaneously or sequentially. The time required for such treatments can be long, possibly measured in decades rather than years, depending on the impact that is being addressed. A comparison of the results of this manipulation in terms of structured hypotheses yields information about which alternative is likely to be best in terms of resolving uncertainty and achieving plan objectives.

Active AM is often presumed to be more appealing from the standpoint of improving knowledge and contributing to the scientific and, in turn, management knowledge base. However, active AM also tends to require a higher level of expenditures and increased opportunity costs (in part, because other management actions cannot be conducted simultaneously due to concerns about confounding study results), typically involves the analysis of management initiatives over a longer time period, and results in a different distribution of risks (in that a broader range of actions is tried, some of which may not be successful). The temporal benefits, costs, and risks of passive and active AM initiatives are therefore often quite different. Although there are exceptions, an active AM approach will tend to be preferred by research-oriented scientists (who tend to place a higher priority on scientific learning and are more comfortable with obtaining results over the longer run). Passive AM approaches, on the other hand, typically are favoured by government decision makers, who tend to place a higher priority on short-term results from the decision process and certainty of operations. Both groups hope to avoid mismanagement of natural resources, particularly to the extent that they might (with hindsight) be blamed for some of the adverse consequences. Community and other non-government (NGO) stakeholders, also involved in the overall decision process, often are left with unrealistic beliefs about the ability of the proposed AM initiatives to deliver on their promises and/or worries about the extent to which the proposed experiments might ultimately deliver wrong or inconclusive information at a relatively high price.

Although the concept of AM is highly appealing, and the approach is at the forefront of modern ecological science, the case-list of successful applications remains small. A review article by Walters (1997), for example, cites only seven examples of adaptive management that have resulted in relatively large-scale management experiments. Not surprisingly, decision makers remain mixed in their support for adaptive management approaches. One perspective sees little value in experimentation, relying instead on baseline studies augmented with modeling results and arguing that, in most cases, enough is now known to develop models that can successfully identify preferred management alternatives. Another perspective argues that ecological models may be sufficient to expose key uncertainties and identify candidate policy alternatives, but that models generally are ineffective for strategies outside those observed as part of baseline studies; this group sees few alternatives to experimental testing. Of course, the role of modeling and the extent to which it can be used to support decision making varies with different contexts. However, a key point is that neither advocates nor opponents of