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Implementing adaptive forest management: The challenge of a wicked human environment

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Abstract

Adaptive management, as a strategy to integrate science and management for improved social learning, meets daunting challenges in the wicked human environments that typify the forest manager's world. Technical and rational-planning interpretations of adaptive management may be useful, but they clearly are not adequate. This paper surveys 25 years of adaptive management literature as a development from emphasis on quantitative and formal tools eventually to include non-technical, social-science perspectives. These new perspectives provide few readily applicable prescriptions for implementing effective adaptive management, but rather indicate a challenging new personal discipline for forest managers. I emphasize context-sensitivity and flexibility in applying the science of adaptive management within the constraints and opportunities of specific human, as well as natural, environments.

"... adaptive management has had more influence as an idea than as a way of doing conservation." (Lee 1999, p. 5)

"It is emphasized that the discovery of such [successful adaptive management] strategies is a matter of luck and imaginative synthesis, not of mechanical systems analysis." (Walters 1986, p. 334)

Introduction

Forest management is a classic example of a "wicked problem" (Allen and Gould, 1986). Wicked problems involve a mix of contentious science and contentious objectives — that is, uncertainty of both a technical and a social nature. Furthermore, natural and human environments are dynamic and evolving in their basic structure, so that a wicked problem has no clear rule for recognizing when planning and decision-making processes are complete. Thus, the challenge is to tailor forest management to the complex and surprising dynamics of specific natural and the human environments that constrain our activities (Gunderson et al., 1995a). The forest ecology and management literature uses a variety of terms — complexity, uncertainty, surprise, dynamic survival landscapes — to describe aspects of wickedness. In any case, the task is immense, and the question of management strategy is far from resolved.

"Adaptive management" has been a major advance in approaches to dealing with uncertainty in our understandings of forest ecosystems. However, success in understanding the social side of forest management has been less clear. Adaptive management's early applications (Walters, 1986; Holling, 1978a), and its best-known and clearest success story (Sainsbury, 1991), address social concerns that are quite simple by comparison with those of forest management (Halbert, 1993). Even the case of New Brunswick spruce budworm management, which is one of the earliest and most frequently-reviewed applications of adaptive management theory to forest management (Baskerville, 1995; Cuff and Baskerville, 1983; Holling, 1978b; Peterman, 1977), pales in comparison with the full range of active controversies in, for example, U.S. Pacific Northwest forests: interactions with salmon fisheries, loss of old growth and associated species, the aboriginal rights and title of First Nations, impacts on tourism values, fire control, and so on. Technical natural science alone, adaptive or otherwise, is not adequate to the challenges of such wicked problems (Miller, 1985; Allen and Gould, 1986; Walters, 1986; Gunderson et al., 1995a).

In response to the limits of technical approaches, adaptive management theory has continually expanded its scope to address more aspects of wicked problems. A “social learning” perspective on adaptive management is one of the key thrusts of this expansion (Röling and Wagemakers, 1998; McLain and Lee, 1996; Gunderson et al., 1995a; Lee, 1993), seeking institutional forms that can effectively interface technical science tools with social energies and constraints for improved, more rapid learning. However, success still remains uncertain. Particularly disturbing to forest managers are the serious doubts that social learning theory raises about whether it is even *possible* to deliberately design our institutions for better learning (Stacey, 2002; Westley, 1995; Lee, 1993). This “largest question” (Lee, 1993, p. 182) is the focus of the paper. To what extent can forest managers *design to learn*? And what are the alternatives?

Scientific adaptive management

Origin of adaptive management theory

Adaptive management originally developed within the tradition of applied systems analysis for optimization, specifically under the leadership of C.S. Holling and Carl Walters at the

University of British Columbia and International Institute for Applied Systems Analysis (Holling, 1978a; Walters and Hilborn, 1978). The team's work built on the key insight that, due to high uncertainty in our behavior models of resource management systems, all management actions are properly described as experiments with uncertain outcomes. That is, rather than implementing "best management practices", resource managers are actually relying on a "working hypothesis" — whether they realize it or not. Unfortunately, the design of policies, and the collection of information to evaluate the effects of those policies, is seldom adequate to produce reliable, timely new understandings. For example, inferences about causal relations are vulnerable to confounding alternatives, and important changes in the system frequently elude early detection. These problems are especially acute in large ecosystems (Lee 1993, Walters and Holling, 1990).

By bringing the technical tools of quantitative systems analysis and experimental design to management actions, scientists sought to improve the reliability and efficiency of knowledge accumulation (McAllister and Peterman, 1992; Walters, 1986; Holling, 1978a). In addition, the authors prescribed formal institutional arrangements that would ensure appropriate and timely use of new knowledge to adjust policy and management in a continual, iterative fashion (Figure 1). Dovers and Mobbs (1997) identify this contribution as the key value of adaptive management: "Crucially, *it is the only approach to policy and management where ecology has played and is playing a core role*." In particular, systems modeling techniques enabled analysts to begin the daunting tasks of integrating information from multiple disciplines and attacking the problems of complex ecosystem dynamics across multiple scales of organization.

Thus, the emphasis of early adaptive management theory was on formal analytical tools such as quantitative system models, economic optimization, quantitative objectives and hypotheses, experimental design at the scale of large ecosystems, statistical power analysis of monitoring programs, and formal decision analysis. The high-quality information yielded through the use of these tools would, if communicated effectively, form a convincing foundation for decision-makers to adjust policies.

Limitations of scientific adaptive management

Or at least, this is how many ecosystem scientists now depict the early development of adaptive management (McLain and Lee, 1996). In fact, the same literature also shows a strong concern for the messy, emotional, values-laden dynamics of the policy/science interface — in other words, the challenge of wickedness. For example, adaptive management was first presented as a framework for interdisciplinary, cross-functional (scientist/policy-maker/manager) modeling workshops designed expressly to overcome human and social barriers to embracing uncertainty and recognizing the need for policy adjustments (Walters, 1986; Holling, 1978a). Hilborn and Walters (1977) note that forcing parties to quantify their objectives not only enables rigorous modeling and analysis, but also helps to clarify and explore differences among stakeholder values. Walters and Hilborn (1978) discuss barriers to adaptive management such as incentives that discourage admission of uncertainty and failure, emotional commitments to pet theories, and risk aversion.

Among these early works, perhaps Walters (1986) is most emphatic in acknowledging the social and political realities of adaptive management for wicked problems. Simulation models serve as gaming tools to stimulate “discovery learning” in managers and resource users that would not accept the same information in a technical report or a policy document. Frustration and conflict act not only as barriers to implementing technical procedures, but also as necessary preludes to inductive breakthroughs. Natural curiosity and enthusiasm sustain commitments to long-term monitoring programs. In consideration of these and other socio-political realities, Walters is clear in identifying limits to the value of technical tools in a wicked policy situation.

Despite this early attention to the limits of technical tools, it is the scientific, rational-planning elements of the adaptive management literature that continue to receive emphasis in many circles. Such interpretations risk a naïve assumption that good management begins with good science (Walters and Green, 1997; McLain and Lee, 1996; Hilborn, 1987). When natural scientists evaluate the success or promise of applied adaptive management, the perspective is often one that frames socio-political factors as "barriers" to the implementation of experimental management and rational planning, rather than as positive, complementary learning processes that provide for important human needs. McLain and Lee (1996) term this focus "scientific adaptive management", and I follow their usage here.

The wicked human environment as a barrier to scientific adaptive management

Barriers to scientific adaptive management include but are not limited to those in Box 1. Framed in another way, these constitute an overview of the wicked human environment within which we implement adaptive management. Hilborn et al. (1995 — cited in Carpenter, 1998) identify a major failing in scientific adaptive management's neglect of social system dynamics. Walters and Green (1997) and Walters and Holling (1990) show that trade-offs of rigorous scientific approaches with socio-political acceptability are inevitable. Lee (1999), Halbert (1993), and McLain and Lee (1996) conclude that scientific adaptive management may be of relatively minor value where wickedness prevents agreement on clear, simple objectives.

Box 1. Human-environmental barriers to scientific adaptive management.

- Natural resources management, and particularly forest management, is subject to a **diversity of stakeholder values, objectives, and problem definitions.** Especially when quantification of "intangible" values is difficult, this diversity prevents straightforward application of optimization procedures, experimental design principles, and formal decision analysis (Pinkerton, 1999; Lee, 1999; Susskind and Secunda, 1998; Brunner and Clark, 1997; Walters and Green, 1997; McLain and Lee, 1996; Halbert, 1993; Leamann and Stanley, 1993; Allen and Gould, 1986; Walters, 1986; Simon, 1983). It also poses the risk of a "**principal-agent problem**", where policies are not implemented faithfully because operational personnel and resource users do not share the understandings and objectives of decision-makers (Lee, 1993; Hilborn and Luedke, 1987; Walters, 1986). Conflicting objectives may even cast doubt on the value of learning itself where experimentation poses risks to vulnerable populations and ecosystem components such as endangered species (Noble, 2000; Meretsky et al., 2000; Gunderson, 1999; Taylor et al., 1997; Lee, 1993; Halbert, 1993; Volkman and McConnaha, 1993; McAllister and Peterman, 1992). Not only do values, objectives and problem definitions vary across stakeholders and individuals, but they also change with time (Michael, 1995; Parson and Clark, 1995; Lee, 1993) — perhaps faster than systematic monitoring can produce reliable evidence of policy success (Lee, 1993).
- The **limits of human cognitive abilities** prevent complete rationality in revising and adjusting policies on the basis of feedback from monitoring activities (Michael, 1995; Anderson, 1998; Parson and Clark, 1995; Levitt and March, 1988; Walters, 1986; Simon, 1983; ESSA, 1982). This is called "bounded rationality" (Simon, 1983). At the scale of whole organizations, fragmentation of understandings into sections, divisions, and branches can lead to similar limitations (Yaffee, 1997; Simon, 1983).
- **Neglected human emotional needs** — for respect, for equitability, for stability, for harmonious relationships, for identity in a group — can form resistance to acknowledging uncertainty, risking failure of alternative policies, and revising opinions, policies, and institutions (Röling and Wagemakers, 1998; Taylor et al., 1997; Michael, 1995; Lee, 1993; Halbert, 1993; ESSA, 1982; Walters and Hilborn, 1978). These emotional factors, and the cognitive limitations discussed above, can also inhibit interdisciplinary communication needed to model complex systems.
- **Information is often communicated throughout a management system in a form either (a) too simplified to be convincing and enlightening** (Westley, 1995; Baskerville, 1995) **or (b) too complex to be grasped and applied readily** (Walters, 1986; Holling, 1978a).
- **Incentive systems (laws, working rules, public opinion, and organizational cultures) often punish risk-taking, ambiguity, and collaboration** (Noble, 2000; Gunderson, 1999; Walters, 1998; Carpenter, 1998; Wagemans and Boerma, 1998; Taylor et al., 1997; McLain and Lee, 1996; Costanza and Greer, 1995; Lee, 1993; Halbert, 1993; Volkman and McConnaha, 1993; Levitt and March, 1988; Walters, 1986; Walters and Hilborn, 1978).

- Efficient policy implementation requires at least temporary closure to alternative viewpoints and uncertainty (Westley, 1995; ESSA, 1982). This phenomenon, where immediate costs of adjusting practices greatly exceed those of maintaining the status quo, is called “**path dependence”** (Ostrom, 1992), a “**competency trap**” (Levitt and March, 1988), or “**lock-in**” (Geldof, 1995). Most often, it is characterized as simply “institutional rigidity”. A competency trap may also take the form of costly up-front investments in long-term physical infrastructure such as dams and sawmills (Light et al., 1995).
- **Spatial and temporal scales of management institutions and policy models are usually inadequate** to the multiple scales of a management problem (Lee, 1993; Ostrom, 1995; Holling, 1995; Taylor et al., 1997). Large-scale, long-term processes are particularly ill-served: learning benefits far in the future are discounted (Walters and Green, 1997), jurisdictional and ownership boundaries challenge coordination over large ecosystems (Lee, 1993; Taylor et al., 1997), and patience and political terms of office are short (Volkman and McConnaha, 1993; Leamann and Stanley, 1993; Halbert, 1993).
- **Powerful stakeholder groups** may dominate agenda-setting, monopolize funding resources, and suppress information and perspectives that point to new practices, values, and objectives (Pinkerton, 1999; Wagemans and Boerma, 1998; McLain and Lee, 1996; Halbert, 1993; McFarland, 1987). They may also use uncertainty as an excuse to delay decisive change (Dovers and Mobbs, 1997; Westley, 1995). Similarly, **power deadlocks among stakeholder groups** can inhibit explicit, systematic treatment of uncertainty (Gunderson, 1999; Parson and Clark, 1995).
- **Scarcity of financial and human resources** imposes constraints on implementing experimental design, monitoring, and communication (Taylor et al., 1997; Walters and Green, 1997; Lee, 1995; Halbert, 1993; Volkman and McConnaha, 1993; Lee, 1993; Levitt and March, 1988; Walters, 1986).

Due in large part to difficulties in the interaction of science with the non-science phenomena in Box 1, confirmed “success” of adaptive management in wicked policy situations is rare (Lee, 1999; Stankey and Shindler, 1997; McLain and Lee, 1996; Lee, 1993; Halbert, 1993). In North America, forest management systems are frequent among these ambiguous cases, including New Brunswick spruce budworm management (McLain and Lee, 1996; Baskerville, 1995), U.S. Forest Service adaptive management areas (Stankey and Shindler, 1997), and Washington State’s Timber/Fish/Wildlife agreement (Halbert, 1993). Ambiguous outcomes obviously are due in part to the long-term framework of many projects (Lee, 1993), but there is plenty of room for skepticism about early claims (e.g., ESSA, 1982) that the success and cost-effectiveness of adaptive management is dependable.

Dissatisfaction with the success rate of scientific adaptive management has led many writers to look more closely at the list in Box 1 on its own terms, seeking to understand the significance and functioning of these phenomena in a broader system that can be viewed as processes of *social learning* (Gunderson et al., 1995a; Lee, 1993). By situating scientific adaptive management within a larger socio-political system, the researchers hope to develop a more pragmatic and balanced view of scientific adaptive management as one of many social learning strategies (Figure 2). Scientific adaptive management may be a *necessary* component of social learning, but it appears not to be adequate. What else do we need to consider?

The turn to social learning

Adaptive management versus social learning

Lee (1993) is the first of the classic adaptive management literature to make comprehensive use of the term "social learning" and the original streams of social science behind it. While some authors appear to *equate* adaptive management and social learning (Bormann et al., 1999; Pinkerton, 1999; Röling and Wagemakers, 1998; Gunderson et al., 1995), Lee clearly limits the term "adaptive management" to *scientific* adaptive management — a sub-component of the larger concept of social learning. The same basic limitation on the term "adaptive management" is made by Grumbine's (1994) classic paper, although in Grumbine's case the larger concept is "ecosystem management"[1]. Social learning, in contrast, includes an extremely wide range of theory, including human and cultural ecology (Pinkerton, 1999; Röling and Wagemakers, 1998;

[1] Lee (1993) himself alternates the term "ecosystem management" with both "adaptive management" and "social learning" in an unclear manner. Consistent use of these broad terms appears to challenge the best of us.

Michael, 1995), institutional economics (Ostrom, 1992), Kuhnian (1962) histories of shifts in scientific paradigms, policy-oriented learning (Sabatier and Jenkins-Smith, 1993), evolutionary economics (Schumpeter, 1950), and organizational learning (Senge, 1990; Levitt and March, 1988; Argyris and Schon, 1978). In addition to Lee (1993), Parson and Clark (1995) provide an excellent review of these various theories.

While a comprehensive review of social learning theories is beyond the scope of this paper, I pause on one frequently-cited example of the limitations of science in wicked problems. This is the distinction between “single-loop” and “double-loop” learning. The classic presentation of these concepts is within the mainstream of organizational learning/management science literature (Argyris and Schon, 1978). I use the example as a concrete transition to a broad categorization of “top-down” and “bottom-up” processes within social learning systems.

The challenge of double-loop learning

Single-loop learning is the process of ongoing adjustment of practices or structures in response to detected failures in meeting one’s objectives. For example, a forester may alter her standard logging prescriptions for riparian forests when stream temperature monitoring indicates failure to meet a regulation that protects salmon. At a higher level, government agency may revise the regulation itself in response to evidence that it is inadequate to prevent major physiological stress on the fish. Scientific adaptive management is well-equipped to handle this kind of learning. But how can science help us to decide when the cost of the regulations in terms of lost timber value and lost jobs exceeds the benefits — financial, cultural, symbolic, ecological — of protecting the fish? Going further, how can science inform the symbolic value of the fish?

Adjusting our higher goals and values themselves is *double-loop learning*, and science appears to play a limited role in this process.

Instead, double-loop learning involves extremely messy, complex interactions among (1) small-scale, rapidly varying processes of face-to-face communication and daily practical experience, and (2) slowly changing, large-scale political, cultural, and institutional structures. The former is considered a bottom-up process of emerging new understandings; the latter provides top-down stability and limited opportunity for change. Both types of causality are represented in Box 1, and both are potential loci for learning. Yet the interaction among them is difficult characterize simply (Figure 3).

For example, Lertzman et al. (1996) challenge the common view that broad social learning is only possible when crisis in top-down controls creates opportunity to inject change from below (Sabatier and Jenkins-Smith, 1993). They describe learning processes in British Columbia forest policy that involve strong roles for *both* established relationships among major organized interests *and* the power of public debate and ongoing management experience to challenge those relationships through emerging ideas like integrated management. Forces for learning and change stem from a wide range of internal and external actors, and the causal linkages are extremely complex. I now turn to look more closely at interactions between bottom-up and top-down processes of social learning. Ultimately, however, the complexity of these interactions requires that we abandon such a simple dichotomy.

Bottom-up: communicative rationality

One stream of social learning literature advocates management strategies that focus on facilitating and empowering actors that are left out of the scientific adaptive management approach, such as citizens, resource users, and implementation personnel (Allen et al., 2001; Röling and Wagemakers, 1998; McLain and Lee, 1996; Westley, 1995). In contrast to the top-down, rational planning approach of scientific adaptive management (Lee, 1999; McLain and Lee, 1996), this literature focuses on the power of everyday face-to-face micro-interactions to create novel, emergent social structures that ultimately can alter higher-level institutions and relationships. It uses a "social constructionist" epistemology to critique positivistic, "technology transfer" traditions of natural resources management, adaptive or otherwise (Röling and Wagemakers, 1998).

Social constructionism proposes that all understandings — of nature, of humans, of societies — result exclusively from processes of communication and relating among humans. In contrast with institutionalist and rationalist models of learning, social constructionism emphasizes differences among individual actors (Stacey, 2002; Lee, 1993). That is, each person responds to particular situations in a different way, based on a unique temperament, experiential history, and relevant set of power relationships with other individuals. The need for co-operative action in the face of such differences demands that we continually negotiate shared understandings to bound conflict in a network of actors. It is the shared experience of these negotiations that validates knowledge (Woodhill and Röling, 1998; Westley, 1995).

This stream of "communicative rationality" lies at the root of scientific learning processes as well as any other learning process (Woodhill and Röling, 1998; Feyerabend 1993). Out of a ubiquitous, chaotic process of conflict, negotiation, and development of shared understandings, more stable social structures emerge unpredictably, scaling up through informal cliques, organizational cultures, networks, and social movements to the point where they have the capacity to alter higher-level structures such as political power coalitions and formal laws

(Giddens 1984, Stacey 2002). Two key conclusions about scientific adaptive management result from this epistemology.

- First, the scientist is not an independent expert; he is an advocate and a voice with a particular kind of limited knowledge (Woodhill and Röling, 1998; Westley, 1995; Lee, 1993). In fact, the information he generates through the scientific method cannot become *knowledge* until it enters the stream of communicative rationality among social and policy actors (Stacey, 2002).

- Second, people cannot be completely controlled instrumentally for implementation of pre-ordained policies or for application of prepared scientific knowledge (Woodhill and Röling, 1998; Westley, 1995; Michael, 1995; Lee, 1993) — a version of the principal-agent problem (Box 1). Since no set of formal structures can anticipate even a fraction of all potential futures under all human- and natural-environmental conditions, actors inevitably weave their own meanings and applications around and through these structures (Stacey, 2002; Brunner and Clark, 1997).

Thus, any model of social learning must explicitly include the entire range of actors as *knowledge* actors. Resource users, implementation personnel, and citizens are as essential to the construction of valid knowledge and meaning as are scientists, managers, and policy makers (Stacey, 2002; Woodhill and Röling, 1998; Korten, 1981). No actor is a mere recipient and implementer of knowledge and policy, but rather must undergo a process of "participatory learning" (Röling and Wagemakers, 1998; also called "transformative learning" [Pinkerton, 1999]) — that is, an internalization of understandings in whose construction they have shared through face-to-face negotiation and enlightening first-hand experience (McLain and Lee, 1996; Westley, 1995; Senge, 1990). The predicted results are better policy and better implementation, as the social learning process harnesses the emotional energies and local, context-specific knowledge of relevant actors.

Bottom-up plus top-down: a fundamental tension

However, dynamics of power and larger institutional structures are poorly incorporated in the literature of the previous section (Woodhill and Röling, 1998; Westley, 1995). Top-down control of bottom-up variability obviously both exists and is valued by humans. Conflict is important for learning, but the conflict must be bounded to avoid system-wide chaos (Gunderson et al., 1995; Lee, 1993). In addition, while science may have no ultimate privilege in a social constructionist epistemology, it is nonetheless true that modern western cultures generally share a stable understanding of rigorous science as an especially reliable source of knowledge (Woodhill and Röling, 1998). We must not neglect the role and value of stability and science for social learning. For example:

- Stability enables efficiency and accumulation of resources (Gunderson et al., 1995a). These are strong incentives to resist adjusting to changes in social and natural environments. We see this in the ethical challenge of recent mill closures in British Columbia forest communities where timber supply and market conditions have changed gradually over the course of decades: the need for change is obvious, but too much change, too fast, is reckless (Geldof, 1995).
- Stability enables implementation of strategies for learning itself, whether it is through scientific adaptive management or inclusive participatory learning (Carpenter, 1998; Gunderson et al., 1995a).

- Stability enables long-term retention of knowledge that is generated through communicative rationality (Brunner and Clark, 1997; Westley, 1995).
- Even at small scales *within* processes of communicative rationality, stable linguistic and other symbolic forms are essential to interaction (Stacey, 2002). This fact helps to explain the frequent observation that even where the *products* of formal quantitative analysis are inadequate in wicked management problems, the *process* of using such rigor can improve development of helpful shared understandings (Maguire and Boiney, 1994; Halbert, 1993; Lee, 1993; Hilborn and Walters, 1977).

Thus, there is a fundamental tension in the practice of adaptive management for improved social learning — how to balance clear communication, stability, and efficiency with diversity of perspectives, unpredictable emergent understandings, and double-loop learning (Geldof, 1995; Westley, 1995)? Science needs institutional stability and faithful implementation, yet its findings cannot produce change without entering a process of communicative rationality that is capable of disrupting the very structures that implemented the science. On the other hand, communicative rationality constantly reinterprets social structure, yet out of this re-interpretation frequently emerge stable social structures that resist further bottom-up influences unless crisis creates a chaotic window of opportunity. Westley (1995) summarizes this as a tension between closed structure for action and open structure for learning. Lee (1993) calls it the challenge of centralized coordination and decentralized implementation. Holling (1995) identifies it as the fundamental paradox of "sustainable development" — persistence and change at the same time. Social learning dynamics appear to move constantly between these two poles.

And it is not an orderly process. Lee (1993, pp. 177-178) quotes Hugh Heclo in a passage that is a familiar nightmare to the forest manager: "[Social learning] is a maze where the outlet is shifting and the walls are being constantly repatterned; where the subject is not one individual but a group bound together; where the group disagrees not only on how to get out but on whether getting out constitutes a satisfactory solution; where, finally, there is not one but a large number of such groups which keep getting in each other's way." *Somehow*, out of this apparent chaos, (relatively) stable structure emerges. *Somehow,* over time, the same chaos overwhelms and revises previous structures. It does not happen through planning or institutional design alone — it is surprising and unpredictable, depending on factors ranging from individual personalities in informal network relationships to the influence of global timber markets and endangered species conventions (Gunderson et al., 1995a). Social learning *appears to organize itself*, beyond the prediction and control of any individual or group of actors (Gunderson and Holling, 2002; Stacey, 2002; Stewart and Ayres, 2001; Checkland, 1981).

Practical adaptive management and social learning

The social learning perspective requires scientists, managers, and policy-makers to abandon many aspirations for control and absolute objective knowledge. While such ideas are no longer new to many social scientists, Stacey et al. (2000) provide a thorough demonstration that the habits of thinking die hard in even the most progressive social learning and management science authors. The question for the forest manager interested in adaptive management becomes, how can I work with these difficult, often frustratingly general insights? How can I act to improve the rate of learning if the learning organizes itself? Is adaptive management, as an effort deliberately to *design for learning*, a pipe dream?

More recent adaptive management literature has begun to digest the social learning perspective thoroughly. One can detect managers' and scientists' growing comfort with a more humble approach, using scientific adaptive management tools eclectically to address the needs and constraints of the human, as well as the natural, environment (Lee, 1999). Small-scale human factors receive a weight (almost) equal to planning and natural science. Of course, a distinction between "passive" and "active" adaptive management, each applicable under different human-environmental conditions, has been well-known since Walters and Hilborn (1978). However, the assumption, consistent with the approach of scientific adaptive management, has usually been that active adaptive management is always ultimately preferable. New attitudes are finally moving beyond this assumption.

Stankey and Shindler (1997, p. 6) write of the need to facilitate "synergy between people and place" in the U.S. Forest Service adaptive management program. Bormann et al. (1999) is an excellent source of alternative adaptive policy designs and forest management case studies, emphasizing citizen participatory learning and exemplifying Lee's (1993) vision of "civic science". Lee (1999) discusses the trade-offs that can and should be made between experimental design and socio-political feasibility. Brunner and Clark (1997), while they make no explicit mention of "adaptive management", propose a "practice-based" approach to ecosystem management that emphasizes detailed comparison of alternative practices within the context of their specific social and natural environments. Far-flung case studies are accumulating in published journals (Meretsky et al., 2000; Gray, 2000; Pinkerton 1999; Johnson and Williams 1999; Gunderson et al., 1995; Hennesey, 1994; Volkman and McConnaha, 1993; Hilborn, 1992; Hilborn and Luedke, 1987; and many others). None of these works provide forest managers with easily transferable prescriptions, but they enrich our collective experience in implementing alternative forms of adaptive management — the challenge of bringing science to wicked human environments.

Further research needs

The need for case studies

We need to continue building the collection of empirically rich case studies, as perceived by the learner-practitioners themselves (Gunderson and Holling, 2002; Parson and Clark, 1995). Not only do such studies serve to test the insights and concepts surveyed in this paper, they also provide managers with vivid "war stories" of other systems. Such rich story-telling is an opportunity for a type of participatory learning — challenging the assumptions of the listener, providing adequate contextual detail for the listener to form her own interpretations, and generally "sensitizing" the listener to new ways of viewing old problems.

For example, the British Columbia Ministry of Forests implements adaptive management with far more rigor in experimental design and formal structure for feedback to policy than the U.S. Pacific Northwest Forest Service. While the former agency largely assigns non-scientific social learning processes to the Land and Resource Management Plan (LRMP) process, the latter appears almost to equate adaptive management with the whole of social learning. Comparing the parallel development of these two cases, which share many similar natural environments but very different human environments, would shed much light on the practitioner's art of making trade-offs and catalyzing learning change in wicked forest policy situations.

Most needed are *long-term* case studies. This is because change in relatively stable institutions and relationships may take decades to emerge from more rapid change at lower levels in the system (Holling, 1995; Lee, 1993). Evaluation of social learning asks not only whether the scientists and managers learned something, but also whether the entire system has evolved and adapted as a whole. Given the dynamic nature of human and natural environments, we also ask whether the system is capable of further, *ongoing* adaptive change. Gunderson et al. (1995b) note that their freshest insights in evaluating and conceptualizing social learning were triggered by recent developments in frequently-analyzed, multi-decade adaptive management efforts such as New Brunswick spruce budworm management and U.S. Columbia Basin power and fish management. What once looked like failures of *adaptive management* now appear in a more favorable *social learning* light. Therefore, in addition to tracking the future progress of relatively recent adaptive management efforts, researchers should take advantage of opportunities to review progress in long-established adaptive management programs like Washington State's Timber/Fish/Wildlife program (Collins and Pess, 1997a, 1997b; Montgomery et al., 1995; Flynn and Gunton, 1995; Lee, 1993; Halbert, 1993; Pinkerton, 1992; Protasel, 1991; Halbert and Lee, 1990; Fraidenburg, 1989).

The form of case studies

What specific issues should these case studies address? First, I suggest they describe the *formal structure* of an adaptive management program. We are looking for information about the degree to which the program structure conforms to the quantitative, formal, and rational-planning ideals of scientific adaptive management. Where the elements of the model in Figure 1 are partly or wholly fulfilled through informal non-scientific strategies, these should also be described. For example, "modeling" may consist in numerical simulations, but it may also be solely conceptual and qualitative (Walker et al. 2002). Similarly, "monitoring" may conform to high standards of experimental design, or it may amount to incidental observation by managers in the course of fulfilling other duties (MacDonald and Smart 1993).

Second, case studies should describe *why* the adaptive management program took its particular structure. This amounts to describing the linkages between scientific adaptive management and the larger forest management system — that is, the trade-offs that have been made in allocating financial and human resources among different strategies for social learning. "Making a trade-off" may be either a *deliberate* decision or an *incidental* effect of deliberate decisions. The list of human-environmental "barriers" in Box 1 is a good starting point in explaining why.

The third need in these case studies is an enormous challenge, and I take it up in a separate section: assessing the consequences of the particular adaptive management program structure for social learning.

The problem of assessing outcomes in a wicked situation

The social learning concepts discussed above tell us that learning is a messy, multifarious, unpredictable, values-laden process. In addition, an evaluative focus on implementing scientific adaptive management risks obscuring other important social learning processes. What evaluative criteria can capture the full range of social learning and do justice to the specific context of each unique wicked problem? If we view learning as an emergent property of a system whose purpose and outcomes are unpredictable and self-organized (Stewart and Ayres, 2001; Checkland, 1981; Röling and Wagemakers, 1998), what external standard can we use to determine the degree of success? Much of the literature is surprisingly silent on this problem.

Learning may be interpreted as change that enables more efficient or effective action to achieve one's goals. Under this definition, evaluative criteria could ask how far a given case has moved towards its goals. These goals may be found in relevant laws, policy documents, and informal but stable agreements. However, the distinction between single-loop and double-loop learning tells us that learning also includes adjusting one's goals themselves. In fact, this may be the crucial task for shifting towards sustainable forest management.

We have also seen that social learning theory views *all* actors in a forest management system as loci of learning, embodying a variety of perspectives, constraining relationships, and goals. Moreover, little of this variety is made explicit and formal, but rather remains informal, unspoken, and often unrecognized even by the actors themselves. Under these conditions, measuring learning success is an enormous challenge.

Thus, the third specification for the case studies I advocate is to develop assessments of learning success that are grounded in the perceptions of participants themselves. While formal documentation is certainly an important part of these perceptions, participant interviews and active involvement in the case will often be a major source of (qualitative) data. The social constructionist epistemology described above undermines models of the "independent researcher" that evaluates a case according to "objective criteria" (Stacey, 2002; Woodhill and Röling, 1998; Checkland, 1981). Instead, the researcher becomes a case participant herself, bringing her own history and unique perspectives to bear on the case, but nonetheless *co-constructing* meaning with those who have a longer history in the case. In any reasonably wicked situation, participants' assessments will vary widely, and the study's causal linkages among environments, program structures, and outcomes will likely remain ambiguous and tentative (Parson and Clark, 1995) — another step in the stream of communicative rationality for social learning.

Finally, case studies of adaptive management programs must return to the literature and basic questions surveyed in this paper: how can we best use the concepts of adaptive management to further social learning? That is, what is its value and what are its limitations? Can we really plan to learn?

Conclusion

While the turn of adaptive management theory to embrace social learning concepts has produced a wealth of promising new perspectives, the practicing forest manager remains without strong, readily applicable advice about how best to design a program for improved social learning. We do not seem to have moved decisively beyond Walters's (1986) warning in this paper's epigraph. Thus, the challenge for forest managers in a wicked human environment is not to seek favored new models of adaptive management for more predictable success, but rather to develop a new personal discipline — one that recognizes the limited usefulness of scientific adaptive management while simultaneously resisting dismay and cynicism about deliberate initiatives to improve social learning. This is the path of patience (Lee, 1993) and bravery (Geldof, 1995). It is also the path of alertness — alertness to the power of everyday communicative rationality and to unpredictable opportunities for large-scale change in our more stable institutions. Adaptive management represents a challenge far beyond the technical traditions of science and rational planning.

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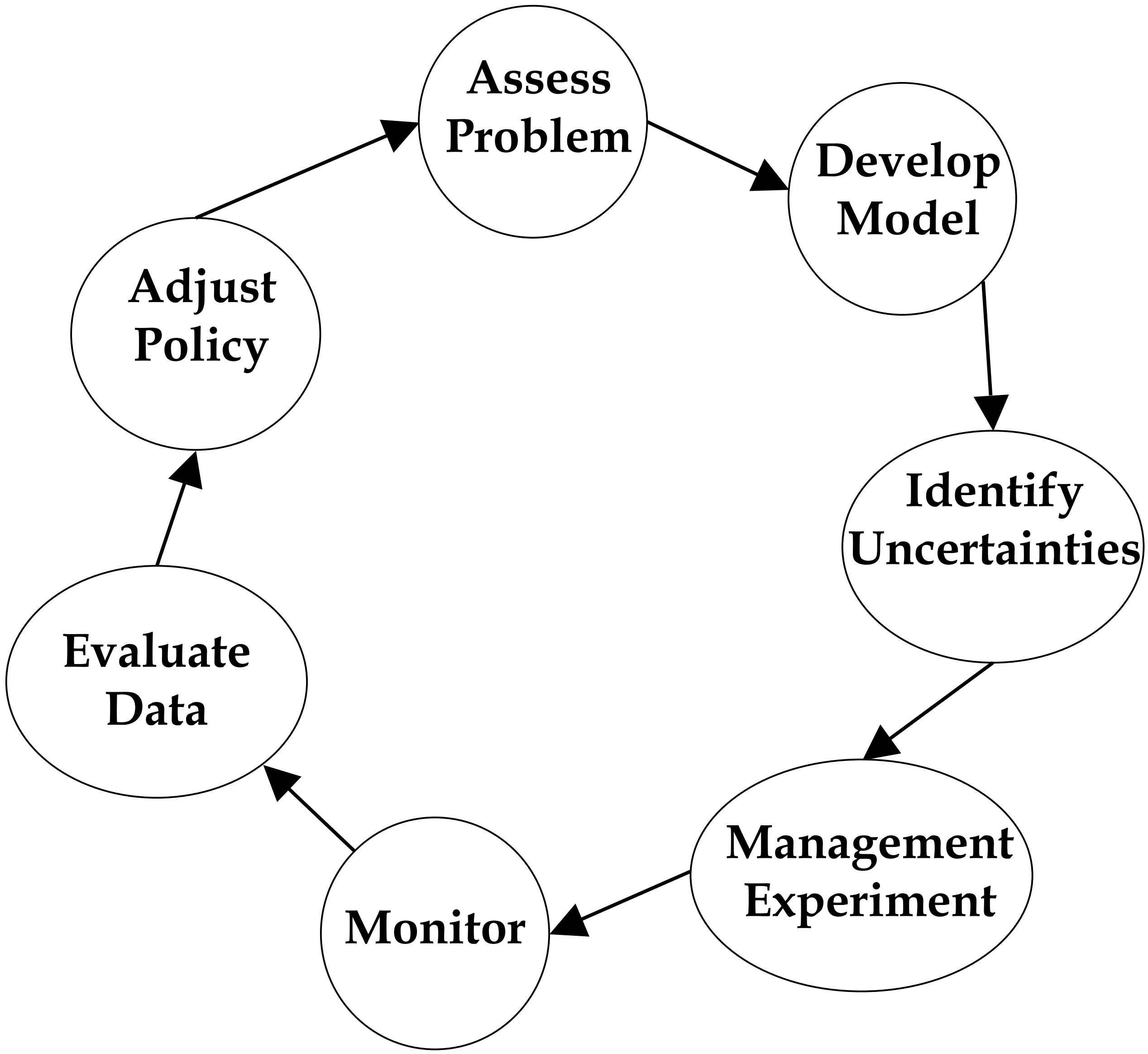

Figure 1. A model of adaptive management. This general formulation is derived from Walters (1986) , Lee (1993), Haney and Power (1996), and Taylor et al. (1997). The “scientific” variant of adaptive management emphasizes quantitative, formal approaches to this model wherever possible. For example, “assessing problems” should include quantification of objectives; models should be numerical; management should use experimental design principles and statistical power analysis of monitoring programs to test clear hypotheses; and policy adjustments should be based on clear, pre-set decision rules for evaluating data against defined objectives.

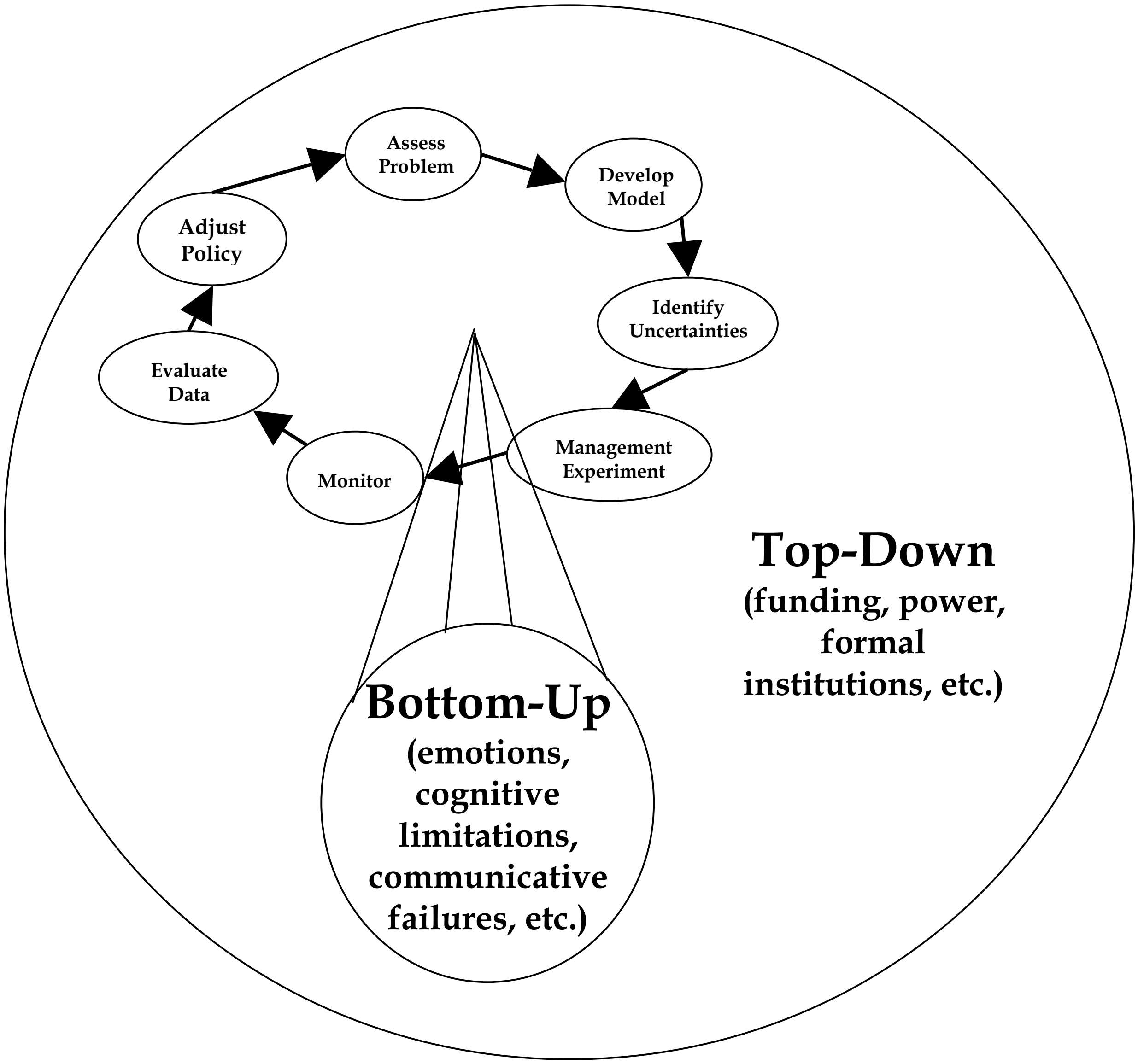

Figure 2. Adaptive management within a social learning system. Implementation of scientific adaptive management is constrained by complex interactions with non-science social phenomena that amount to additional processes of social learning. We can categorize social learning processes as either "top-down" or "bottom-up" influences.

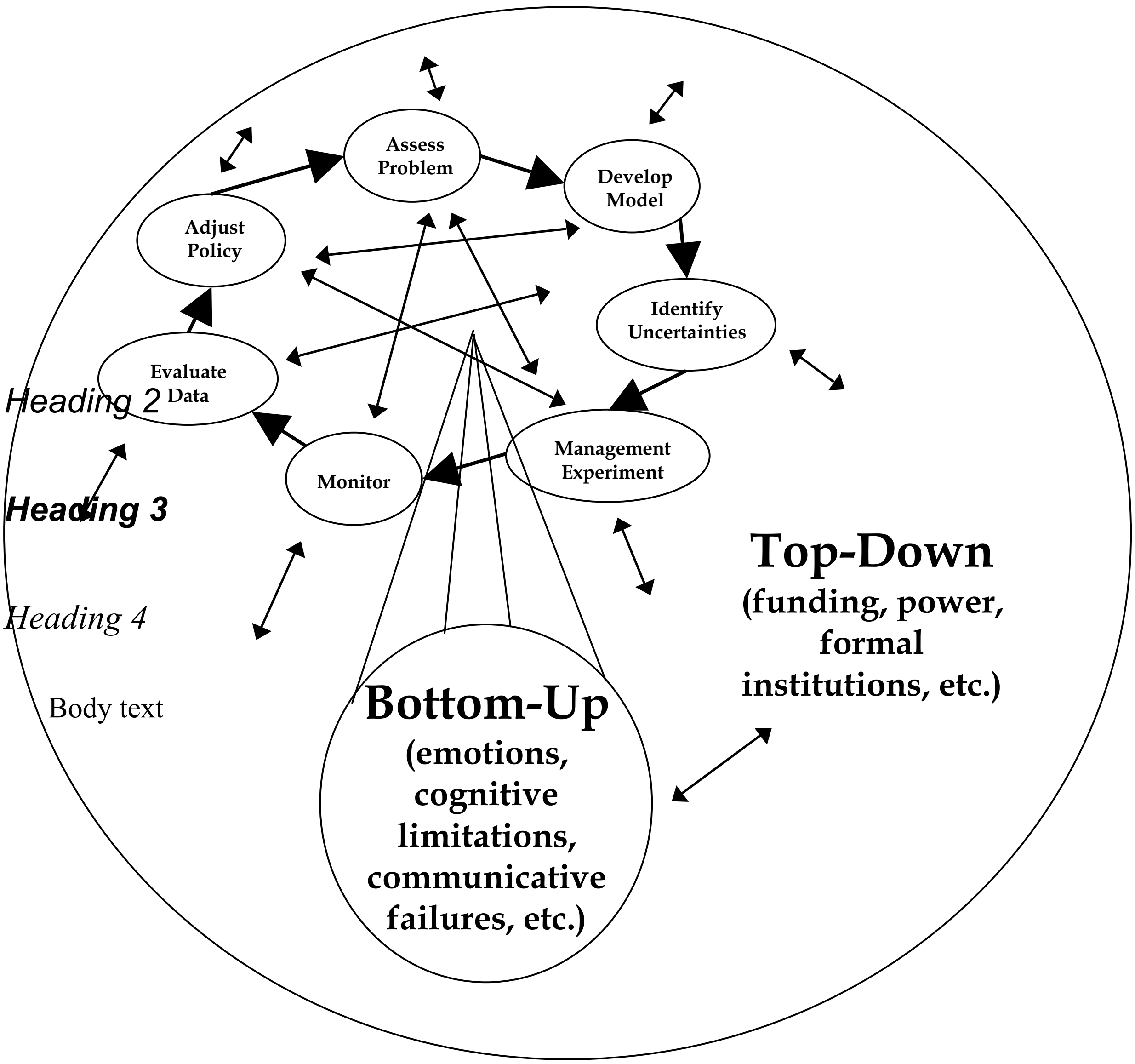

Figure 3. Complexity and chaos in the social learning system. Bottom-up processes are also the original sources of stable social structures that eventually exert a top-down influence. In addition, an adaptive management program will exert its own reciprocal influences on the social learning system. Furthermore, communicative linkages among all components are ubiquitous and frequently informal. Thus, close inspection of the social learning system reveals complexity far beyond simple characterizations. Chaos is frequently a more useful concept.