Adaptive Management: Potential and Limitations for Ecological Governance of Forests in a Context of Normative Pluriformity

Janice Jiggins[1] and Niels Röling[2]

Adaptive management is reviewed a paradigm that addresses a widely perceived need to give more prominence to ecological imperatives. Its contribution to the management of complex problem situations is addressed with reference to the facilitation of social learning and the creation of institutions. The role of simulation modelling and ways to overcome social dilemmas are highlighted. Recent critical reflection on experience is offered with a deeper exploration of learning processes in adaptive management Adaptive management is of particular relevance in forestry to aid forest managers to accommodate multiple interests. Community forestry and collaborative forest management provide illustrative examples of adaptive management within the forestry domain and illustrate its relevance.

INTRODUCTION

Adaptive management is short-hand for a paradigm that satisfies a widely perceived need to give more prominence to ecological imperatives, at a time when economics provides the dominant model for the future. The term 'adaptive management' was coined in 1978 by an inter-disciplinary team of biologists and systems analysts under the leadership of the Canadian ecologist Clarence Holling (Lee 1993). Adaptive management is a guiding principle for the interface between society and the biosphere:

"*The release of human opportunity requires flexible, diverse and redundant regulation, monitoring that lead to corrective action, and experimental probing of the continually changing reality of the external world*" (Holling 1995).

The formulation of adaptive management was based on detailed studies of complex ecosystems such as the Florida Everglades, the Columbia River, the New Brunswick spruce forests, the Baltic Sea and others in which humans play a dominant role (see for instance Gunderson *et al* 1995; Holling and Sanderson 1996; Walters 1986; and Birkes and Folke 1998).

Adaptive management has become a dominant paradigm informing real attempts to manage large ecosystems in a sustainable manner. This important position is increasingly motivating critical reflection on adaptive management (see for instance Roe 1999).

Adaptive management has been gaining ground in response to a widely perceived sense of societal crisis. This perception is essentially concerned with the relations between people and their physical and biological environment, and the ways in which those relations are changing the function and capacity of the ecological processes on which human existence depends. The nature of change is seen as generating -fundamentally new kinds of irreducible uncertainty. The conventional tools of risk assessment, planning and design, and the methodological and explanatory reductionism of conventional science are held to constitute an incomplete, inadequate, and an inappropriate toolbox for the construction of the future in situations in which surprise becomes increasingly determinant of outcome.

Various authors have described this crisis. Funtowicz and Ravetz (1993) speak of *post normal* science now that we are faced with great uncertainty with respect to issues for which the stakes are high. Post-normal science goes beyond *normal* (in the Kuhnian sense) problem solving science and beyond consultancy. it represents widespread involvement in, if not a total democratisation of, science. It is, therefore, built by *extended peers* and includes such *extended facts* as what people believe about an issue.

Beck (1992) has called ours a *risk society* which requires reflexive modernisation, i.e., deliberate self-reflection about the future we are designing. Such deliberate social construction of the future seems the only way forward now that science is widely seen to have become part of the problem.

Lubchenco (1998) identifies the *eco-challenge* as the basis for a new social contract for science. The eco-challenge has been created by people, as a major force of nature. Human survival depends on human

understanding of the impact of human activity on the biosphere and on concomitant adaptation of human activity on the basis of this understanding. For Lubchenco, science is not part of the problem but very much a source of solutions.

In his review of the state of the art of the life sciences, Capra (1996) shows how human life is inextricably part of an evolving complex web of life that sets the conditions upon which continued human survival is predicated. *"A major clash between economics and ecology derives from the fact that nature is cyclical, whereas our industrial systems are linear... the market gives the wrong information "* (Capra *op cit*).

It is in this context that adaptive management has come to the fore. It is an approach to the management of complex systems based on incremental, experiential teaming and decision-making, buttressed by active monitoring of and feedback from the effects and outcomes of decisions. it is thought to offer three important benefits. One is that it might avert crises in conditions of uncertainty and surprise by increasing societal capacity to 'roll with the punches'. A second benefit is that it offers a social steering instrument complementary to market, fiscal, regulatory and normative measures that strengthens broad scale, multi-stakeholder engagement in the evolution of more sustainable relations between people and their environment. Thirdly, it offers a way in which universalised abstractions of science, and the technologies which flow from science, can be re-coupled with lay persons' knowledge of reality-in-context, and with the values and meanings which inspire and motivate people at local levels of interaction.

Through adaptive management, the lesson is being learned, or perhaps re-learned, that consequential actions are always and necessarily specific, and embedded in the historical causalities of particular contexts. Adaptive management translates essential ecological understanding based on extended studies of complex ecological systems into localised implications for human society, and more specifically for human (social) learning and institutional change in a context. It is this promise that gives adaptive management its policy impact and influence.

This article analyses basic ideas behind adaptive management, reviews the credibility of its promise, and applies adaptive management to the field of forestry.

ADAPTIVE MANAGEMENT'S PROMISE: THE MANAGEMENT OF COMPLEXITY

Adaptive management addresses the management of complex system. Complexity is seen as arising in open, non-linear systems. While basic understanding of complexity is increasing, it would appear by definition impossible to build a body of scientific knowledge that allows prediction and control. We can map and model single, or even multiple relationships, but not a total set of evolving interactions (Waldrop 1992). Secondly, complexity refers to emergence, i.e., the fact that relatively simple events at the micro level may lead to the emergence of complex phenomena at the macro level. In other words, properties emerge at system levels that cannot be predicted by knowledge of lower level components and their interaction (Holland 1995). The focus of attention shifts from the components and their relationships, to structural dynamics.

Unfortunately, human beings do not seem to be very good at making decisions that produce desired effects in complex problem situations. Their tendency demonstrably is to isolate and treat specific aspects (components) of a problem, and to become hooked into commitments to particular courses of action, which typically solve local or partial dilemmas while making systemic and long-term outcomes more problematic. Dörner has called this *"the logic of failure"* (Dörner 1996).

Adaptive management offers an umbrella under which new approaches to dealing with complexity can be profiled and related to each other. We shall focus on two: social learning and institution.

Social learning, recognised as a key ingredient of adaptive management (Parson and Clark 1995), is usually seen as learning by a collective. That is, groups, communities, or organisations can collectively learn on the basis of shared perception of problems, their causes and solutions, and agreement on goals and take concerted action. As part of a complex evolving system, human communities that rely only on bodies of tradition or inherited knowledge are vulnerable to surprise. Many studies show societies in fact to be capable of rapid social learning, that is, of evolving new knowledge (*"effective action in the domain of existence"* [Maturana and Varela 1992]), even if that means discarding cherished traditions. However, studies of societies that have collapsed show that people are also perfectly capable of persisting in entrenched ways long after environment feedback has shown these to be no longer sustainable (Pain 1993). One of the risk factors is the role of elites who use their access to resources, power and privileges to maintain life-styles long after the imprudence of doing so has become evident. In this respect, George Bush's remark at UNCED 1992

that *"the American life style is not negotiable"* is a reminder that such mechanisms are also operative today.

Given the importance of breaking through entrenched ways, and the desirability of optimising ways in which societies are sensitive and responsive to environmental feedback, it is small wonder that social learning, and the facilitating of learning, have become hot topics of research (see for example Maarleveld in prep.). Of particular interest are the factors involved in turning around the reliance on the free market as the best model for society, since the market fails in bringing about adaptive management of natural resources and ecological services (Rölling and Maarleveld 1999)[3].

The facilitation of social learning within the framework of adaptive management typically emphasises two approaches. One is the development by system stakeholders of vision or pictures of future states, which they consider desirable (Weber 1995). The envisioning process can be both formal, relying on high tech simulation of future scenarios derived from objective data (see for example Gilbert and Triotzsch 1999), and informal, incorporating values and frameworks of meaning. A variety of back-casting techniques then allow, within transparent procedural processes, the sketching of the steps necessary to shift the system toward a desired future state.

The second approach to facilitation of social learning, and one which has become a core of adaptive management, is the interactive use of simulation models of such complex systems as the Everglades (Gunderson *et al.* 1998) the Upper Mississippi Catchment (Light et al. 1998), or the Balinese water temples (Lansing 1991). These models are used with groups of decision-makers and stakeholders in the complex ecosystem as a basis for understanding those systems and for taking decisions to regenerate them. Interactive simulation modelling seems exceptionally promising for social learning of complexity management, and is going through very rapid development, but so far, no clear results have been achieved (see also the next section: A Critique). In addition to conventional simulation models based on differential equations built around objective values and coefficients, multi-agent simulation is rapidly emerging because it allows model situations in which the outcomes are determined by the interaction of autonomous cognitive agents such as human stakeholders (Jennings et al. 1998; see also Gilbert and Troitzsch 1999 and Röling in press[4]). Multi-agent simulation is in a very early stage of development and so far only a few efforts have been made to use it interactively

Institution are another complex of ideas that are explored under the umbrella of adaptive management. This exploration emphasises the role of institutions as the mechanism that couples people to their environment. This institutional strand has received considerable publicity, largely through the work of Elinor Ostrom (Ostrom 1990,1991, 1992, 1998; Ostrom and Schlater 1996; Ostrom et al. 1994) and of Fikrit Birkes and Carl Folke (Birkes and Folke 1998). They have taken two somewhat different although strongly complementary paths. Ostrom and her group of international researchers examined in great detail common pool resources, and the principles of common property resource' management. They have complemented their field studies with laboratory experiments, based on Game Theory, to elucidate further the conditions and principles identified in field studies. This work addresses the pervasive issue of social dilemmas, for example, the tendency for people to continue to destroy their environment because they expect others to do so too and are reluctant to change their ways unless reciprocity can be depended upon. Ostrom and her colleagues address this issue by analysing the institutional conditions under which such selfish choices can be turned around into situations in which people feel they can afford to make co-operative choices and engage in concerted action. Uphoff (1992) describes how facilitation of institutional development in an irrigation project could lead to such a turn around. The results of such studies provide deep insight and clarity at the principle level; however it is not as yet clear how useful these will prove to be as guidelines for action and institutional design elsewhere, since one of the clear lessons is that history and context matter. The specific ways in which principles are mixed and operationalised lead to great diversity, not to simple transferable models. Antecedents and environment are causative; the dynamic is evolutionary and not designable (in any blueprint fashion at least).

Birkes and Folke and their colleagues have explored the achieved and potential role of institutions in matching socio-economic dynamics more closely to ecological dynamics, taking Holling's *"lazy eight"* description of system states (exploitation, conservation, release and reorganisation; Holling 1995) as one of their starting points. Their work offers the potential for guided institutional reform and evolution coupled with greater sensitivity to ecological process. one of their key questions is the extent to which institutional diversity confers resilience and, if so, at which system level(s). Another concern is the extent to which it is possible, or even desirable in the cause of conserving ecological resilience, to articulate institutional relations across different temporal and spatial scales in ways that match the varying cycles of ecological dynamics. Researchers working on the institutional aspects of adaptive management have been particularly influential in the United States, where large-scale adaptive management, for example with respect to the Everglades (Gunderson *et al*, 1998); the Columbia River (Lee 1993) or the Upper Catchment of the Mississippi River (Light et al. 1998), has produced important lessons (for further information see the next section: A Critique). International bodies of evolving practice, such as watershed management, nature conservation, community forestry and landcare,

with their emphasis on stakeholder learning, and concerted action through institutional development, offer promise of the feasibility of adaptive management.

In all, adaptive management is a promising idea in a world starved of good news. It is an umbrella that gives added meaning to a number of important intellectual developments in recent years. Adaptive management elaborates the observations of the Chilean biologists Maturana and Varela (Maturana et al. 1992) with respect to organisms operating as cognitive systems in their environment. According to the Santiago School of Biology and Capra (1996)[5], organisms can not perceive *"the real world out there"*. There is no way by which the external world could be projected onto the nervous systems of organisms, nor do other mechanisms exist by which they could receive objective information. In fact, organisms are *informationally* closed because the mechanisms in the outside world (e.g., light and sound waves) are totally different from those operating in the nervous systems (neurological processes). However, changes in the outside world can trigger changes in the nervous system. Thus organisms bring forth a world. But it is not any world. Through their mutual perturbance, organisms and environment maintain vital structural coupling. Hence, organisms must bring forth a world that allows them to engage in effective action in their domain of existence. Adaptive management elaborates on these general insights of modern biology for the case of human society and language-based social learning.

A CRITIQUE

Although generating numerous success stories, the last decade of adaptive management has also given rise to more critical reflections. These might be summarised under the following six headings.

The Politicians' Dilemma

Politicians and bureaucrats asked to invest in, and support, adaptive management as experiential learning, have become somewhat sceptical. Experiential learning at the scale of major eco-systems such as the Everglades is (very) costly and takes considerable time. The outcomes of such learning are basically 'unfinished' in that they always require further experiments and seldom lead to conclusively cut-and-dried answers that politicians need. They reasonably ask, when does the experimentation provide results that can form the basis of policy formulation? When such results would become available, they would still need to be translated from the ecology/society interface into political decisions. (Roe 1999).

Unwarranted Extension

Emery Roe *(op cit)* has pointed to the growing tendency to claim adaptive management as the approach to the management of societal change, rather than as one approach, apt for certain problem situations, but not for all. He identifies four characteristic states, of which only one (the second) would suggest an adaptive management application. Briefly the four states are:

1. Situations in which human activity has a low impact with evolution of environmental quality driven largely still by ecological processes;

2. Situations in which environmental change is driven by high impact human activity, which threatens to undermine essential ecological functions and capacity;

3. Heavily history-rich, context-laden situations which must be addressed as unique cases; and

4. Situations already in crisis, in which there is contest and confrontation over socioeconomic and environmental futures.

The challenge then becomes to match the approach to the situation and, perhaps also, to develop ways in which situation 4 might be modulated into situations 3 and 2.

Scenarios and Models as Traps

As we said earlier, the interactive use of computer-supported simulation models has become an important and promising tool for adaptive management. However, three problems have emerged with respect to the interactive use of complex simulation models. In the first place, typically the models are too complex to be easily understood by stakeholders themselves and require highly skilled mediation that does not add to the transparency of the modelling. In this respect, simple models constructed by stakeholders themselves rather

than by experts, such as the physical clay models of irrigation schemes used by CARE in Bangladesh, are more effective. In the second place, scientists' tendency to try to develop true models interferes with interactive learning (Frost in press). Thirdly, it has proved hard to translate the understanding gained through modelling into political action. Much work remains to be done in these areas. Interactive tools which allow interrogation of diverse scenarios, gaming simulations that admit the messy human interactions of real life, and multi-agent modelling are three interesting lines of exploration.

Cross-Scale Problems

Spatial scale issues in adaptive management have begun to yield to innovative mixes of methodology and process. For example, the combined use of participatory resource inventories and maps, Global positioning systems technology, and a computer-based Geographic Information System (GIS), allow the visualisation of spatial dynamics at various scales, and qualitative assessments of state variables and trend virtues which are based on local knowledge and which are *owned* by local stakeholders (see Powell 1999; Gonzalez 1999; and Campbell 1994). Such mixed methodologies allow stake-holders to envisage their environment in a systemic way and to become aware of how their own immediate surroundings fit into a larger picture that affects other stakeholders. Such methodologies are, therefore, a necessary basis for building platforms for resource use negotiation (see for example Röling 1994, 1995; Röling and Jiggins 1998; Steins 1999). Temporal scale problems have proved to be more intractable. A typical example is provided by inter-generational differences in future equity stakes, as present generations discount the value of a healthy environment for future generations. The articulation of action among different scale levels, and of cascades or pulses of action among nested hierarchies, are proving similarly intractable. Solving problems at one level does not automatically add up to solving problems at another system level with different emergent properties. For example, pushing local advantage might undermine the development of a larger unit, and vice versa. Similarly, the very fact that simple and innocuous activities at the micro level might lead to the emergence of complex and undesirable phenomena at the macro level means that it is difficult to convincingly work back from the macro to the micro level. Thus, it is difficult to demonstrate that desired change at the micro level leads to desired change at the macro level. One innovative attempt by Sylvio Funtowicz and his group interactively uses computer models in small groups to create awareness of the larger ecological footprint and the emergent effects of everyday household activities.

Boundary Problems

The theory of holarchy[6] (see Capra 1996) implies that adaptive management is possible only within a defined system boundary. There is no objective way to establish boundaries in socio-economies; to the extent that boundaries exist, they do so as a result of historical processes of negotiation and use of power Adaptive management approaches must thus embrace *"soft system thinking"* (Checkland and Scholes 1990) and procedures which assist stakeholders in a situation *defined by someone as problematic* in order to negotiate the definitions of the boundary they propose to manage adaptively. Adaptive management, in fact, is possible only within a boundary, even if that boundary encompasses the entire biosphere. In fact, problems such as the depletion of the ozone layer can only be tackled successfully at the global level. This does not repudiate the need for that boundary to be agreed upon and for concerted action to address the system agreed upon. The theory of holarchy also necessarily assumes that the rate of external change is relatively stable, as is the nature and intensity of change. This may pose a fundamental limitation to the applicability of adaptive management. The mounting evidence from a whole range of measures is that the rate of change is exponential, and that the nature and intensity of change is producing unpleasant surprises.

The Feasibility of Large-Scale Concerted Action

A key assumption of adaptive management is that social learning will lead to concerted action at the scale of the ecosystem being managed. In the case of such ecosystems as the Everglades or the Baltic Sea, for which it has so far been difficult to establish effective management regimes, this scale is many times larger than the scales at which common property regimes have been successfully established. Common property regimes are those in which stakeholders (Grimble and Wellard 1996) agree to act in the common interest because institutional arrangements have been created which give confidence that others Al reciprocate, especially with respect to *taking less* from the common pool resource, or giving more to the public good. So far, common property regimes seem to be successful at scales at which personal interaction and inter-subjective agreement are possible. This raises the question whether social learning involving larger ecosystems can be translated into concerted action. Decentralisation of adaptive management to area-based or community-based approaches, though advocated by, for example, the eco-regional approach (see for example Dore and Woodhill 1999) would run into cross-scale problems mentioned above[7]. As problems of, for example, reducing global warming demonstrate[8], the need to take large-scale action is not just an abstract problem affecting adaptive management theoretically, but a very real survival problem for humans and most other species also. The key issue is the willingness of people to adapt their desired life styles and economics to agreed-upon

outcomes instead of the other way around. Large-scale concerted action to regenerate the biosphere is relatively easy wherever it is possible to do so without compromising the socially constructed life-styles and economies of the time (e.g., agreement on ozone depletion). Though among the most ephemeral, most socially constructed factors in social change, standards of living, lee styles and other expressions of human intentionality seem to be the most intractable problem in achieving a sustainable society. So far, adaptive management has not addressed the issue of how human ends can be adapted to ecological means.

HELPFUL PERSPECTIVES

This section reviews important ideas current in studies of learning, adaptation, and intelligence.

Evolutionary Psychology

Empirical research and theoretical developments have deepened understanding of how *"nurture ho nature"*[9] (Plotkin 1997). The evolutionary variation, selection, and retention of constrained intelligence in humans are nested in embodied structures with potential for learning. While the specific mechanisms for teaming remain unclear, important clarifications are emerging. One is that learning mechanisms function to facilitate goal-directed interactions with the features of the world for which the learning is adaptive, i. e., learning is both the originator and the adaptive solution to the constructed world. Learning always has an adaptive outcome (Clark 1997). A second clarification is that biological organisms, including humans, do not have access to an indefinitely large search space or a number of search paths. They are constrained by their antecedent evolution and the scope of the senses by which they are structurally coupled to the world (Maturana and Varela 1987). A third clarification is that, since our intelligence is biologically constrained, we can learn about the world only by acting upon it. Thus what we need in adaptive management is an agreed and declared, systematic procedure for socially constructing reality in agreement with empirical adequacy (Van Fraassen 1980). Finally, our evolved minds seem to have an inherited capacity to recognise both physical and social causation (Plotkin 1997). Research has so far not searched for evidence of a similar ability with respect to ecological causation. It would seem plausible that the millions of years during which humankind's ancestors depended on their ability to capture opportunity from complex ecosystems would have led to a human mind with a fine sensitivity to ecological dynamics.

Institutions

Human beings have developed unique additional capacities operative in the social rather than the biological realm. One of these is the creation and use of institutions, which both define the scope for, and constrain the search space and pathways of goal-directed behaviour[10]. In so far as the effects of human behaviour upon our environment appear to threaten continued human enjoyment of life-giving resources, our behavioural goals must change, and thus also must our institutions be purposively recreated.

Culture

Another human capacity is culture, here understood as the shared knowledge and beliefs through which we socially construct value and meaning. Our cultural artefacts, too, have causal power: A dollar bill is physically nothing but a piece of printed paper, but the money markets through which it is exchanged decide the quality of life each of us enjoys. In so far as we seek to adapt our culture to be less predatory on our environment, then we must examine afresh the processes by which knowledge and meaning are generated and shared, and the use to which we put our cultural artefacts.

Language

The aspect of language that concerns us here is as a mechanism for bringing forth institutional and cultural change, i.e., its power for communicative action. This concept, invented by Jürgen Habermas (Habermas 1984, 1987), has generated immense hope and optimism because it posits an alternative to the more familiar instrumental action (using physical causation to gain control) and strategic action (using social causation to win). In fact, according to Habermas, communicative action can counter the invasion of the life world by the economic and technical systems we have created, in that human beings can agree to do things differently. In that sense, language can be seen as an artefact for self-willed social causation, a concept not dissimilar to Beck's *"reflexive modernization"* (Beck 1994).

We believe that taken together, the emerging perspectives on evolutionary psychology, the biology of the mind,

and the role of institutions, culture and language in adapted change, greatly strengthen our ability to design management processes that underpin sustainability. We will illustrate this briefly with reference to Community Forestry and Collaborative Forest Management.

ADAPTIVE MANAGEMENT IN FORESTRY: A LEARNING PERSPECTIVE

As discussed above, originally the adaptive management approach was developed for concerted action at the level of large-scale ecosystems such as the Everglades or Baltic Sea. Gradually increased attention is also being given to apply this approach for smaller-scale ecosystems such as forest ecosystems. For instance, the newly evolving Ecosystem Management approach in the USA involves the principles of adaptive management (Grumbine 1994). Indeed, adaptive management seems to hold a major promise for forest management. Due to the multi-functional character of forests, forest managers are faced with a variety of demands by various stakeholder groups concerning forest use. During the last decade it has become increasingly clear, that various stakeholders have, and probably will have, different, and often conflicting, experiences, positions and opinions as regards forest management (Anderson *et al.* 1998). Consequently, there is no single, absolute and permanent solution to what should be considered as the most rational approach to forest management. In viewing this normative pluriformity surrounding forest management, it is no longer possible for forest managers to base activities on standardised technical measures derived from the objective of the forest owner. Rather, they have now to conceive of forest managers as providing social values to various groups of forest owners. As the required social values of different stakeholders do not necessarily coincide, and even may conflict, this means that a major task of forest managers should be to act as engaged customer facilitators and negotiators (Kennedy *et al.* 1998).

In view of the normative complexity regarding forest management, it is increasingly recognised that exclusive management by a single, professional entity does often not ensure sustainable forest management (Vira *et al.* 1998). There is a growing consensus that without basic agreement amongst the local stakeholders about what, and for what, purpose the forest resources should be maintained, sustainable forest management cannot be achieved and forest degradation will continue. Consequently much attention is now being given to the principle of involving local stakeholders in forest conservation and management. This can be accomplished by either allowing local communities to establish their own forest management systems (= community forest management), or by basing forest management on shared government and community authority (= collaborative forest management) (Fisher 1995 and Wiersum 1999a).

When stimulating community involvement in forest management, conflicting perspectives as to the global ecological imperatives and community-level livelihood imperatives frequently emerge. Moreover, local communities and professionals have often radically different values, perceptions and objectives in forest management (Wiersurn (1999b). Consequently, an adaptive approach to forest management is of particular importance in community and collaborative forest management. This experimental approach to learning and decision-making, which involves all relevant stakeholders in the process, should be able to accommodate the pluriform interests of stakeholders and allow establishment of sustainable agreements that serve both human and environmental needs (Babin and Bertrand 1998).

CONCLUSION

This article has reviewed adaptive management as a powerful idea that brings together numerous strands of disciplinary theory, research and practice. It consolidates these within a normative frame for the management of complex problem situations, the key concern of our time. Our review, however, suggests there are four areas which merit further theoretical development and experimentation.

The first is lifestyles, better covered by the more general term 'human intentionality'. Of the three essential elements in (collective) cognitive systems, perception, action, and intentionality (Maturana and Varela 1987 and Capra 1996)[11], current work in adaptive management, through its focus on social learning for collective action, seems to address mainly the first two while leaving intentionality untouched. This leaves learning vulnerable to the introduction of substitute *quick fixes*, which do not necessarily address the principle that 'local people are experts regarding their own livelihood conditions', or the need to bring farmers' and society's objectives in line with ecological imperatives.

The second concerns the point at which learning occurs. The evidence so far suggests that the impact will be greater when learning processes are devolved and dispersed among citizens rather than largely confined to

officials, experts, and interest groups.

The third is the unwarranted limitation of many present adaptive management practices to large-scale system management, rather than seeking creative, decentralised opportunities and ways of linking these.

Finally, there remains the challenge of linking understanding of complex anthropogenic change back to feasible political action.

References

Anderson, J., Clement, J., and Crowder, L.V 1998. Accommodating Conflicting Interests in Forestry - Concepts Emerging from Pluralism. *Unasylva* 49(3): 3-10.

Babin, B., and Bertrand, K. 1998. Managing Pluralism: Subsidiary and Patrimonial Mediation. *Unasylva* 49 (3): 19-25.

Beck, U., 1994. The Reinvention of Politics. Towards a Theory of Reflexive Modernisation. In: U. Beck... A. Giddens, and S. Lash. (eds.). *Reflexive Modernisation: Politics, Tradition and Aesthetics in the Modem Social Order*. Standford University Press, Standford. pp 1-55.

Koestler, A., 1967. *The Ghost in the Machine*. Arkana (The Penguin Group), London. Especially chapter 3. The Holon, pp. 45-59

Beck, U., 1992. *Risk Society. Towards a New Modernity.* Sage Publications, London. (First published as Risikogesellschaft: Auf dem Weg in eine andere Moderne. Frankfurt am Main: Suhrkamp Verlag 1986).

Birkes, R., and Folke, C. (eds.). 1998. *Linking Social and Ecological Systems. Management Practices and Social Mechanisms for Building Residence*. Cambridge University Press, Cambridge.

Campbell, A., 1994. *Landcare. Communities shaping the land and the future*. Allen and Unwin, St. Leonards. For the case of using participatory GIS in Landcare in Australia,

Capra, F., 1996. *The Web of Life. A new synthesis of mind and matter*. Harper and Collins, London.

Checkland, P., and Scholes, J., 1990. *Soft System Methodology in Action*. John Wiley, Chichester.

Clark, A. 1997. *Being There: Putting Brain, Body and World Together Again.* The MIT Press, Cambridge, Mass.

Dangbegnon, C., 1998. *Collective Action for Regenerative Natural Resource Management*. Caw studies from Benin. Wageningen: Agricultural University, published doctors dissertation, for further theory development and case studies from Benin and Burkina Faso.

Dore. J., and Woodhill. J., 1999. *Sustainable Regional Development. An Australia-wide study of regionalism, highlighting efforts to improve the community, economy and environment.* Greening Australia, Canberra.

Dömer, D., 1996. *The Logic of Failure. Recognising and Avoiding Error in Complex Situations.* Addison Westley, Reading. Translated by Rita and Robert Kimber from the German: Logik des Misslingens. Rowolt Verlag GMBH 1989.

Fisher, R.J., 1995. *Collaborative Management of Forests for Conservation and Development.* IUCN-The World Conservation Union and World Wide Fund for Nature, Gland, Switzerland.

Frost J., In press. *Computer Modeling and the Management of Complex Environmental Conflict. The Case of the Upper Mississippi River.* University of Minnesota; Institute for Economic and Ecological Sustainability, St Paul, Minn.

Funtowicz, S.O., and Ravetz, J.R., 1993. Science for the post-normal age. *Futures* 25, (7). September pp. 739-755.

Gilbert, N., and Troitzsch, K. 1999. *Simulation for the Social Scientist.* Open University Press, Buckingham.

Gonzalez, R., 1999. *Platforms and Terraces. Using Participatory Methods and GIS in Linking Local Knowledge and Remote Sensing for Watershed Monitoring in Ifugao, Philippines.* Agricultural University, Wageningen. Published doctoral dissertation, for the case of interactive GIS use based on mapping and resource inventorising with Ifugao terrace builders in Northern Philippines.

Grimble, R., and Wellard, K. 1996. Stakeholder Methodologies in Natural Resource Management A Review of Principles, Contexts, Experiences and Opportunities. *Agricultural System*, Vol. 65 (2): 173-193.

Grimble, R.E., 1994. What is Ecosystem Management? *Conservation Biology* 8(1):27-38.

Gunderson, L., Light, S.S. and Holling, C.S. 1998. Lessons from the Everglades. Learning in a turbulent system. *Science and Bio-Diversity Policy. Bioscience Supplement*, S-66 to S-73.

Gunderson, L. H., Holling, C.S., and Light, S.S. (eds.) (1995). *Barriers and Bridges to the Renewal of Ecosystems and Institution*. Columbia Press, New York

Habermas, J., 1984. *The Theory of Communicative Action. Vol 1: Reason and the Rationalisation of Society*. Beacon Press, Boston.

Habermas, J., 1987. *The Theory of Communicative Action. Vol 2: Life world and System. A Critique of Functionalist Reason*. Beacon Press, Boston.

Holland, J.H. 1995. *Hidden Order. How Adaptation Builds Complexity*. Addison Wesley, Reading.

Holling, C.S., and Sanderson, S. 1996. Dynamics of (Dis)harmony in Ecological and Social Systems. in: Hanna, S.S., Folke. C., and Mäler KG. (eds.). *Rights to Nature: Biological, Economic, Cultural, and Political Principles of Institutions for the Environment*. island Press, Washington, D. C.

Holling, C.S., 1995. What Barriers? What Bridges? In: Gunderson, L.H., Holling C.S. and light S.S. (eds.). *Barriers and Bridges to the Renewal of Ecosystems and Institution*. Colombia Press, New York. pp. 3-37.

Jennings, N., Sycara, K, and Woolridge, M. 1998. A Roadmap to Agent Research and Development. *Autonomous Agents and Multi-agent System*. 1: 275-306.

Kennedy, J.J., Dombeck, M.P., and Koch, N.E. 1998. Values, Beliefs and Management of Public Forets in the Western World at the Close of the twentieth Century. *Unasylva* 49(1):16-26.

Lansing, J.S., 1991. *Priets and programmers: Technologies of Power in the Engineered Landscape of Bali*. Princeton University Press, Princeton, NJ. USA

Lee, K. 1993. *Compass and Gyroscope*. Island Press, Washington p-54.

Light, S.S., Carlson, E., Blann, K., Fagrelius, S., Barton, K., and Stenquist, B. 1998. *Citizen, Science, Watershed Partnerships and Sustainability. The Case in Minnesota. St Paul (Minnesota):* Minnesota Dept of Natural Resources, Surdna Foundation and Science Museum of Minnesota.

Lubchenco, J., 1998. Entering the Century of the Environment A New Social Contract for Science. *Science*. 279: 491- 496, January 23, 1998.

Maarleveld, M., in prep. Working tide: *Social Learning in Resource Management Dilemmas*. Agricultural University, Wageningen. Published doctoral dissertation in preparation.

Maturana, H.R., and Varela, F.J. 1987. Revised edition: 1992. *The Tree of Knowledge, the Biological Rook of Human Understanding*. Shambala Publications, Boston.

North, D.C., 1990. *Institution, Institutional Change. And Economic Performance* Cambridge University Press, New York and Cambridge.

Ostrom, E., 1990. *Governing the Commons. The Evolution of Institution for Collective Action*. Cambridge

University Press, New York.

Ostrom, E., 1991. *Governing the Commons. The Evolution of Institutions for Collective Action*. Cambridge University Press, New York.

Ostrom, E., 1992. *Governing the Commons. The Evolution of Institutions for Collective Action*. Cambridge University Press, New York.

Ostrom, E., 1998. Coping with Tragedies of the Commons. Paper for 1998 Annual Meeting of the Association for Politics and Life Sciences, Boston, September 3-6, 1998.

Ostrom, E. and E. Schlater. 1996. The Formation of Property Rights. In: Hanna, S.S., Folke. C. and Müller K.G. (eds.). *Right to Nature. Ecological, Economic, Cultural, and Political Principle of Institution for the Environment*. Island Press, Washington, D.C.P.

Ostrom, E., Gardner. R. and Walker. J. 1994. *Ruff, games and common pool resources*. University of Michigan Press, Ann labour.

Pain, S., 1993. 'Rigid' Cultures Caught out by Climate Change. New Scientist, 5 March 1993.

Parson, E.A., and Clark, W.C., 1995. Sustainable Development as Social Learning: Theoretical Perspectives and Practical Challenges for the Design of a Research Program. In: Gunderson, L.H. Holling C.S. and Light S.S. (eds.) 1995, *Barries and Bridges to the Renewal of Ecosystem and Institution*. Colombia Press, New York- pp. 428-461.

Plotkin, H., 1997. *Evolution in Mind, An Introduction to Evolutionary Psychology*. The Penguin Press, UK.

Powell, N., 1999. *Co-Management in Non-Equilibrium Systems, Cases from the Namibian Rangelands.* Swedish University of Agricultural Sciences, SLU Press, Uppsala, Published doctoral dissertation, for the case of GIS use informed by Namibia Bushmen's conception of their environment.

Roe. E., 1999. Report to the Rockefeller Foundation. www.instantvision.com/rockefelter_report

Röling, N., 1994. Platforms for decision making about ecosystems. In: Fresco L.O. *et al* (eds.). *Future of the Land: Mobilising and Integrating Knowledge for Land Use Option*. John Wiley and Sons, Ltd, Chichester. pp. 386-393.

Röling, N., 1995. Creating human platforms to manage natural resources: first results of a research programme. *Proceedings of the International Symposium on System Onented Research in Agriculture and Rural Development*, Montpellier, France, 21 - 25 November 1994. pp. 391 - 395.

Röling, N., and Jiggins, J., 1998. The ecological knowledge system. In: Rölling. N and Wagemakers. A (eds.). *Facilitating Sustainable Agriculture. Participatory Learning and Adaptive Management in Times of Environmental Uncertainty*. Cambridge University Press, Cambridge. pp. 283- 307;

Röling, N., and Maarleveld, M., 1999. Facing Strategic Narratives: An Argument for Interactive Effectiveness. In: *Agriculture and Human Value*. 16:295-308. The Netherlands: Kluwer Academic

Röling, N., in press. *Modelling the Soft Side of Land. the Potential of multi-agent system. Integrated Design for Agriculture*, Agricultural University, Wageningen.

Steins, N.A., 1999. *All Hands on Deck. A Social Constructivist Perspective on Complex (Coastal) Common-pool Resource Management*. Wageningen: Agricultural University, published doctoral dissertation, for further theory development and case studies from Ireland, UK and the Netherlands. Wageningen. Wageningen University

Tainter. J., 1988. *The Collapse of Complex Societies*. Cambridge University Press, Cambridge. ISBN 0 321 38673 X (paperback).

Uphoff, N., 1992. Learning from Gal Oya. *Possibilities for Participatory Development and Post-Newtonian Social Science*. Cornell University Press, Ithaca.

Van Fraassen, B., 1980. *The Scientific Image*. Clarendon Press, Oxford.

Vira, B., Dubois, O., Daniels S.E., and Walker, G.B. 1998. Institutional Pluralism in Forestry: Considerations of Analytical and Operational Tools. *Unasylva* 49(3):35-42.

Waldrop, M.M., 1992. *Complexity: The Emerging Science at the Edge of Complexity and Chaos*. Harmondsworth. Penguin Books, Middlesex.

Walters, C., 1986. Adaptive Management of Renewable Resources. MacMillan, New York

Weber, J., 1995. Patrimonial Mediation en Madagascar: Occupation Humaine des Aires Proteges a Madagascar; Diagnostic et Elements pour une gestion viable. *Natures*, *Sciences et Societes*. 3 (2).

Wiersum, K.F., 1999a. Tropical Forestry Policies: From Colonial Forestry to Rural Development Forestry. In: Wiersum. K.F., *Social Forestry: Changing Perspectives in Forestry, Science or Practice?* Dissertation. Wageningen Agricultural University, the Netherlands. pp-53-73.

Wiersum, K.E., 1999b. Normative Pluriformity in Forest Management: Professional and Community Perspectives. In: *FAO Pluralism and Sustainable Forestry and Rural Development*. FAO, Rome, Italy pp.365-379.

Notes

---

[1]Department of Rural Development Studies, Swedish University of Agricultural Sciences, Post Box 7005. SE-75007 Uppsala, Sweden. Email: janice.jiggins@lbutv.slu.se

[2]Group Communication and Innovation Studies, Wageningen Agricultural University, Hollandseweg. 1 6706 KN Wageningen, the Netherlands. niels.roling@alg.vlk.wau.nl

[3]In which we argue for interactive effectiveness. This paper was produced for a Panel Session on Multiple-use CPRs, Collective Action and Platforms for Resource Use Negotiation. 'Crossing Boundaries', 7th Conference of the International Association for the Study of Common Property Vancouver, Canada, June 10-14, 1998.

[4]Specifically chapter by Leeuwis et al.

[5]Specifically the final chapter which provides a descriptive overview

[6]The theory, coined by Koestler (1967), suggests that systems are whole, evolving, emergent, and nested. Every system can be considered both an integral part of a larger system (looking up) and an autonomous entity (looking down). A holon therefore faces the dilemma of choosing between integration and self-assertion. A holarchy comprises nested systems. Since systems are human constructs, their boundaries are always arbitrary and often negotiated, Management of ecosystems is inconceivable without the stakeholders in those system agreeing on the boundaries of the nested systems with which they are trying to deal.

[7]Common property management scholars suggest that it in nevertheless better to manage large scale ecosystems by decentralising to levels with which human management can cope. For further information see Ostrom 1998.

[8]The agreements made in Kyoto to implement control of global warming have not been met. In fact, carbon dioxide emissions seem to be a function more of economic growth (e.g., Russia for the case of declining emissions and the Netherlands and Australia for rapidly increasing emissions) than of international agreements.

[9]One of the key James evolutionary psychology addresses is evolved nature of mind. For a long time psychologits (especially behaviourists) assumed that people were born (nature) with a mind that could be

called a *'tabula rasa'*, an unwritten sheet of paper that would be filled by socialisation and experience (*'nurture'*). According to evolutionary psychology, it seem highly unlikely that the thousands of years that people have lived as hunter/gatherers has not affected the evolution of the mind and its capacities.

[10]Institutional economists, such as North (1990) look upon institutions as ways by which people solve the problem of imperfect information or bounded rationality, a term first coined by Herbert Simon.

[11]Specifically the final chapter