ROY C. DUDGEON AND FIKRET BERKES

LOCAL UNDERSTANDINGS OF THE LAND: TRADITIONAL ECOLOGICAL KNOWLEDGE AND INDIGENOUS KNOWLEDGE

Much of the literature on traditional ecological knowledge (TEK) deals with similarities and differences between Western science and traditional knowledge (e.g., Johannes, 1989; Williams and Baines, 1993; Berkes, 1999). By contrast, little has been written about the relationship between TEK and indigenous knowledge (IK). These two areas constitute two closely related and broadly overlapping literatures. While each approach seeks to understand local knowledge of the land, there are both similarities and differences between the two. One of the primary differences is the insight provided by TEK regarding some new understandings in ecology and resource management.

This chapter deals with TEK and IK as two distinct approaches to the study of local knowledge of the environment. The chapter discusses the differences between these two approaches with respect to their understandings of the philosophy of science, especially in relation to the science of resource management. It concludes with a contrast between TEK and IK with regard to their implications for the policy and politics of development and their implications for the political autonomy of indigenous peoples.

The most obvious differences between TEK and IK are in the different names they choose to describe their research and in the definitions provided for these key terms. IK has been used to refer to the local knowledge of indigenous peoples or to the unique, local knowledge of particular cultural groups (Warren *et al.*, 1995). As commonly used in the development literature, the term "indigenous" is meant to emphasize the culture of the original inhabitants of an area, as opposed to globalized culture. The term "knowledge" is meant to focus attention upon the contrast between local ways of knowing and interacting with one's environment versus the dominant understandings of economic development derived from modern understandings of development science. IK can be used as a synonym for "traditional knowledge", which recognizes that traditions are not static but continually changing and evolving over time, as cultural groups innovate, borrow and adapt their traditions to changing circumstances.

H. Selin (ed.). Nature Across Cultures: Views of Nature and the Environment in Non-Western Cultures, 75–96.

Traditional *ecological* knowledge, on the other hand, has been defined as "a cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes, 1999: 8). This definition, evolving from our earlier work (e.g., Berkes *et al.*, 1995), recognizes TEK as a knowledge-practice-belief complex and focuses on the ecological aspects of this knowledge. TEK may be viewed as a more specific focus within the larger IK literature. While sharing IK's emphasis on the area-specific and culture-specific nature of indigenous knowledge, the above definition of TEK also adds an explicitly ecological emphasis.

Consequently, TEK focuses explicitly not only upon the social patterns of relationship within the culture under study and those within the ecosystem, but also upon the patterns of relationship between the two. This includes local ways of knowing and interacting with the ecosystem. Such an explicitly holistic approach – informed by recent ecological philosophy, philosophy of science and political ecology – allows TEK to avoid some of the shortcomings of conventional development approaches, and provides support for local political and economic autonomy for indigenous peoples.

IK AND DEVELOPMENT LITERATURE: SOME CRITIQUES

In providing a background for the discussion to follow, this section starts with a history of the IK approach and the substantive areas which have provided the central focus for this literature. It will also highlight several important criticisms which will form the subject matter of the rest of the discussion, including Brouwer's (1998) critique of Sillitoe (1998), who articulates one predominant view of the role of IK in development.

Sillitoe's review proposes that the central purpose of IK research is to "introduce a locally informed perspective into development" (1998: 224) and to make explicit connections between local understandings and practices and those of researchers and development workers. This understanding of local experiences and of the objectives of local people is undertaken in order to "link them to scientific technology" and to contribute to "positive change, promoting culturally appropriate and environmentally sustainable adaptations acceptable to the people as increasingly they exploit their resources *commercially*" (1998: 224, emphasis added). Consequently, Sillitoe argues for the necessity of anthropological participation in this research, since it requires that there be someone trained to mediate between the two cultures, people who can act as "knowledge brokers" (1998: 247).

The evolution of this trend away from top-down approaches to development, and towards those which include some attention to bottom-up approaches has, according to Sillitoe, been informed by two different strands of thought. The first is academic, including various studies in ethnoscience and human ecology which have been carried out over the last few decades. The second strand, which is development focused, has arisen in about the last decade, and has

largely applied itself to research concerning farming systems and participatory development (Sillitoe, 1998: 223). This view is reflected in the writings of other students of IK. For example, Agrawal (1995) observes that IK research has focused largely upon agricultural production systems and sustainable development, while Purcell (1998: 265) notes that much of the early IK work focused upon "agricultural and environmental practices, areas of immediate concern for survival".

Because of the turn towards bottom up research, Sillitoe (1998) suggests that there has been a "sea change" in the paradigms structuring concepts of development, in which approaches such as modernization theory and dependency theory have been replaced by either "market-liberal" or "neo-populist" approaches. Where the former "promotes market forces and decries state intervention", the latter "advocates [the] participation and empowerment" of local peoples (Sillitoe, 1998: 224).

The main point seems to be that anthropologists must participate in these various approaches to the development process, especially by making local knowledge relevant and understandable to development scientists. "The idea of harnessing anthropology to technical knowledge to facilitate development puts the discipline where it should be, at the centre of the development process" (1998: 231). However, to do so need not involve a critique of conventional development. Sillitoe seems to accept development science as it presently stands, for as he states:

> The implication of considering indigenous and scientific perspectives side by side is *not* ... that scientists need to revise their working suppositions regarding objectivity, positivism, reductionism, and so on, to accommodate other views (Sillitoe, 1998: 226, emphasis added).

Instead, the suggested partnership between ethnographers and development scientists "offers an opportunity to compare indigenous statements and explanations against scientifically measurable data" (1998: 227). Sillitoe does acknowledge that "the heretical idea is gaining currency that others may have something to teach us", as well as the possibility that their knowledge "may advance our scientific understanding" by challenging our received models of natural processes (1998: 227). It seems clear, however, that development science remains the final arbiter of the validity of knowledge (Brouwer, 1998: 351). After all, Sillitoe simply dismisses the arguments of "anti-positivistic social scientists" who seek to "undermine" natural scientists without further comment, suggesting instead that it is really a question of "seeking to make scientists work more effectively through partnership" with indigenous peoples (Sillitoe, 1998: 232).

The type of "development-oriented indigenous-knowledge work" which Sillitoe advocates makes no pretense of "understanding others as they understand themselves", that is, of attempting to understand their emic perspective on the world.[1] Rather, its goal is to understand and interpret "other cultures and their environments as the demands of development require" (Sillitoe, 1998: 229).

Similarly, Sillitoe's stance with regards to political and policy issues, which

might involve questioning the aims rather than the methodology of development, is consistent with his views on development science. As he suggests, for example, while IK research "intimately and unavoidably involves political issues", anthropologists working in the area should merely "inform politicians and others about issues as they perceive them and leave the responsibility for policy decisions to them" (Sillitoe, 1998: 231). In Sillitoe's opinion, anthropologists are "not politicians, management consultants, or policy makers", and any pretense towards such ends would test "the limits of our disciplinary competence" as anthropologists (1998: 246–247).

Others have criticized the non-critical stance advocated by Sillitoe with regards to both development science and development policy. Both Stirrat (1998: 243) and Posey (1998: 241), for example, suggest that Sillitoe has ignored much of the "political context" in which IK research takes place. The point has been raised in more general critiques of the IK literature as well. For example, Agrawal (1995: 430) commented that the central objective of much IK research is politically inappropriate in that it involves the *ex situ* preservation of IK in centralized, bureaucratically organized databases. This, he claims, is "not just the preferred strategy ... it is almost always their only strategy" for preserving IK (1995: 430). IK researchers have tended to advocate the external preservation and exploitation of IK by development agencies, without insisting upon the concurrent preservation of the indigenous cultures which produce it. Nor have they supported indigenous peoples concerning their ownership of that knowledge.

As a way to approach political relationships between the global capitalist system and local systems of production, Agrawal (1995: 431) suggests that "it might be more helpful to frame the issue as one requiring modifications in political relationships". Thus, he suggests an alternate position, which advocates the *in situ* preservation of IK through changes to "state policies and market forces", and offers a detailed discussion of the arguments for and against such a course of action (Agrawal, 1995: 432). Stone echoes a similar view:

> Goodwill and inter-disciplinary open-mindedness will not be enough to change this highly bureaucratized system and world of development planning, implementation, and evaluation unless accompanied by institutional and policy change (Stone, 1998: 243).

Brouwer raises yet another issue, which appears to be a response to Sillitoe's contention that IK research "is largely ethnographic reporting of others' production systems" (1998: 234). Such a view

> deals only with indigenous technical knowledge in the field of agriculture ... More important than this dimension, is an awareness of the epistemology on which the anthropologist's science is based and the one which informs the participant's knowledge (Brouwer, 1998: 351).

Such an emphasis would call for the development of an emic understanding of the culture under study; in contrast with the views of those in favour of studies which approach IK "as the demands of development require", and views which reject an "anti-positivist critique" (Sillitoe, 1998). These contrasting views indicate that there is more than one approach to IK research and to the issues which it raises. Sillitoe's contrast between market-liberal and neo-populist

approaches is useful, but it does not adequately encompass the issues. Neither is a contrast between the IK and the TEK approaches adequate – not only because the latter is encompassed by the former, but also because none of the authors considered above explicitly identify themselves with TEK, although both Agrawal (1995) and Purcell (1998) make much more explicit reference to ecological issues.

Purcell provides a more useful suggestion with his contrast between the "indigenous knowledge" approach and the "ecoliberal" approach. The former approach is based upon an understanding of the fact that "capitalist transformation threaten[s] local communities and ecological systems and is therefore unsustainable" (Purcell, 1998: 265). The "ecoliberal" approach, by contrast, "aims at helping to integrate people into the capitalist market on their own terms" (1998: 267). While both might remain compatible with IK research, therefore, only the former explicitly questions the aims of development and the policies which guide it and, by implication, the epistemology and worldview of traditional development science. This is also a position which is suggested by the explicitly ecological focus provided by an emphasis upon TEK.

QUESTIONS OF IDEOLOGY AND EPISTEMOLOGY

While Sillitoe proposes that "the philosophy underlying indigenous-knowledge research is unexceptionable" (1998: 224), the same cannot be said of TEK, primarily because of its explicit emphasis upon the importance of ecological knowledge and issues. This allows TEK researchers to draw upon several decades of theoretical development within the broader area of ecological philosophy. The contrast drawn by Purcell between the indigenous knowledge approach and the ecoliberal approach to development, for example, is highly reminiscent of similar contrasts between two approaches to ecological problems in the earlier ecological literature.

Both Naess' (1973) contrast between shallow and deep ecology, and Bookchin's (1980: 58–59) contrast between environmentalism and ecology raise the same distinction. This is a contrast between an approach which seeks to solve ecological problems (or problems of "development") without questioning the premises of contemporary science and society and a more radical approach which sees the political, economic and scientific status quo as in large part the cause of global ecological problems. In fact, this contrast in approaches to ecological problems is traceable to the earlier works of Leopold and his discussion of the "A-B cleavage" amongst the conservationists of his day. Where one group saw the land merely as soil and its function as merely "commodity production", the other group saw it as something much broader, an ecosystem with a variety of functions (Leopold, 1949: 221).

This more radical approach to ecology has also developed an alternative understanding of what holism entails. As Ingold suggests, for example, while anthropologists have long espoused an holistic approach, "[t]hey have ... been inclined to take this holism as entailing an approach that focuses on 'wholes' – conceived as total societies or cultures – as opposed to their parts or members" (1992: 695).

By contrast, ecological philosophy has developed an explicitly relational understanding of holism, which arises from ecology's self-definition as the study of the interrelationships among living organisms, and between living organisms and the biophysical environment. For example, Bateson (1979: 100) has suggested that, "all serious holism, is premised upon the differentiation and interaction of parts" (1979: 100). This view proposes that holism consists of the study of patterns of relationship, rather than of abstract wholes of some type, including the relationships between theory and practice, between ideology and production systems, and between societies and their ecological circumstances.

The holistic perspective provided by TEK's explicit emphasis upon ecological knowledge allows it to draw upon a more sophisticated understanding of both epistemological and political issues. Informed by ecological philosophy and philosophy of science, some TEK research has emphasized not only the differences between the epistemologies and worldviews of modern science and indigenous philosophies, but also the similarities between indigenous worldviews and the alternative approaches to science.

This holistic perspective also leads to a more explicit focus upon political issues, because part of its mandate is to study the varying patterns of relationship between different social and ecological systems and their adaptive consequences. Once again, this line of inquiry suggests both a contrast between indigenous systems and those of global capitalism, as well as an explicit critique of the latter. Consequently, TEK has developed a more sophisticated critique of current patterns of development and has proposed policy alternatives as well.

All of these issues – including the critique of conventional resource management practices, its greater emphasis upon proposing political and policy alternatives, and upon comparing and contrasting diverse systems of knowledge – are well illustrated by a recent debate over the inclusion of TEK in an environmental impact assessment process in the Northwest Territories of Canada. This debate responded to the position of the Government of Canada's Environmental Assessment Panel, which proposed that TEK must be given "equal consideration with scientific research in assessing the environmental and socio-economic impacts" of a proposed diamond mine in the Northwest Territories (Howard and Widdowson, 1996: 34).

On one side of the debate are its instigators (Howard and Widdowson, 1996, 1997), who have argued that TEK is unscientific and should not be made a mandatory part of environmental impact assessments because it is spiritually based. Their argument is twofold. First, they object to the mandatory inclusion of TEK in impact assessments because they consider that it implies "the imposition of religion" upon Canadian citizens (Howard and Widdowson, 1996: 34). Second, and more importantly with regards to the present argument, they suggest that TEK is unscientific, since "spiritualism is obviously inconsistent with scientific methodology". They conclude, therefore, that TEK "hinders rather than enhances the ability of governments to more fully understand ecological processes", since there is no way in which "spiritually based knowledge claims can be challenged or verified" (Howard and Widdowson, 1996: 34).

On the other side of the debate are those who argue in various ways for the

importance and value of TEK and, most importantly to the present question, suggest that the scientific community and environmental managers may have something to learn from a study of TEK (Berkes and Henley, 1997; Fenge, 1997). Berkes and Henley (1997: 30), for example, argue for pluralism and "the recognition of indigenous knowledge as a legitimate source of information and values", as opposed to the "the simplistic view that there is such a thing as objective, value-free science".

Although they explicitly deny that their arguments are intended to promote the idea of a "universal truth", or a "totally objective science", however, Howard and Widdowson's (1997: 46–47) reply to their critics only serves to reinforce the fact that they do. They contend, "There are not different ways of knowing. There are different beliefs about the same phenomena" (Howard and Widdowson, 1997: 46). Clearly, the only legitimate way of knowing which they recognize is that of conventional science, in the same way that some IK proponents, such as Sillitoe (1998), consider development science to be the final arbiter of the validity of all knowledge, as seen in the debate analyzed in the previous section.

There are remarkable parallels between the two debates in terms of the epistemological questions raised. While Sillitoe clearly recognizes the value of indigenous or traditional knowledge, at least insofar as it contributes to the development process, his understanding of science, and of its role in development, differs little from that of Howard and Widdowson. As Sillitoe suggests, for example, "the perspective of natural science has proved successful in promoting the kinds of interventions that development demands" (1998: 226). Yet whether the types of interventions which development demands have proven to be successful adaptations, or whether they are ecologically appropriate, is a question which is never raised. Sillitoe's reasons for not questioning the scientific orthodoxy concerning development issues, however, are quite clear, for as he states, "It is unrealistic to think that the scientific community could be persuaded to abandon its successful orthodoxy; it would be unable to make sense of the natural world without it" (1998: 232).

Such a position assumes two things: first, that scientific orthodoxy is successful, and second, that there is no alternative to the dominant approach to development science. An ongoing critique of the scientific orthodoxy from the perspective of ecological philosophy and TEK research, however, challenges both of these assumptions. The two sides in this debate within the philosophy of science (concerning the nature of science, its aims, methods and worldview) also closely parallel the contrast drawn by Purcell. The following discussion will particularly highlight the way in which this debate applies to ecological and resource management issues, its implications for policy, and the manner in which it supports the importance of traditional or indigenous knowledge in developing a better understanding of contemporary ecological problems.

On one side of the debate are conventional views of science, which arose with the advent of modern philosophy in the sixteenth century, and which remain predominant today. Based upon a combination of Newton's physics, Descartes' philosophy, and Bacon's experimental method (Holling *et al.*, 1998:

344), this view has several characteristics. "The general conception of reality from the seventeenth century onward saw the natural world as a multitude of separate material objects assembled into a huge machine". Its methodology is essentially analytic or reductive, in that it believes that natural phenomena can best be understood by breaking them down into parts for separate study, in isolation from their larger context (Holling *et al.*, 1998: 344). Through experimental manipulation of the parts, it then seeks to learn to predict and control phenomena through the discovery of causal laws governing the motion of a mechanical universe. This reductionistic philosophy has also been institutionalized with the historical fragmentation of "natural philosophy", as science was originally called, into many separate and specialized disciplines.

On the other side of the debate is an alternative view of science arising from a variety of sources, including biological ecology (Holling, 1973; Holling *et al.*, 1998; Gunderson and Holling, 2001), ecological philosophy (Berman, 1984; Capra, 1982; Griffin, 1988; Merchant, 1980), and anthropology (Bateson, 1972, 1977; Bateson and Bateson, 1988; Ingold, 1990, 1992, 2000; Harries-Jones, 1992, 1995; Rappaport, 1979, 1994). This alternative view can be seen in the context of the paradigm shifts suggested by Kuhn (1970) who argued that the history of science has been characterized by a series of scientific revolutions through which its understandings of the nature of the world, and of science itself, have been fundamentally altered. Essentially, this alternative view calls for a paradigm shift away from mechanistic understandings of science and towards more organic models (Berman, 1984).

The most pragmatic reason for this is that mechanical models and methods appear to be substantially challenged by the types of questions which contemporary ecological problems have brought to the forefront. Many of these problems have no simple solutions; there are scale issues, time lags in response, and the scientific evidence is never clear-cut and always incomplete, making it very difficult to apply cause-effect science of the conventional kind (Kates *et al.*, 2001). As Holling *et al.* (1998: 352) suggest, "there is a worldwide crisis in resource management because the existing science that deals with the issue seems unable to prescribe sustainable outcomes".

This proposed paradigm shift, therefore, needs to involve a variety of changes in the aims and methodology of science. Unlike conventional science, this approach is fundamentally "integrative" and "interdisciplinary", focusing upon the study of complex systems (Holling *et al.*, 1998: 345). It focuses largely upon the study of patterns of relationship, including "the interaction of social systems with natural systems" (1998: 346). In this way it challenges the dualism of conventional science, which is "disciplinary, reductionist, mechanistic, and detached from people, policies and politics" (1998: 345–346).

The new science responds to the ecological dilemma posed by Ingold (2000: 3) – "human beings must simultaneously be constituted both as organisms within systems of ecological relations, and as persons within systems of social relations". Rather than dealing with culture and nature as essentially separate phenomena, it proposes that social systems must be viewed as a part of larger living systems, upon which they depend for their survival. Such a participatory

view also flies in the face of traditions which consider science to be value-free and objective, because when society is considered to be a part of a larger living system, human values and their variant effects upon that system become an important component of the system to be studied. Rather than the analytic and reductive methodology of traditional science, this stream proposes a more synthetic and holistic approach, in the sense that it focuses upon studying the patterns of relationship between the parts, rather than the parts themselves (Bateson, 1979: 100; Holling *et al.*, 1998: 346).

Bateson provides perhaps the most articulate statement of this new approach in his discussion of the concept of "abduction" (Bateson, 1979: 149, 153–155; Bateson and Bateson, 1988: 37, 174–175). Bateson used this term in order to distinguish his own methodology from that of induction and deduction. The methodology he proposed was essentially qualitative and metaphorical, and consistent with a relational understanding of holism, in that it involved a comparison of patterns of relationship with one another and an evaluation of their symmetry or asymmetry.

This is the same methodology that is applied in the system of scientific classification in biology, for example, through which individual animals and plants are classified into species, genera and the like on the basis of just such similarities of patterning in their phenotypes. Not surprisingly, this methodology is also perfectly tailored to the central question with which this view of science is concerned – the adaptation of human patterns of social and economic relationship to the larger patterns of relationship exhibited by ecological systems.

When applied to resource management issues, each view has very different consequences for scientific practice. The reductionist model is based upon utilitarian premises, which view nature merely as a collection of commodities which have no value until humans make use of them (Berkes and Folke, 1998). The conservation practices suggested by this tradition have, since the 1930s, tended to rely upon a calculation of the maximum sustainable yield for any particular resource. This approach not only attempts to predict and control the abundance of the resources harvested, but is also reductive in two different senses. First, it concentrates upon single species, in isolation from the ecosystem within which they are embedded. Second, it reduces the question of sustainable management to an equation which seeks to calculate the maximum possible harvest. This approach appears, therefore, to have adapted itself quite effectively to the monetary calculus of economics, but rather less effectively to the ecosystems which it exploits, as the collapse of Canada's east coast cod fishery, among many other examples, seems to illustrate (Rogers, 1995).

The synthetic and relational approach, on the other hand, proposes the development of a type of "adaptive management" (Holling *et al.*, 1998: 358), which seeks to integrate not only the science of resource management, but also human institutions, techniques and values into the larger system of which they are a part. One of the premises of this view "is that knowledge of the system we deal with is always incomplete. Surprise is inevitable" (1998: 346).

There are two reasons for this unpredictability in complex organic systems.

First, the complexity of the social-ecological system is such that we can never have complete knowledge of all of the relevant variables. Second, an important characteristic of complex organic systems is their "non-linearity" (Holling *et al.*, 1998: 352–354), in the sense that the same stimulus, applied to the same system at a different time, may produce strikingly different results. Consequently, "adaptive management ... treats policies as hypotheses, and management as experiments from which managers can learn" (1998: 358).

Ecological and resource management issues thus necessitate an approach that does not fit well with the conventional mechanistic, linear science of the Age of Enlightenment. As Kates *et al.* (2001) argue, a new science of sustainability must differ fundamentally from most science as we know it. The common sequential analytical phases of scientific inquiry such as conceptualizing the problem, collecting data, developing theories and applying the results do not work. We must also consider the consequences of our actions within a complex organic system and the non-linear effects which these actions have upon ourselves (Bright, 1999). In the emerging sustainability science, the parallel functions of social learning, adaptive management and policy as experiment become key.

This new kind of science recognizes the need to act before scientific uncertainties can be resolved. This is not only because it is difficult to get agreement among experts, but because some uncertainties are not resolvable by science. Hence, it becomes important to design institutions and processes that can facilitate cooperation between scientists and resource users. For example, the participation of fishers in management decisions not only increases the likelihood that they agree to these decisions, but it also ensures that the parties share the risk in decision-making in a fundamentally uncertain world (Berkes *et al.*, 2001).

Such a new paradigm of resource and environmental management promises a much humbler role for the manager. It also changes the role of science in dealing with ecological crises. Scientific orthodoxy comes under question, and expert-knows-best science is abandoned in favour of a kind of science in which "research must be created through processes of co-production in which scholars and stakeholders interact to define important questions, relevant evidence, and convincing forms of argument" (Kates *et al.*, 2001). The implications of such a paradigm are far reaching. Not only are the roles of science and experts altered, but the processes of knowledge making and decision making are also changed. This, in turn, has implications for the empowerment of resource users and other stakeholders in areas such as the management of small-scale fisheries (e.g., Berkes *et al.*, 2001) and for the recognition of the value of the knowledge they hold.

TRADITIONAL ECOLOGICAL KNOWLEDGE AND NEW UNDERSTANDINGS OF RESOURCE MANAGEMENT

The possibility of learning from the values, epistemologies and practices of non-Western cultures has not been lost on scholars dealing with complex organic systems and adaptive management (Berkes and Folke, 1998; Folke and

Colding, 2001; Gunderson and Holling, 2001). Conventional science and management has a questionable record with regard to long-term sustainability, whereas some indigenous or traditional peoples have developed systems that seem more sustainable than our own (Bodley, 2001). Traditional resource management systems may thus be viewed as experiments in successful living, and drawing upon knowledge of these alternatives may provide insights and "speed up the process of adaptive management" (Holling *et al.*, 1998: 359).

There are several similarities between traditional or indigenous management systems and adaptive management. If the orderly and rational science of the Age of Enlightenment is replaced by a new paradigm along the lines of adaptive management, the chasm between indigenous knowledge and Western science essentially evaporates. In support of this view, at least one Native American scholar (Cajete, 2000) has recently gone so far as to describe TEK as a "Native science" which focuses upon the study of "natural laws of interdependence".

Many of the prescriptions of traditional knowledge and practice are consistent with adaptive management as an integrated method for resource and ecosystem management (Berkes *et al.*, 2000). Adaptive management, like many TEK systems, emphasizes processes that are part of ecological cycles of renewability and regards human use of the environment in terms of how well it fits these cycles. Like many TEK systems, adaptive management considers change as inevitable and assumes that nature cannot be controlled and yields cannot be predicted. In both adaptive management and TEK, uncertainty and unpredictability are considered to be characteristics of all ecosystems, including managed ones; in both, social learning appears to be the way in which societies respond to uncertainty. Often this involves social learning at the level of society or institutions.

TEK, based on detailed observation of the dynamics of the natural environment, feedback learning, social system/ecological system linkages, and resilience-enhancing practices, bears a strong resemblance to adaptive management (Berkes *et al.*, 2000). In a sense, adaptive management may be seen as a "rediscovery of traditional systems of knowledge". Even though there are no doubt major differences between the two, adaptive management may be viewed as the scientific analogue of TEK. Drawing on management practices based on TEK and understanding the social processes behind them may speed up the process of designing alternative resource management systems.

Table 1 provides a list of management practices documented from TEK systems from around the world (Berkes *et al.*, 2000). The first heading of the list itemizes five practices that are found in both TEK systems and in Western science, including species conservation and habitat conservation, for example, through taboos and sacred areas (Ramakrishnan *et al.*, 1998; Folke and Colding, 2001). The second identifies three practices (multiple species management, rotation, succession management) that have been abandoned by those Western management methods which emphasize yield maximization but are demonstrably alive and well in many TEK systems, for example, including those that use fire for forest succession management (Boyd, 1999).

The third heading in Table 1 is most interesting because it identifies five

Table 1 Social-ecological practices in traditional knowledge and practice (Berkes *et al.*, 2000, adapted from Folke *et al.*, 1998)

Management practices based on ecological knowledge
(a) Practices found both in conventional resource management and in some local and traditional societies
• Monitoring resource abundance and change in ecosystems
• Total protection of certain species
• Protection of vulnerable life history stages
• Protection of specific habitats
• Temporal restrictions of harvest
(b) Practices largely abandoned by conventional resource management but still found in some local and traditional societies
• Multiple species management; maintaining ecosystem structure and function
• Resource rotation
• Succession management
(c) Practices related to the dynamics of complex systems, seldom found in conventional resource management but found in some traditional societies
• Management of landscape patchiness
• Managing ecological processes at multiple scales
• Responding to and managing pulses and surprises
• Nurturing sources of ecosystem renewal
• Watershed-based management

resource management practices documented from TEK systems but seldom found in Western resource management. Ecologists have discussed one of these, landscape patchiness, but its management has not to any extent become part of conservation practice. The next three (managing ecological processes at multiple scales, responding to pulses, nurturing renewal sources) deal with kinds of ecosystem dynamics that have been discussed only with the development of the notion of adaptive management and adaptive renewal cycles (Holling *et al.*, 1998; Gunderson and Holling, 2001). The existence of these practices in some TEK systems is further evidence of the similarity between TEK and adaptive management.

Take for example the management of ecological processes at multiple scales. Based on ethnohistorical information and current practice, Cree hunters of James Bay in subarctic Canada seem to be simultaneously managing beaver populations on a 4–6 year time scale, lake fish on a 5–10 year scale, and caribou on a 80–100 year scale, with a well established code of practice appropriate for each resource type. The rules and practices of resource use, for both temporal and spatial scales, and the kinds of environmental information that provide feedback, for example, to relocate to a new fishing area, have been documented extensively through participatory research with the Cree (Berkes, 1999).

The fifth item in the third heading, watershed based management, has been known to ecologists at least since the watershed experiments of the 1970s (Bormann and Likens, 1979), even though it is not yet being used extensively in conservation and management practice. A watershed unit provides the

biogeographic boundary for a terrestrial ecosystem; as such, it is the starting point for ecosystem management. The use of watershed units in TEK systems provides evidence for the existence of ecosystem-like concepts among several Amerindian, Asia-Pacific, European and African cultures. The rediscovery of such ecosystem concepts among traditional peoples has been important in the appreciation of TEK among scientists.

Table 2 provides examples of the application of ecosystem-like views in TEK systems. Southeast Asia and Oceania had, and to some extent still have, a wealth of these traditional ecosystem management practices. Examples in Table 2 include TEK systems from the Pacific Northwest, Southeast Asia, Japan, and West Africa. Watershed units are commonly used in TEK systems in North America to mark out tribal boundaries and hunting territories. For example, tribal chiefs of the Gitksan (Gitxsan) and Wet'sewet'en of the Pacific Northwest describe their land boundaries as "from mountain top to mountain top". They orient themselves by two directional axes within this watershed, vertically up and down from valley bottom to mountaintop, and horizontally, upstream and downstream (Tyler, 1993). Similarly, family hunting territories among the James Bay Cree are based on watersheds. The height of land between adjacent river systems provides a convenient and enforceable way of delimiting territorial boundaries.

Some of the most highly developed ecosystem applications were found in the Asia-Pacific region. The ancient Hawaiian *ahupua'a* (Costa-Pierce, 1987), the Yap *tabinau*, the Fijian *vanua*, and the Solomon Islands *puava* (Ruddle *et al.*, 1992) all refer to generically similar watershed-based management systems. In ancient Hawaii, valleys within watersheds were used for integrated

Table 2 Examples of traditional applications of the ecosystem view (Berkes *et al.*, 1998)

System	*Country/region*	*Reference*
1. Watershed management of salmon rivers and associated hunting and gathering areas by tribal groups	Amerindians of the Pacific Northwest	Williams and Hunn (1982)
2. Delta and lagoon management for fish culture (*tambak* in Java) and the integrated cultivation of rice and fish	South and Southeast Asia	Lasserre *et al.* (1983)
3. *Vanua* (in Fiji), a named area of land and sea, seen as an integrated whole with its human occupants	Oceania, including Fiji, Solomon Islands, ancient Hawaii	Ruddle and Akimichi (1984); Baines (1989)
4. Family groups claiming individual watersheds (*iworu*), as their domain for hunting, fishing, gathering	The Ainu of northern Japan	Watanabe (1973); Ludwig (1994)
5. Integrated floodplain management (*dina*) in which resource areas are shared by social groups through reciprocal access arrangements	Mali, Africa	Moorehead (1989)

farming. The ecosystem unit extended from upland forests protected by taboo, through several agricultural zones, downstream to the coral reef and lagoon. Similarly in the Solomon Islands, a *puava* in the widest sense includes all resources and land in a watershed, from the top of the mainland mountains to the open sea outside the barrier reef (Hviding, 1996). [Editor's note: See Hviding's article in this volume.] In each of these cases, the social group inhabiting the ecosystem unit was considered to be part of the system, and affiliation with a particular area was considered to be part of a person's identity.

These characteristics highlight the fact that ecosystem-like concepts in TEK systems are fundamentally different from that of scientific ecology. The scientific concept of ecosystem that emerged in the postwar period was very much in the positivistic tradition, "a machine theory applied to nature"; the ecosystem was often conceived as a mechanistic device and represented as a computer model (Golley, 1993: 2). By contrast, many TEK systems depict ecosystems not as lifeless, mechanical and distinct from people, but as fully alive and encompassing humans. In all cases, TEK makes sense only in the context of active engagement with the land, which Ingold (2000) calls the "dwelling perspective".

Ecosystems are in part socially constructed, and resource management and conservation practices in TEK systems are based on a variety of social processes. Table 3 summarizes four clusters of social processes that inform the ecological practices used in TEK systems. One set deals with the generation, accumulation and transmission of TEK. A second set concerns the structure

Table 3 Social-ecological processes in traditional knowledge and practice (Berkes *et al.*, 2000, adapted from Folke *et al.*, 1998)

Social processes behind management practices
(a) Generation, accumulation and transmission of local ecological knowledge
• Reinterpreting signals for learning
• Revival of local knowledge
• Folklore and knowledge carriers
• Integration of knowledge
• Intergenerational transmission of knowledge
• Geographical diffusion of knowledge
(b) Structure and dynamics of institutions
• Role of stewards/wise people
• Cross-scale institutions
• Community assessments
• Taboos and regulations
• Social and religious sanctions
(c) Processes for cultural internalization
• Rituals, ceremonies and other traditions
• Cultural frameworks for resource management
(d) Worldview and cultural values
• A worldview that provides appropriate environmental ethics
• Cultural values of respect, sharing, reciprocity, and humility

and dynamics of institutions, including leadership and rule making. A third set is about rituals and ceremonies that provide cultural processes for the internalization of TEK practices. A fourth set deals with the worldview and cultural values of the group in question. Each of the processes outlined in Table 1 has in fact been described in the TEK literature from various places in the world.

Much of this literature recognizes TEK not only as "knowledge" or "technique", but also as a knowledge/practice/belief complex in which the context is provided by culture and history (Berkes, 1999). Thus, in the study of the importance of TEK to the conservation of biodiversity, for example, one cannot merely learn from traditional techniques of biodiversity conservation outside of their cultural context (e.g., Berkes *et al.*, 1995). Nor can one discuss, in a decontextualized way, the possible contribution of TEK to sustainable land use (Preston *et al.*, 1995), to environmental assessment (Stevenson, 1996), or to ecological restoration (Kimmerer, 2000). Indeed, there is an increasing recognition of the potential contributions of indigenous knowledge and indigenous cultures in a number of areas towards the creation of a sustainable world.

In this, TEK, as Western academics understand it, again betrays the legacy which it owes to earlier works in the ecological literature, which have long demonstrated a willingness to learn about ecological patterns of living and thinking from non-Western cultures. In this vein, for example, Capra (1975) studied in detail the similarities between the emerging scientific paradigm discussed above and Daoism. Similarly, deep ecologists often draw explicit links between their own position and Buddhism (Devall and Sessions, 1985: 100–101; Fox, 1990: 11–12; Zimmerman, 1994: 313–317). Many other ecological thinkers explore the possibility of learning about environmental ethics and ecological understanding from an examination of the traditional views of Native Americans and other Aboriginal peoples (Bird-David, 1993; Booth and Jacobs, 1990; Callicott, 1982; Hughes, 1983, 1991; Reed, 1991; Salmon, 2000). Perhaps the most comprehensive survey to date is provided by Callicott (1994), with his consideration of ecological ethics from around the world.

What TEK research adds to this tradition, which has largely remained focused upon ideological, ethical and epistemological issues, is its clear emphasis upon practical matters such as resource management and biodiversity conservation. Perhaps one of the more important lessons provided by a study of indigenous or traditional approaches to the management of resources, however, is as much theoretical as it is practical. This is that indigenous resource management systems tend to be non-dualistic, in the sense that values are explicitly incorporated into the system. As Berkes *et al.* (1998) suggest, for example, in traditional management systems, morality and ethics are explicitly a part of the management system; in Western scientific systems they are merely implicit. The newer approach to science is attempting to make these values explicit as well, for two reasons. First, following Kuhn, any scientific paradigm needs to be based upon premises about the nature of the world. Second, as social systems are embedded within ecological systems, the ecological implications of various value systems are an important research question. Given these

premises, the system of values enacted within the global socioeconomic system, and within processes of development, cannot remain immune from scrutiny.

Therefore, unlike those who consider that there is but a single way of knowing or understanding "truth", the proponents of this new scientific paradigm have long suggested that there is much to be learned not only from a study of other cultural practices, but from other cultural ways of *knowing* as well. As Bateson once suggested with regard to contemporary ecological problems, "it is possible that some of the most disparate epistemologies which human culture has generated may give us clues as to how we should proceed" (Bateson and Bateson, 1988: 136). Further,

> other attitudes and premises – other systems of human 'values' – have governed man's relation to his environment and his fellow man in other civilizations and at other times ... In other words, our way is not the only possible human way. It is conceivably changeable (Bateson, 1972: 493).

IMPLICATIONS FOR POLITICS, POLICY AND PRACTICE

The broader approach to indigenous knowledge, including understandings of ecology, resource management and environmental values, would seem to suggest that there is much more to be learned from traditional peoples than simply techniques for improving the success of ongoing development initiatives. Rather than promoting research which uncritically serves the development process, the alternative approach seeks, as Purcell suggests, "the application of anthropological knowledge to ecological problems – both indigenous and non-indigenous" (1998: 267).

There is a rich global heritage of local environmental knowledge developed over millennia, and a diversity of worldviews (Callicott, 1994). Just as biodiversity provides the raw material for ecological evolution, cultural diversity provides the raw material for the evolution of sustainable relations between humans and their biophysical environment (Gadgil, 1987). "The alternative world views of traditional peoples could provide insights for redirecting the behavior of the industrial world towards a more sustainable path" (Berkes *et al.*, 1995: 299).

This emphasis upon identifying both the diversity of opinion which characterizes the scientific and development communities, and the similarities between its own understandings and those of indigenous peoples, allows TEK to transcend the opposition between Western and indigenous knowledge which Agrawal (1995: 414) claims has "seduce[d] modernization and indigenous theorists alike". For "it may be more sensible to accept differences within these categories and perhaps find similarities across them" (1995: 427).

Yet this type of cross-cultural study, which examines both the worldviews and knowledge, as well as the production systems and techniques, of indigenous peoples, is not without its political obstacles. As Purcell observes, for example, "interest in the study and application of IK – or indigenous praxis as a transformative process – logically implies indigenous people assuming relative autonomy" (1998: 260). Such autonomy would imply not only that indigenous people achieve greater political control, or self-government, but also that they

assume much more control over resource management decisions in their traditional territories.

Such a community-based and decentralized pattern of resource management, however, is almost the polar opposite of the highly centralized patterns of development which are currently practiced and is not without its detractors. Howard and Widdowson, for example, suggest that allowing aboriginal peoples to control their own resource management strategies leads to a conflict of interest. "Aboriginal groups are the main harvesters of renewable resources in the north; clearly they should not be placed in a position of regulating these resources" (1996: 35).

This quote helps to bring into focus the politics of TEK. Giving legitimacy to TEK may be seen to be in support of self-determination and local political autonomy, including decision-making in the area of land and resource management. However, it does not fit the world of top-down decision making. The question of ownership or authority over resources is a fundamental issue in the debate over the management of common property resources (e.g., Ostrom, 1990). The use and control of TEK by the indigenous peoples themselves helps them manage their own resources (community-based management) or become partners in decision-making (co-management). The sharing of power and responsibility between aboriginal groups, governments and public development agencies in such a co-management situation "implies a partnership of equals. One of the ways for creating an equitable relationship lies with the recognition of indigenous knowledge as a legitimate source of information and values" (Berkes and Henley, 1997).

A major problem in this regard is the pressure to use TEK outside of its cultural context. The self-proclaimed goal of much of TEK research in the North, Nadasdy points out, is to integrate it with scientific knowledge. Nadasdy (1999: 15) argues that

> framing the problem as one of 'integration' [of TEK with science] automatically imposes a culturally specific set of ideas about 'knowledge' on the life experiences of aboriginal people. The goal of knowledge-integration forces TEK researchers to compartmentalize and distill aboriginal people's beliefs, values and experiences according to external criteria of relevance, seriously distorting them in the process.

Nadasdy could just as easily have made this statement on the issue of collecting IK for development. The very idea of IK as technique to be incorporated into Western-style development, or the very idea of aboriginal knowledge as data that can be integrated into resource management science "implicitly assumes that knowledge is an intellectual product which can be isolated from its social context" (Nadasdy, 1999: 11). Such an approach "also takes for granted existing power relations between aboriginal people and the state by assuming that traditional knowledge is simply a new form of 'data' to be incorporated into already existing management bureaucracies" (Nadasdy, 1999: 15).

Challenging this power relation, rather than taking the status quo for granted, requires either empowering the indigenous group to carry out their own research or developing participatory research methodologies that serve the indigenous group as well as the researcher. A rich literature base is developing

in both of these approaches (Taiepa *et al.*, 1997; Beaucage, 1997; Alcorn and Royo, 2000; Nabhan, 2001; Riedlinger and Berkes, 2001). A review of such participatory TEK research and the forces that have led to its development is beyond the scope of this chapter. Suffice it to say, however, that recent developments in international law and policy regarding the rights of indigenous peoples and local communities to their knowledge have changed the nature of indigenous knowledge research, especially regarding biodiversity. This, in turn, radically changes older concepts of IK as the "common heritage of mankind" and increasingly requires that policy and management be made with the full participation of indigenous and local communities (Mauro and Hardison, 2000).

* * *

An explicitly ecological approach to the study of traditional knowledge appears to answer many of the criticisms which have been made concerning IK research. This is largely due to the holistic or relational approach of TEK and to the theoretically sophisticated ecological literature upon which it is able to draw. Such a relational approach also forces this type of ecologically oriented approach to examine patterns of relationship as diverse as the relationships between varying ideologies and production systems; allows it to compare the symmetry and asymmetry of various worldviews; and, most importantly, allows it both to critique the dominant patterns of development promoted by global capitalism and to suggest alternatives. For "it is economic development based on the logic of unbridled growth that destroys indigenous territories" (Purcell, 1998: 265). This is also the case with the cultures and systems of knowledge – as praxis – of local cultures and communities.

As indigenous knowledge researchers, our choice of methodology and focus is as much ethical and political as it is practical. Shall we study indigenous knowledge "as the demands of development require", or shall we promote its importance for the benefit of the people who possess it? Purcell (1998) and Nadasdy (1999), for example, suggest the importance of either fully collaborative research or the promotion of IK research conducted by indigenous peoples themselves, for their own use and benefit, rather than that of agents of development. Therefore, researchers of indigenous knowledge "must chose between being facilitators of local autonomy ... as the indigenous perspective demands, or be agents of hegemonic 'progress'" (Purcell, 1998: 267).

From an ecologically informed perspective, such as that which TEK brings to indigenous knowledge research, the choice between these two options is clear – to support local autonomy and local participation in resource management. Diversity, after all, is a universal characteristic of complex organic systems; *cultural* diversity is required for successful adaptation to our diverse ecological circumstances. We must support local cultures in their efforts to continue to live sustainably within a wide variety of ecological contexts, so that they may continue to adapt to change.

NOTE

[1] *Emic* is a perspective in ethnography that uses the concepts and categories that are relevant and meaningful to the culture under analysis, that is, a view from the inside. *Etic* is a perspective that uses the concepts and categories of the anthropologist's culture to describe another culture, that is, a view from the outside.

BIBLIOGRAPHY

Agrawal, Arun. 'Dismantling the divide between indigenous and scientific knowledge.' *Development and Change* 26: 413–439, 1995.

Alcorn, Janis B. and Antoinette G. Royo. *Indigenous Social Movements and Ecological Resilience: Lessons from the Dayak of Indonesia.* Washington, DC: Biodiversity Support Program, 2000.

Baines, Graham B.K. 'Traditional resource management in the Melanesian South Pacific: A development dilemma.' In *Common Property Resources*, F. Berkes, ed. London: Belhaven, 1989, pp. 273–295.

Bateson, Gregory. *Steps to an Ecology of Mind.* New York: Ballantine Books, 1972.

Bateson, Gregory. *Mind and Nature: A Necessary Unity.* New York: Bantam Books, 1979.

Bateson, Gregory and Mary Catherine Bateson. *Angels Fear: Towards an Epistemology of the Sacred.* New York: Bantam Books, 1988.

Beaucage, P. and Taller de Tradición Oral del Cepec. 'Integrating innovation: The traditional Nahua coffee-orchard (Sierra Norte de Puebla, Mexico).' *Journal of Ethnobiology* 17: 45–67, 1997.

Berkes, Fikret. *Sacred Ecology. Traditional Ecological Knowledge and Resource Management.* Philadelphia and London: Taylor and Francis, 1999.

Berkes, Fikret, Johan Colding and Carl Folke. 'Rediscovery of traditional ecological knowledge as adaptive management.' *Ecological Applications* 10: 1251–1262, 2000.

Berkes, Fikret and Carl Folke. 'Linking social and ecological systems for resilience and sustainability.' In *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience*, F. Berkes and C. Folke, eds. Cambridge: Cambridge University Press, 1998, pp. 1–25.

Berkes, Fikret, Carl Folke and Madhav Gadgil. 'Traditional ecological knowledge, biodiversity, resilience and sustainability.' In *Biodiversity Conservation*, Charles Perrings, Karl-Göran Mäler, Carl Folke, C.S. Holling, and Beng-Owe Jansson, eds. Dordrecht, The Netherlands: Kluwer Academic Publishers, 1995, pp. 281–299.

Berkes, Fikret and Thomas Henley. 'Co-management and traditional knowledge: threat or opportunity?' *Policy Options*, March 1997, pp. 29–31.

Berkes, Fikret, Mina Kislalioglu, Carl Folke and Madhav Gadgil. 'Exploring the basic ecological unit: ecosystem-like concepts in traditional societies.' *Ecosystems* 1: 409–415, 1998.

Berkes, Fikret, R. Mahon, P. McConney, R.C. Pollnac and R.S. Pomeroy. *Managing Small-Scale Fisheries: Alternative Directions and Methods.* Ottawa: International Development Research Centre, 2001.

Berman, Morris. *The Reenchantment of the World.* New York: Bantam Books, 1984.

Bird-David, Nurit. 'Tribal metaphorization of human-nature relatedness: a comparative analysis.' In *Environmentalism: The View from Anthropology*, Kay Milton, ed. London: Routledge, 1993, pp. 112–125.

Bodley, John H. *Anthropology and Contemporary Human Problems.* Toronto: Mayfield Publishing Company, 2001.

Bookchin, Murray. *Toward an Ecological Society.* Montréal: Black Rose Books, 1980.

Booth, Annie L. and Harvey M. Jacobs. 'Ties that bind: native American beliefs as a foundation for environmental consciousness. *Environmental Ethics* 12: 27–43, 1990.

Bormann, F.H. and G.E. Likens. *Pattern and Process in a Forested Ecosystem.* New York: Springer-Verlag, 1979.

Boyd, Robert, ed. *Indians, Fire and the Land in the Pacific Northwest.* Corvallis: Oregon State University Press, 1999.

Bright, Chris, 'The nemesis effect.' *World Watch*, May/June 1999, pp. 12–23.
Brokensha, David. Comment on 'The development of indigenous knowledge: A new applied anthropology' by Paul Sillitoe. *Current Anthropology* 39(2): 236–237, 1998.
Brouwer, Jan. 'On indigenous knowledge and development.' *Current Anthropology* 39: 351, 1998.
Cajete, Gregory. *Native Science: Natural Laws of Interdependence.* Santa Fe, New Mexico: Clear Light Publishers, 2000.
Callicott, J. Baird. 'Traditional American Indian and western European attitudes towards nature.' *Environmental Ethics* 4: 293–318, 1982.
Callicott, J. Baird. *Earth's Insights: A Survey of Ecological Ethics from the Mediterranean Basin to the Australian Outback.* Berkeley: University of California Press, 1994.
Capra, Fritjof. *The Tao of Physics: An Exploration of the Parallels Between Modern Physics and Eastern Mysticism.* London: Fontana, 1975.
Capra, Fritjof. *The Turning Point: Science, Society, and the Rising Culture.* New York: Bantam Books, 1982.
Costa-Pierce, B.A. 'Aquaculture in ancient Hawaii.' *BioScience* 37: 320–330, 1987.
Devall, Bill and George Sessions. *Deep Ecology: Living as if Nature Mattered.* Salt Lake City, Utah: Peregrine Smith Books, 1985.
Fenge, Terry. 'Ecological change in the Hudson Bay bioregion: a traditional ecological knowledge perspective.' *Northern Perspectives* 25(1): 2–3, 1997.
Folke, Carl, Fikret Berkes, and Johan Colding. 'Ecological practices and social mechanisms for building resilience and sustainability.' In *Linking Social and Ecological Systems*, F. Berkes and C. Folke, eds. Cambridge: Cambridge University Press, 1998, pp. 414–436.
Folke, Carl and Johan Colding. 'Traditional conservation practices.' In *Encyclopedia of Biodiversity*, Simon Levin, ed. Vol. 5. San Diego, California: Academic Press, 2001, pp. 681–693.
Fox, Warwick. *Towards a Transpersonal Ecology: Developing New Foundations for Environmentalism.* Boston: Shambhala, 1990.
Gadgil, Madhav. 'Diversity: cultural and biological.' *Trends in Ecology and Evolution* 2(12): 369–373, 1987.
Golley, Frank B. *A History of the Ecosystem Concept in Ecology.* New Haven and London: Yale University Press, 1993.
Griffin, David Ray, ed. *The Reenchantment of Science: Postmodern Proposals.* Albany: State University of New York Press, 1988.
Gunderson, Lance H. and Holling, C.S., eds. *Panarchy: Understanding Transformations in Human and Natural Systems.* Washington, DC: Island Press, 2002.
Harries-Jones, Peter. 'Sustainable anthropology: ecology and anthropology in the future.' In *Contemporary Futures: Perspectives from Social Anthropology*, Sandra Wallman, ed. London: Routledge, 1992, pp. 157–171.
Harries-Jones, Peter. *A Recursive Vision: Ecological Understanding and Gregory Bateson.* Toronto: University of Toronto Press, 1995.
Holling, C.S. 'Resilience and stability of ecological systems.' *Annual Review of Ecology and Systematics* 4: 1–23, 1973.
Holling, C.S., Fikret Berkes and Carl Folke. 'Science, sustainability and resource management.' In *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience*, F. Berkes and C. Folke, eds. Cambridge: Cambridge University Press, 1998, pp. 342–362.
Howard, Albert and Frances Widdowson. 'Traditional knowledge threatens environmental assessment.' *Policy Options*, November 1996, pp. 34–36.
Howard, Albert and Frances Widdowson. 'Revisiting traditional knowledge.' *Policy Options*, April 1997, pp. 46–48.
Hughes, J. Donald. *American Indian Ecology.* El Paso: Texas Western Press, 1983.
Hughes, J. Donald. 'Metakuyase.' *The Trumpeter* 8(4): 184–185, 1991.
Hviding, Edvard. *Guardians of Marovo Lagoon: Practice, Place and Politics in Maritime Melanesia.* Honolulu: University of Hawaii, 1996.
Ingold, Tim. 'An anthropologist looks at biology.' *Man* (N.S.) 25: 208–209, 1990.
Ingold, Tim. 'Editorial.' *Man* (N.S.) 27: 693–696, 1992.

Ingold, Tim. *The Perception of the Environment: Essays on Livelihood, Dwelling and Skill.* London and New York: Routledge, 2000.

Johannes, Robert E., ed. *Traditional Ecological Knowledge: A Collection of Essays.* Gland: International Conservation Union (IUCN), 1989.

Kates, Robert W., William C. Clark, R. Corell *et al.* 'Sustainability science.' *Science* 292: 641–642, 2001.

Kimmerer, Robin W. 'Native knowledge for native ecosystems.' *Journal of Forestry* 98(8): 4–9, 2000.

Kuhn, Thomas S. *The Structure of Scientific Revolutions.* 2nd ed. Chicago: University of Chicago Press, 1970.

Lasserre, Pierre, *et al. Traditional Knowledge and Management of Marine Coastal Systems.* Biology International, Special Issue 4, 1983.

Leopold, Aldo. *A Sand County Almanac: And Sketches Here and There.* Oxford: Oxford University Press, 1949.

Ludwig, N.A. 'An Ainu homeland: an alternative solution for the Northern Territories/Southern Kuriles imbroglio.' *Ocean and Coastal Management* 25: 1–29, 1994.

Mauro, Francesco and Preston D. Hardison. 'Traditional knowledge of indigenous and local communities: international debate and policy initiatives.' *Ecological Applications* 10: 1263–1269, 2000.

Merchant, Carolyn. *The Death of Nature: Women, Ecology and the Scientific Revolution.* San Francisco: HarperCollins, 1980.

Moorehead, Richard. 'Changes taking place in common-property resource management in the Inland Niger Delta of Mali.' In *Common Property Resources,* F. Berkes, ed. London: Belhaven, 1989, pp. 256–272.

Nabhan, Gary P. *Sonoran Desert Sense of Place Project,* 2001. http://www.desertmuseum.org.

Nadasdy, Paul. 'The politics of TEK: power and the 'integration' of knowledge.' *Arctic Anthropology* 36: 1–18, 1999.

Naess, Arne. 'The shallow and the deep, long-range ecology movement.' *Inquiry* 16: 95–100, 1973.

Ostrom, Elinor. *Governing the Commons: The Evolution of Institutions for Collective Action.* Cambridge: Cambridge University Press, 1990.

Posey, Darrel A. Comment on 'The development of indigenous knowledge: A new applied anthropology' by Paul Sillitoe. *Current Anthropology* 39(2): 241–242, 1998.

Preston, Richard J., Fikret Berkes and Peter J. George. 'Perspectives on sustainable development in the Moose River Basin.' In *Papers of the Twenty-Sixth Algonquian Conference,* David Pentland, ed. Winnipeg: University of Manitoba Press, 1995, pp. 379–394.

Purcell, Trevor W. 'Indigenous knowledge and applied anthropology: questions of definition and development.' *Human Organization* 57: 258–272, 1998.

Ramakrishnan, P.S., K.G. Saxena and U.M. Chandrashekara, eds. *Conserving the Sacred for Biodiversity Management.* New Delhi: Oxford and IBH Publishing, 1998.

Rappaport, Roy A. *Ecology, Meaning and Religion.* Berkeley, California: North Atlantic Books, 1979.

Rappaport, Roy A. 'Humanity's evolution and anthropology's future.' In *Assessing Cultural Anthropology,* R.F. Borofsky, ed. New York: McGraw-Hill, 1994, pp. 153–166.

Reed, Gerard. 'A Sioux view of the land: the environmental perspectives of Charles A. Eastman.' *The Trumpeter* 8(4): 170–173, 1991.

Riedlinger, Dyanna and Fikret Berkes. 'Contributions of traditional knowledge to understanding climate change in the Canadian Arctic.' *Polar Record* 37: 315–328, 2001.

Rogers, Raymond A. *The Oceans are Emptying: Fish Wars and Sustainability.* Montréal: Black Rose Books, 1995.

Ruddle, Kenneth, Edvard Hviding and Robert E. Johannes. 'Marine resources management in the context of customary tenure.' *Marine Resource Economics* 7: 249–273, 1992.

Ruddle, Kenneth and Tomoya Akimichi, eds. *Maritime Institutions in the Western Pacific.* Osaka: National Museum of Ethnology, Senri Ethnological Studies No. 17, 1984.

Salmon, Enrique. 'Kincentric ecology: indigenous perceptions of the human-nature relationship.' *Ecological Applications* 10: 1327–1332, 2000.

Sillitoe, Paul. 'The development of indigenous knowledge: a new applied anthropology.' *Current Anthropology* 39: 223–252, 1998.

Stevenson, Marc G. 'Indigenous knowledge in environmental assessment.' *Arctic* 49: 278–291, 1996.

Stirrat, R. L. Comment on 'The development of indigenous knowledge: a new applied anthropology' by Paul Sillitoe. *Current Anthropology* 39: 242–243, 1998.

Stone, M. Priscilla. Comment on 'The development of indigenous knowledge: a new applied anthropology' by Paul Sillitoe. *Current Anthropology* 39: 243, 1998.

Taiepa, Todd, Phil Lyver, P. Horsley, J. Davis, M. Bragg and H. Moller. 'Co-management of New Zealand's conservation estate by Maori and Pakeha: a review.' *Environmental Conservation* 24: 236–250, 1997.

Tyler, Mary Ellen. 'Spiritual stewardship in aboriginal resource management systems.' *Environments* 22(1): 1–8, 1993.

Warren, D. Michael, L.J. Slikkerveer and D. Brokensha, eds. *The Cultural Dimension of Development: Indigenous Knowledge Systems.* London: Intermediate Technology Publications, 1995.

Watanabe H. *The Ainu Ecosystem, Environment and Group Structure.* Seattle: University of Washington Press, 1973.

Williams, Nancy M. and Graham Baines, eds. *Traditional Ecological Knowledge: Wisdom for Sustainable Development.* Canberra: Centre for Resource and Environmental Studies, Australian National University, 1993.

Williams, Nancy M. and Eugene S. Hunn, eds. *Resource Managers: North American and Australian Hunter-Gatherers.* Washington, DC: American Association for the Advancement of Science, 1982.

Zimmerman, Michael. *Contesting Earth's Future: Radical Ecology and Postmodernity.* Berkeley: University of California Press, 1994.