Changing Resource Management Paradigms, Traditional Ecological Knowledge, and Non-timber Forest Products

Iain J. Davidson-Hunt[1] and Fikret Berkes[2]

Abstract.—We begin this paper by exploring the shift now occurring in the science that provides the theoretical basis for resource management practice. The concepts of traditional ecological knowledge and traditional management systems are presented next to provide the background for an examination of resilient landscapes that emerge through the work and play of humans. These examples of traditional ecological knowledge and traditional management systems suggest that it is important to focus on managing ecological processes, instead of products, and to use integrated ecosystem management. Traditional knowledge is often discussed by resource management agencies as a source of information to be incorporated into management practice; in this paper we go further and explore traditional knowledge as an arena of dialogue between resource managers and harvesters. To enter into this dialogue will require mutual respect among managers and users for each others' knowledge and practice. Such a dialogue could move forest management paradigms beyond our current view of "timber or parks" and toward one of truly integrated use.

INTRODUCTION

"Adopting sustainable development in forestry has meant broadening our overarching goal, *from sustained yields to healthy forest ecosystems*...Our goal is to maintain and enhance the long-term health of our forest ecosystems for the benefit of all living things, both nationally and globally, while *providing environmental, economic, social and cultural opportunities* for the benefit of present and future generations" (Canadian Council of Forest Ministers 1998a: ix-xii, emphasis added).

"We commit ourselves to apply our knowledge and expertise to fulfill our vision by, where applicable: Improving our understanding of forest ecological processes, and enhancing our capacity to manage forests in a way that will maintain the biological diversity, productivity and resilience of these ecosystems" (Canadian Council of Forest Ministers 1998b: 1).

"It seems obvious that the common procedure of incorporating TK [traditional knowledge] into environmental management is one that serves neither the interests of Aboriginal peoples nor the dominant culture. The full contributions of Aboriginal people and their knowledge to managing for sustainable use will not be realized if TK continues to be treated as just some other category of information to be inserted into, or merged with, western scientific knowledge to further the agenda of environmental managers. Rather, they will be realized when we begin to shift focus towards applying those management philosophies and systems that give TK its full meaning, merit, and efficacy" (Stevenson 1998).

[1] *Ph.D. student, Natural Resources Institute, University of Manitoba, and member, The Taiga Institute for Land, Culture and Economy, Suite A, 150 Main Street South, Kenora, Ontario, Canada, P9N 1S9; e-mail: dhunt@cc.umanitoba.ca.*

[2] *Professor, Natural Resources Institute, University of Manitoba, Winnipeg, Manitoba, Canada, R3T 2N2; e-mail: berkes@cc.umanitoba.ca.*

A shift is occurring in how Canadians think forests should be managed. As the Canadian Council of Forest Ministers (CCFM 1998a) noted, we are beginning to view our forests as ecosystems that provide timber, medicinal plants, foods, craft materials, and recreational opportunities. We are also beginning to realize that the long-term health of forest ecosystems and the well-being of people should be complementary, rather than opposing, goals. A healthy forest ecosystem is one that supports more than just logging activities. There may be people felling trees and others picking medicinal herbs or shooting the rapids in a canoe. It is also time to move beyond the idea that a healthy forest ecosystem is one in which there are no people. Healthy forest ecosystems are places where people live, work, and play, as well as visit.

The Canadian Council of Forest Ministers (1997, 1998a) have worked toward an ecosystem vision by outlining a set of criteria and indicators that provide forest management agencies with the tangible means to integrate economic, social, cultural, and ecological values in forest management. However, the chasm between the vision of a healthy forest ecosystem as a vibrant place of activity and its vision as a "silent cathedral" may not be traversed by such an approach. It will also require the ability of resource managers to imagine a healthy forest ecosystem as one that reconciles industrial landscapes with conservation landscapes.

It is not difficult to imagine that economic activity and conservation can overlap within the same landscape. This is a vision that many harvesters find acceptable as the manner in which the relationship between humans and the environment should be structured. Traditional ecological knowledge and traditional knowledge management systems start from the premise that there is no separation between the landscapes in which people live and play and those in which they work. As resource management paradigms shift toward integrated ecosystem management, it appears that there is a convergence between this new kind of resource management and traditional ecological knowledge, opening a new opportunity for dialogue and mutual learning.

This paper begins by exploring the shift occurring in the science that provides the theoretical basis for resource management practice. The concepts of traditional ecological knowledge and traditional management systems are presented next, to provide the background for an examination of resilient landscapes that emerge through the work and play of humans. These examples of traditional ecological knowledge and traditional management systems suggest that it is important to focus on managing ecological *processes*, instead of *products*, and to utilize integrated ecosystem management. Traditional knowledge is often discussed by resource management agencies as a source of information to be incorporated into management practice; in this paper we go further and explore traditional knowledge as an arena of dialogue between resource managers and harvesters. Such a dialogue will require mutual respect among managers and users for each others' knowledge and practice; it could move forest management paradigms beyond our current view of "timber or parks" and toward one of truly integrated use.

CHANGING RESOURCE MANAGEMENT PARADIGMS

Institutions and practices of science and traditional ecological knowledge are often presented as independent and bounded realms of knowledge that are free from any mutual influence. The evolving thinking on science and traditional ecological knowledge is that boundaries between knowledge systems are less rigid than previously thought, and the interchange between science and traditional knowledge more frequent (Agrawal 1995, Usher 2000). Both of us have made such observations in our work both in the Canadian North and internationally. We have noted, for example, the sophistication of Latin American Aboriginal people in the way they manage forest succession, and the use of diverse landscapes in forested mountain environments in the Western Himalaya (Berkes *et al.* 1998b). We learned from the knowledge of Cree fisherfolk to develop a healthy respect and interest in the linkages between the knowledge of harvesters and resource managers. Collaborative projects with the eastern James Bay Cree fishers through the 1970s and the 1980s provided new insights that influenced the way we do ecology.

Twenty-five years after he first started working with the Cree, Berkes reflected, "Somewhat to my surprise, I found myself comfortable with the Cree view of nature, even though, by virtue

of my Western education and scientific training, I was heavily influenced to resist it" (Berkes 1999: xiv). For the Cree, land was a portfolio of resources that sustained life, and landscape itself was full of life, spirit, and mystery. Such a "sacred ecology" was very different from the conventional positivist concept of cut-and-dried, predictable ecosystems consisting merely of lifeless, mechanical processes that could be "managed" by technicians.

The Cree helped Berkes realize that, "although ecology is a science, its greater and overriding wisdom is universal. That wisdom can be approached mathematically, experimentally, or it can be danced or told as myth. It is in Australian aborigines' 'dreamtime' and in Gary Snyder's poetry... The science of ecology did not discuss such views, but Siu, Leopold, McHarg, and later Bateson mentally prepared me to be receptive to a traditional ecology that did" (Berkes 1999: xv). At the same time, many other ecologists and scientists were widening their radius of intellectual search and coming to similar conclusions. Partly as a reflection of this, by the 1990s, there were major changes in the way ecosystems were viewed by ecologists.

The old ecology could be characterized as emerging from the mathematics of Newton, the philosophy of Descartes, and the scientific method of Bacon. The paradigm that emerged from such foundations was mechanistic and reductionistic. This framework led to the idea that an ecosystem was an entity that operated like a machine. Like any other machine, it could be disassembled and the parts identified; the whole machine could then be understood by revealing the mechanisms by which the parts interacted (Holling *et al.* 1998).

The use of these theoretical foundations and frameworks resulted in an ecosystem concept characterized by equilibrium, predictability, linear processes, and controllability. Resource management used this ecosystem view, together with similar models from economics, to suggest that resources could be broken down into discrete categories such as timber, water, and soil. Each discrete category, such as timber, could then be managed independently of the others, using maximum sustained yield and maximum economic yield models, and constructing supply-demand curves for each component of the ecosystem. The unstated assumption was that if each part could be managed for sustained yield, then the machine (forest) as a whole could be sustained. But, as many resource managers know, this is not a good assumption, and there are many resource management disaster stories to prove it (Gunderson *et al.* 1995).

The emerging scientific paradigm tells a very different story about ecosystems and resource management. If the old ecology can be characterized as a science of the parts, the new ecology can be thought of as the science of the integration of the parts (Holling *et al.* 1998). This new ecology suggests that ecosystems must be understood as integrated and holistic entities that are nested across scales. Ecosystems cannot be understood by breaking them into parts but must be understood as a functional and structural whole that exists due to the relationship among the parts. Ecosystems in this view are characterized by multiple equilibria; non-linear processes; surprises (perceived reality departing qualitatively from expectation, in the sense of Holling 1986); threshold effects; and system flips.

Following the emerging paradigm, the ecosystem cannot be broken down into discreet resource categories because of the linkages among ecosystem components. Uncertainty becomes a key property of resource management due to the unpredictable, non-linear, and uncontrollable nature of the systems being managed. Finally, there is a recognition that people, policies, and politics are as much a part of an ecosystem as are timber, fish, and wildlife. This new view of ecosystems has been moving into mainstream thinking, as evidenced, for example, by the Ecological Society of America guidelines for ecosystem management (ESA 1995) and the adoption of ecosystem integrity management objectives by Parks Canada.

These developments have led to a flux in resource management, as current practices are no longer supported by the current scientific thinking. The new resource management will "require policies and actions that not only satisfy social objectives but, at the same time, also achieve continually modified understanding of the evolving conditions and provide flexibility for adaptation to surprises. Science, policy, and management then become inextricably linked" (Holling *et al.* 1998: 347). It could also be said that science, policy, management, and people will need to be more closely linked in the new resource management models.

Also very significant, the new concept of a multiequilibrium, non-linear, unpredictable ecosystem appears to be reducing the distance between science and traditional ecological knowledge. There is a convergence between science and traditional knowledge, as science begins to perceive humans as part of a world that contains a large degree of uncertainty, complexity, and unpredictability. Resource management is beginning to realize the need "to utilise the self-organizing capabilities of natural ecosystems to design harmonious social and natural environments; that is, to try to integrate human production and consumption patterns, infrastructure and settlements with ecosystem processes..." (Berkes *et al.* 1995: 296).

TRADITIONAL ECOLOGICAL KNOWLEDGE

The use of the term traditional ecological knowledge or local knowledge is one way of recognizing that resource harvesters possess knowledge that they use to make decisions about their resource harvesting practices. Many resource harvesters depict their knowledge as based upon the practical adaptation of technique, technology, and institutions within a local environment. We have been using a working definition of traditional ecological knowledge 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 their environments" (Berkes 1999: 8).

Even though there is no clear delineation between traditional ecological knowledge and science (Agrawal 1995), the recognition of traditional knowledge as a legitimate kind of knowledge is significant. It shows that the distinction between traditional ecological knowledge and science is not the absence or presence of management systems but the existence of different concepts of management. Traditional ecological knowledge may best be considered as a knowledge-practice-belief complex. Traditional knowledge may be thought to consist of four mutually interrelated spheres that are nested in one another: local knowledge of plants and animals; land and resource management systems; social institutions; and world view. Local knowledge of land, animals, plants, and landscapes can include knowledge of taxonomies, spatial and temporal cycles, and behaviors. Land and resource management systems use such knowledge to develop appropriate practices, tools, and techniques for a local environment. Traditional resource management systems also require appropriate institutions that allow interdependent harvesters to coordinate activities, cooperate in tasks, devise rules for social restraint, and enforce those rules. Finally, the world view (ethics, religion, values) allows resource harvesters to weave their perceptions of the environment into a coherent system of knowledge and practice.

Is traditional ecological knowledge relevant to current resource management? The term "traditional" is considered by some to denote knowledge and practice that is old and unchanging. However, there is not necessarily a contradiction between the terms tradition and change; change is simply what is noted if tradition is sampled along a temporal spectrum. Tradition often changes by adaptive processes and incorporates trial-and-error learning. Tradition further implies that there is historical continuity in culture and in the system of knowledge. The term "tradition" has often been used by resource harvesters to emphasize that their knowledge has been generated out of accumulated practical experience. Often the term of choice of Aboriginal and other people close to the land, it refers to knowledge and practice generated out of the life experiences of generations of harvesters themselves.

TRADITIONAL ECOLOGICAL KNOWLEDGE IN PRACTICE—DISTURBANCE AND SUCCESSION

Traditional ecological knowledge has not only generated the proverbial "grist for the academic mill" but has also resulted in distinctive landscapes found across the world. We can, for example, learn about forest reclamation in grassland ecosystems from the Kayapo people of Brazil. As shown in figure 1, the Kayapo use crumbled termite and ant nests and mulch to initiate a process of forest succession that results in expanding forest islands in the grasslands (Posey 1985). The process begins by planting useful crops into the prepared mounds (*apete*) for up to 3 years. Sweet potatoes and yams may be harvested for up to 5 years, and papaya and bananas may last as

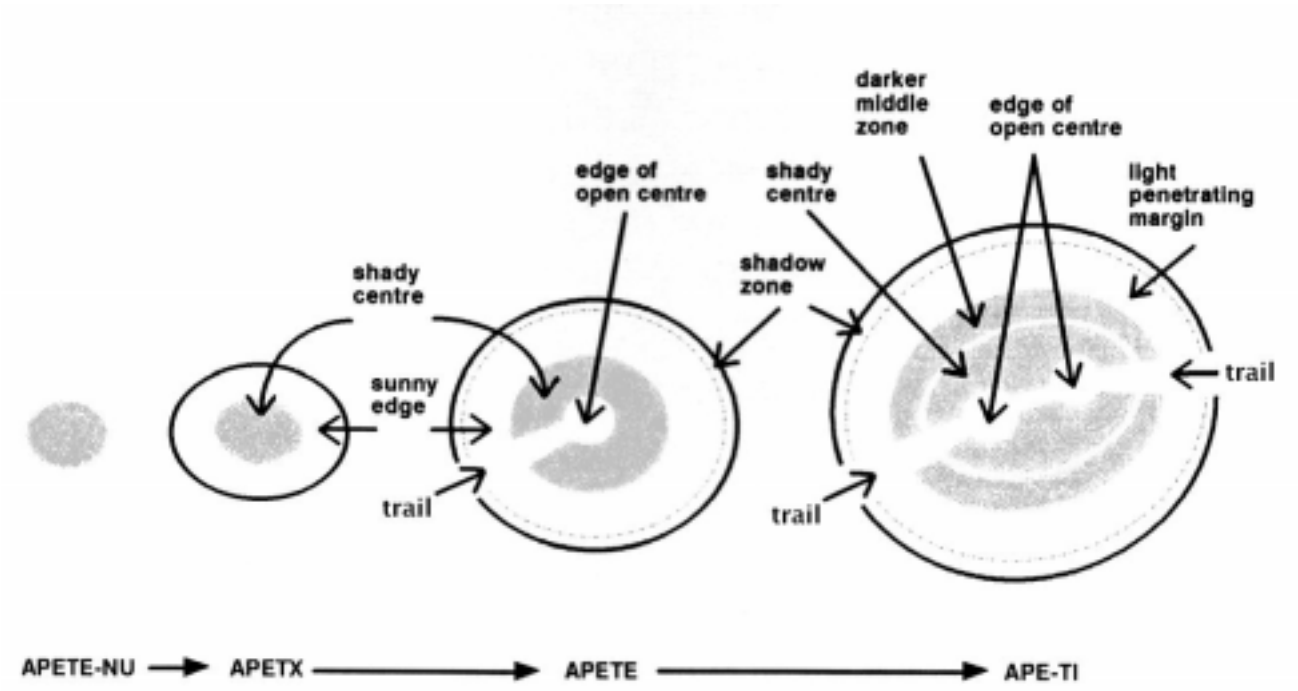

Figure 1.—*Enhancing biodiversity through the creation of forest islands,* apete, *by the Kayapo Indians of Brazil. Through a number of devices the behavior promotes patchiness and heterogeneity in the landscape in time and space.* Source*: adapted from Posey (1985).*

long as 7 to 10 years. Different fruit and nut trees are seeded or transplanted to the *apete* so that the resultant forest acts as a source of products for many years. The forest also continues to attract animals and birds who bring new seeds into the forest or disperse them to other areas of the grassland. The result of this management practice is a grassland landscape with interspersed forests. The knowledge of the relationship between disturbance and forest succession is one of the common traits of many forest management systems based upon traditional ecological knowledge.

Systems of forest management that use the ecological processes of disturbance and forest succession in an intentional manner often rely upon long fallow periods between intentional disturbances to allow for the conservation of ecological processes such as nutrient cycles and species recruitment. Useful plants are planted, transplanted, and harvested following the initial disturbance and for many years during the period of forest fallow. These useful plants can include food, medicines, and timber. If greater levels of production are required, then the forest management systems are often modified so that the fallow period may be shortened or bypassed altogether. Succession management systems grade into what might be termed agroforestry systems of management. An example is shown in figure 2, which depicts the *kebun-talun* management system of West Java, Indonesia. The *kebun-talun* system sequentially combines agricultural crops with tree crops by moving from a mixed garden of annual crops (*kebun*) to a mixture of annual crops and perennials (*kebun-campuran*) to a mixed forest of trees and understory plants (*telun*) (Christianty *et al.* 1986). This type of management practice leads to the classic patch mosaic or quilt landscape. However, the quilt has to be thought of not only as dispersed patches of *kebun, kebun-campuran,* and *talun* over space but also as each patch shifting over time. As the fallow period continues to decrease, the *kebun-campuran* system can move toward a different ecological arrangement called a homegarden.

The homegarden, such as the *pekarangan* in West Java, is an intensification of the *kebun-talun* in which the fallow period disappears altogether (Christianty *et al.* 1986). One way to think of this is to imagine one patch of the quilt where the *kebun-campuran-talun* cycle occurred. Instead of managing a variety of patches, each at a different temporal stage of

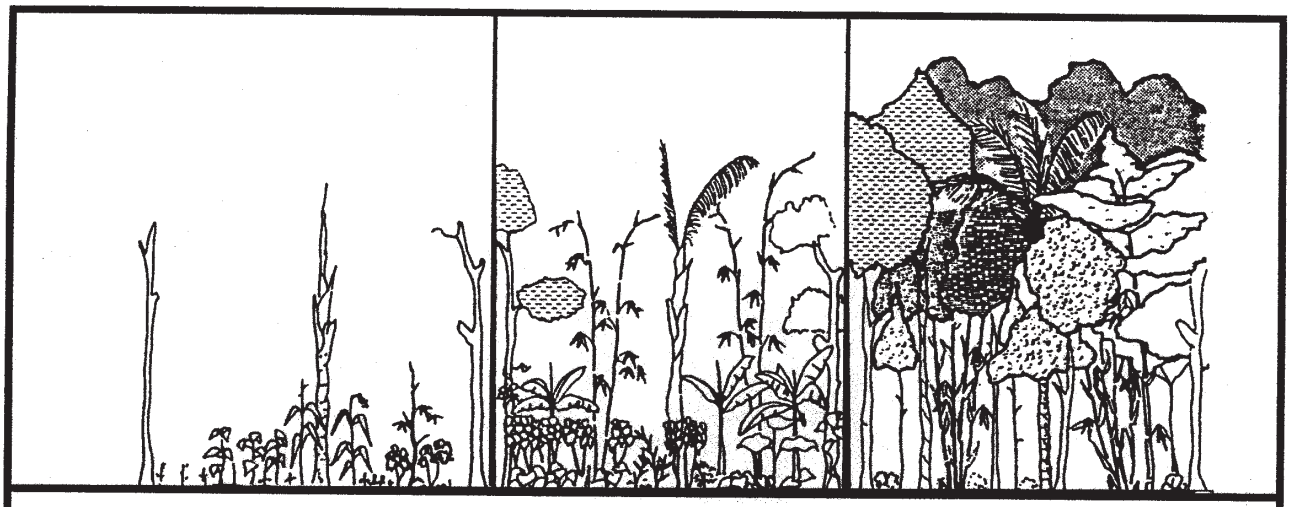

Figure 2.—*Successional stages of the* kebun-talun *system, West Java, Indonesia.* Source*: adapted from Christianty* et al. *(1986).*

the *kebun-talun* cycle, a person may build a house on the patch and begin to manage it as a *pekarangan*. The *pekarangan* combines the annual crop plants with perennial plants for market and home consumption. Species from each stage of the *kebun-talun* cycle may be brought into the *pekarangan* depending upon the market and home needs of the manager. As shown in figure 3, the diversity in the *pekarangan* is greater than in any one stage of the *kebun-talun* cycle. The loss of the temporal dimension of management is compensated for by the more intense management of vertical space within one patch.

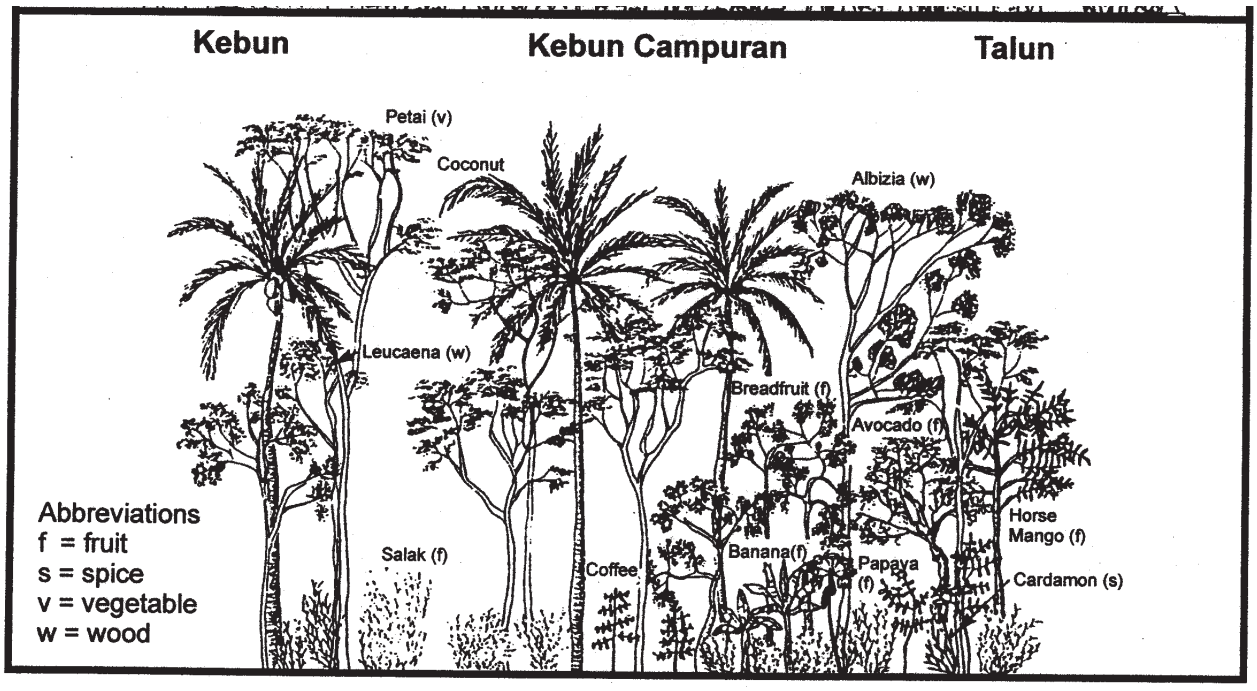

Figure 3.—*A representative homegarden (*pekarangan*), West Java, Indonesia.* Source*: adapted from Christianty* et al. *(1986).*

A similar agroforestry system is the *taungya* of Burma, shown in figure 4. In this system a patch of land is planted with both annual crops and perennial tree crops (Jordan 1986). In the early years, before the canopy of the trees closes, annual crops hold nutrients and prevent erosion. After the canopy closes, it is possible to plant understory crops, such as coffee or cacao, that take advantage of the space and diffuse light that filters through the canopy. The intensification of forest management thus uses disturbance to create intensively managed patches of forest but abandons the fallow period. In this management system, as in all others previously mentioned, a supplementary management objective is the creation of edge habitat to increase the abundance of forest animals and thus the chance of successfully hunting such animals. The outcome of the *taungya* management practices is a landscape that is less variable over time, but highly variable within a given patch of land, as the system takes advantage of vertical space instead of horizontal space (canopy, understory shrubs and herbs).

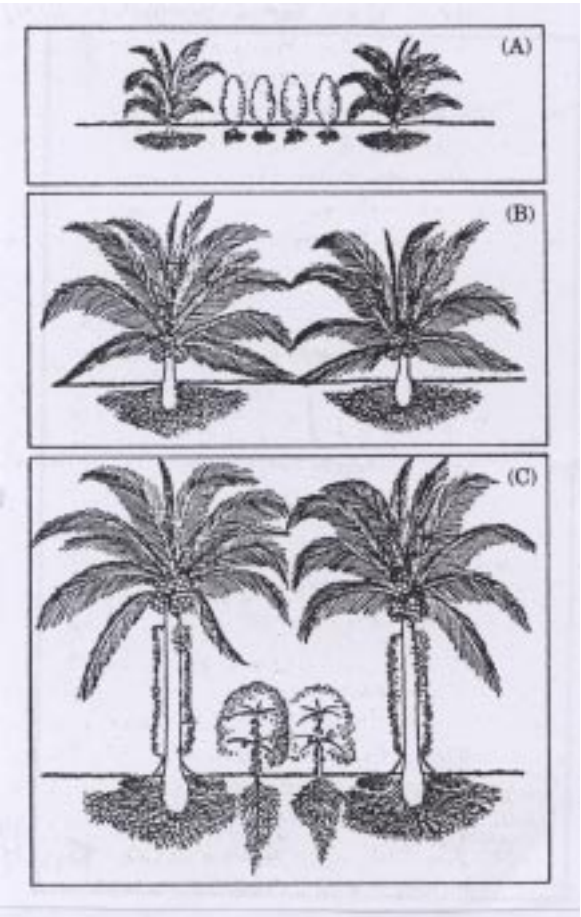

Figure 4.—*Idealized* taungya *system of cultivation using coconut palms as the dominant tree species. (A) Early stage—Coconut intercropped with annuals and short-term perennials. (B) Middle stage—Canopy cover does not allow understory layer. (C) Late stage—High canopy allows light penetration and production of understory crops such as coffee or cacao.* Source*: adapted from Jordan (1986).*

The previous four examples have demonstrated that forest management based on traditional knowledge can vary from low to high intensity. All of these systems are based upon the use of disturbance and succession as a management tool to produce for the market, home consumption, and aesthetic pleasures. These systems appear to reflect practices that can also be useful for temperate forest ecosystem management and for ecological rehabilitation. Robinson and Handel (2000) point out, "Ecological restoration can be likened to accelerated succession, in part because it aims to pass over the early phases of community development, when recovery can be delayed by the effects of past degradation... Following severe habitat damage, the reclamation phase closely resembles primary succession, in which most organisms colonize from external source populations. Indeed, a common goal of ecological restoration is to initiate natural populations as dispersing immigrants" (Robinson and Handel 2000: 174). The experimental work of Robinson and Handel (2000) demonstrates that habitat islands can act as sources of seeds that can be spread to surrounding land by dispersal agents. This is similar to the practice of forest management in Canada whereby islands of vegetation are left scattered throughout clearcuts to act as a seed source and habitat for dispersal agents. The recognition of the linkages between disturbance, dispersal agents, and succession appears to be an area in which the distance between traditional ecological knowledge and science is indeed shrinking and ripe for a process of mutual learning.

TRADITIONAL ECOLOGICAL KNOWLEDGE IN PRACTICE—ECOSYSTEM MANAGEMENT

One of the emerging approaches in forest management practice is ecosystem-based management (CCFM 1997, 1998a). Ecosystem-based management uses systems ecology theory, along with adaptive learning and practice. However, it is a management approach in which theory and practice are at the early stages of development and can thus benefit from insights provided by traditional ecological knowledge. Only recently has it come to the attention of ecologists that ecosystem-like concepts exist in the land wisdom of several Amerindian, Asia-Pacific, European, and African cultures (Berkes *et al.* 1998a).

One of the lessons from traditional knowledge regarding ecosystem-based forest management is that we need to move from a view that sees humans as external managers of forest ecosystems to one that considers humans to be integral components of forest ecosystems. This shift in perspective allows us to recognize the dependence of all human societies on the life-support functions of the ecosystem and the ways by which this may continue into the future (Berkes *et al.* 1998a). An ecosystem-based approach to forest management also needs to focus on spatially bounded units of land or water, consider everything within this unit to be interlinked, and recognize that units are nested and linked from smaller to larger scales.

Table 1 presents some of the applications of an ecosystem view as seen in traditional knowledge and management systems. Science-based resource management may never embrace all of the elements of such systems, such as their spiritual aspects. However, it is still possible that we can learn about ecosystem-based management from these long-standing examples of integrated resource management.

The *tambak* management system shown in figure 5 was used in Indonesia to establish mixed freshwater and seawater fish ponds in delta ecosystems and associated lagoons (Costa-Pierce 1988). The paddy rice fields were used to produce both rice and fish during the flooded period of rice production. The nutrient rich wastes of the paddy rice—fish production system were allowed to flow downstream into polyculture ponds (*tambak*) where shrimps, crabs, fish, vegetables, and tree crops could be produced. The wastes of this system then flowed into the flooded mangrove forests that enriched the coastal fisheries. The lesson of

Table 1.—*Examples of traditional applications of the ecosystem view*. Source*: Berkes (1999)*

System	Country/region	Reference
Watershed management of salmon rivers and associated hunting and gathering areas by tribal groups	Amerindians of the Pacific Northwest	Williams and Hunn (1982); Swezey and Heizer (1993)
Delta and lagoon management for fish culture (*tambak* in Java), and the integrated cultivation of rice and fish	South and Southeast Asia	Johannes *et al.* (1983)
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)
Family groups claiming individual watersheds (*iworu*) as their domain for hunting, fishing, gathering	The Ainu of northern Japan	Watanabe (1973); Ludwig (1994)
Integrated floodplain management (*dina*) in which resource areas are shared by social groups through reciprocal access arrangements	Mali, Africa	Moorehead (1989)

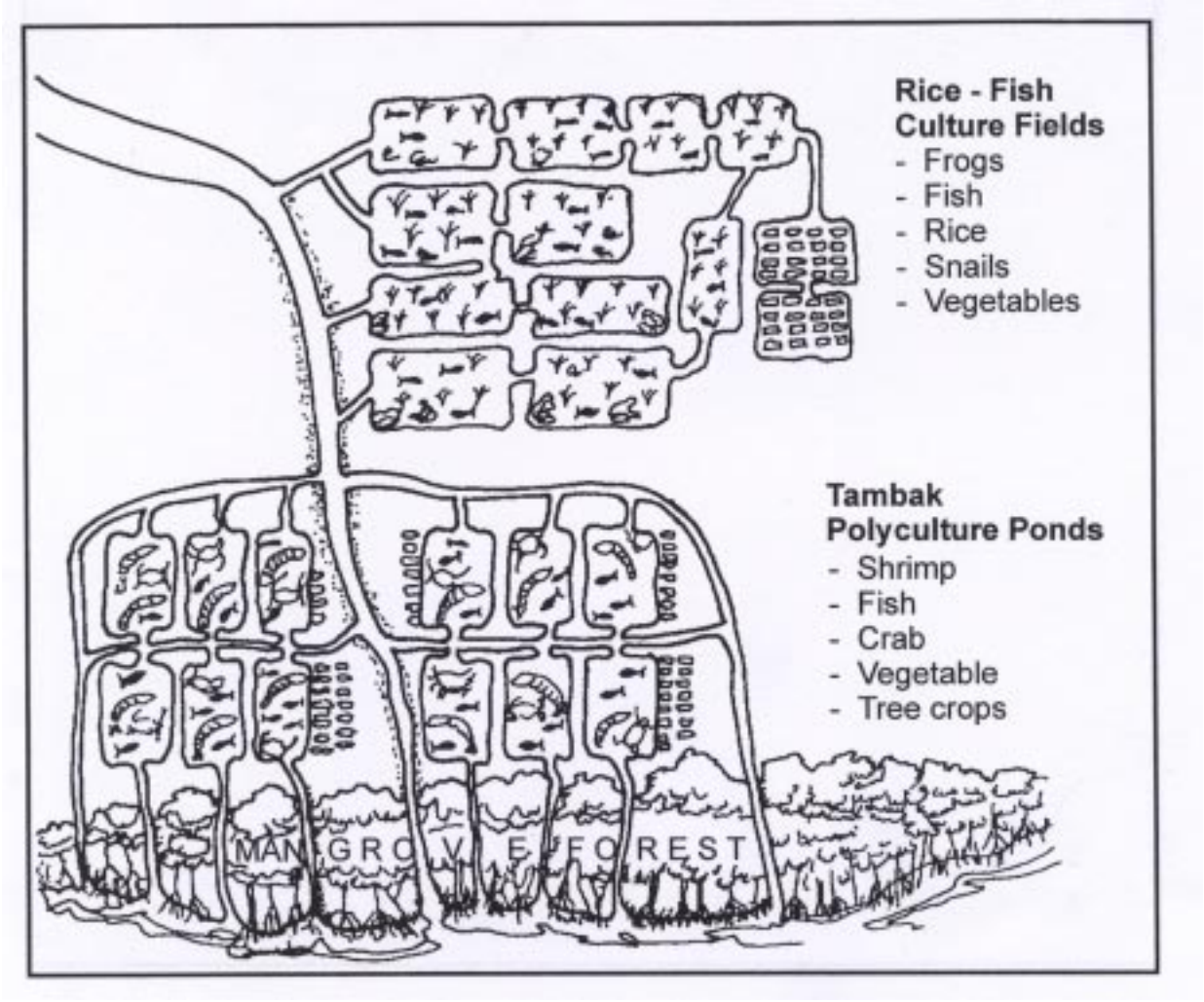

Figure 5.—*Traditional Indonesian coastal zone management.* Source*: adapted from Costa-Pierce (1988).*

this example is that by paying attention to ecosystem processes we can also generate ecosystem products. The linking of the paddy-pond-coastal lagoon to take advantage of nutrient wastes allowed the productivity of the entire system to increase by utilizing the outputs of one system as an input to the other.

Other examples of integrated watershed management can be found in the *vanua* system of Fiji and the *ahupua'a* of ancient Hawaii (table 1). The *ahupua'a* system of Hawaii, shown in figure 6, included entire valleys and stretched from the top of a mountain down to the coast and shallow waters. Each watershed was managed by a chieftanship, a social group under the authority of the king. The idealized version of this system shown in figure 6 included the following elements: forest zone (protected by taboo) at the top of the mountain for water catchment and erosion prevention; integrated farming zones in the uplands and coastal zone; coconut palms along the coastline to provide protection from storms and wind; and brackish water and seawater fish ponds.

The Hawaiian system no longer exists, but similar systems of watershed management can be found in other Asia-Pacific cultures, including Fiji and the Solomon Islands. The idea of managing a watershed as a unit historically appears in a number of different geographical areas, from the ancient Swiss and Turks to the peoples of the Far East (Berkes *et al.* 1998a). In our studies, we have found elements of watershed management in village resource areas in the Himalayas of northwest India in a temperate forest region. As shown in figure 7, each

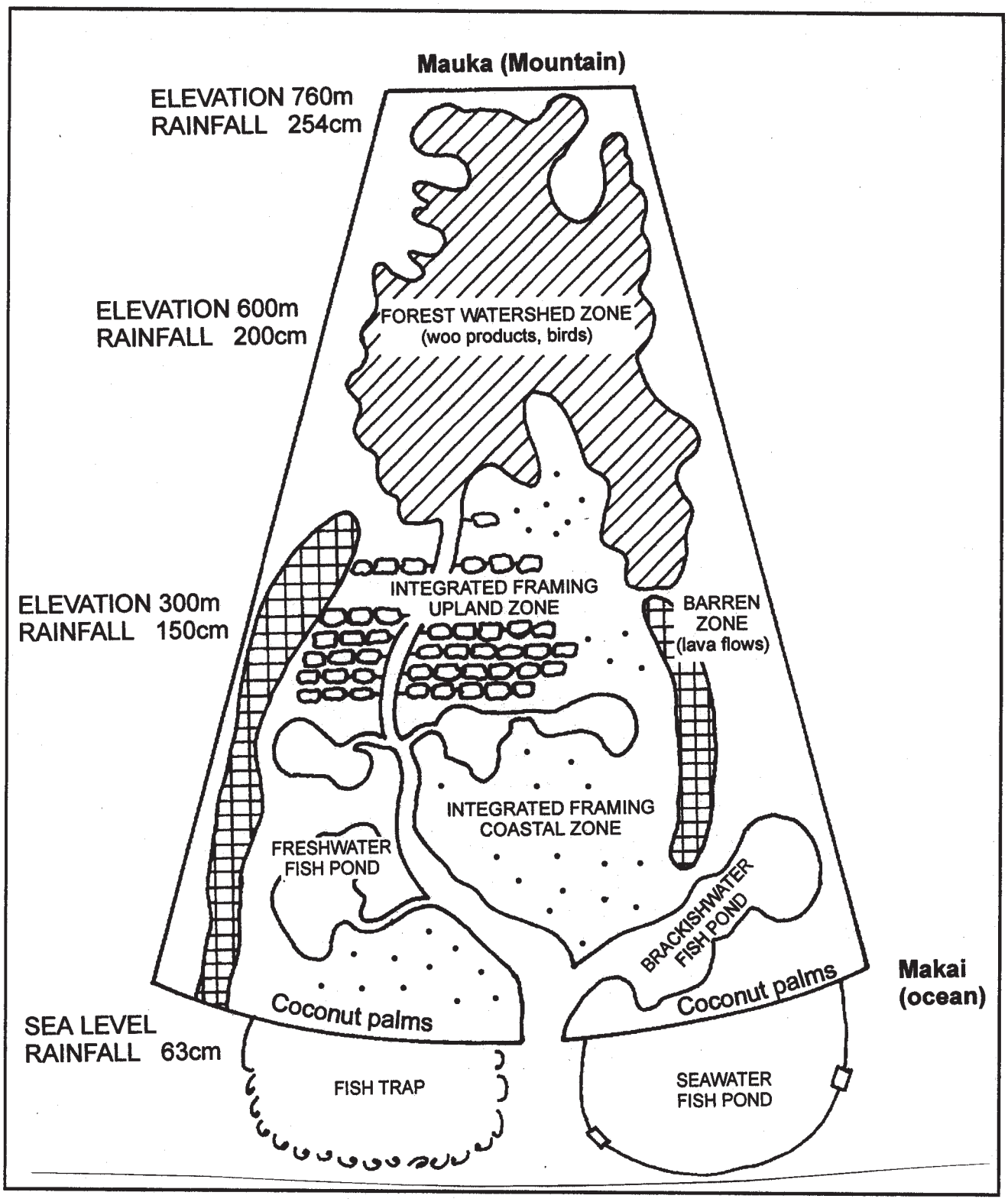

Figure 6.—*The* ahupua'a *system of ancient Hawaii.* Source*: adapted from Costa-Pierce (1987).*

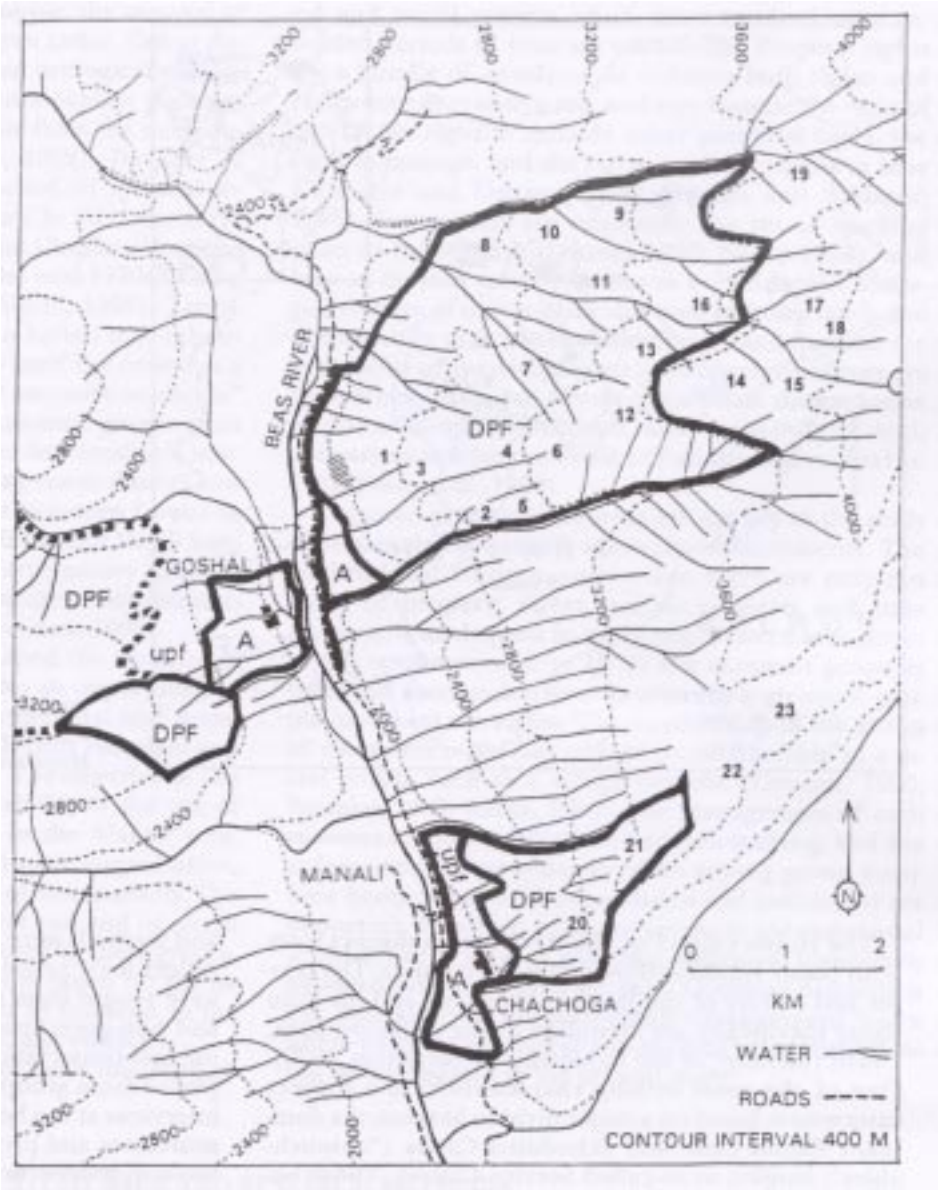

Figure 7.—*Management zones of two villages in the Himalayas of northwest India. Forest zone includes demarcated protected forest (DPF) and undemarcated protected forest (udf). Agricultural zones (A) are also shown.* Source: *Berkes* et al. *(1998b).*

village of the Beas watershed was granted a section of forest under the land settlement during the period of British rule. These units integrated alpine pastures, highland forests, forest meadows, upland agricultural land, and irrigated agricultural land on the valley floor. Both the forest and the agricultural area showed high biodiversity, in part because of the diversity of different social groups with different specializations (such as herding vs. agriculture), and in part because the dominant village agriculturalists used a variety of resources (e.g., different kinds of wood for different purposes) for their livelihoods (Berkes *et al.* 1998b).

One of the lessons from these examples of integrated watershed management is that it is possible to maintain both a productive and a diverse landscape through the integration of different types of land use. For modern resource managers, this will require devising management strategies that focus on ecosystem functions and process at the landscape scale, while paying attention to increasing the diversity of products that can flow from a

management unit. Such approaches have in fact been proposed for the sustainable management of tropical forest ecosystems (Lugo 1995).

It would be naive to suggest that the traditional management systems such as those mentioned above could be imported directly into the variety of ecological and social contexts that make up the boreal and cold temperate forest regions. What may be possible depends on the imagination and practice of the managers, workers, harvesters, and inhabitants of these regions. For example, by recognizing the value of both timber and non-timber forest products, we can increase the intensity and diversity of forest management, an idea consistent with some of the traditional systems discussed above, even though some of these examples may at first seem rather exotic. At this relatively early stage of ecosystem-based forest management in the boreal and cold temperate forest regions, it is through such explorations that we can begin to imagine what ecosystem-based forest management may look like "on the ground."

We can also learn from the principles developed by people who have investigated these systems. Janis Alcorn, for example, has derived seven principles from traditional knowledge and management systems. These principles can provide guidance as we address the challenge to focus on ecosystem processes while meeting the productive needs of society. She recommends that ecosystem-based management strategies (1) take advantage of native trees and native tree communities; (2) rely on native successional processes; (3) use natural environmental variation; (4) incorporate numerous crops and native species; (5) be flexible; (6) spread risks by retaining diversity; and (7) maintain reliable backup resources to meet needs should the regular livelihood sources fail (Alcorn 1990).

NON-TIMBER FOREST PRODUCTS AND CHANGING RESOURCE MANAGEMENT PARADIGMS

Traditional ecosystem knowledge and traditional management systems have often been placed in opposition to science-based management systems. However, with the advent of the changing views on ecosystems, there appears to be an increasing convergence between traditional ecological knowledge and some of the holistic science that pays attention to non-linear dynamics, complexity, uncertainty, and the location of human activities firmly within the ecological and social environment. We know something that we did not know 20 years ago: some traditional ecological knowledge is very good science, and some traditional management systems are very good management systems. For example, the practices of the Kayapo are currently reflected in the pages of the *Journal of Ecological Applications* (Robinson and Handel 2000), while the designs of ecosystem-based management appear strikingly similar to the landscapes created by Hawaiian and Himalayan systems of forested watershed management.

Many traditional knowledge practices are also consistent with scientific trends toward ecosystem-based management that focus on ecosystem processes, health, and resilience instead of maximum sustained yields of single species (Holling *et al.* 1998). It may not be possible to "manage" nature, but as Nancy Turner says, "you can keep it living" (Turner, this volume). "Keeping it living" in the boreal and cold temperate forests depends upon paying attention to ecological processes, such as disturbance and succession, and integrated resources management.

The study of non-timber forest products has run a parallel course to the study of traditional ecological knowledge and ecosystem-based forest management. Non-timber forest product studies of the past tended to focus more on production than on managing ecosystem integrity and process. However, the study of non-timber forest products provides an emerging arena of investigation in which ecology, traditional ecological knowledge, ecosystem-based forest management, and production can be brought together. Many non-timber forest products are linked to the ecological processes of disturbance and succession. Although timber is also linked to these processes, a focus on non-timber forest products provides the means by which we may be able to reverse the order of priority for forest management.

Ecosystem-based forest management means protecting the integrity, health, and resilience of ecosystems. It does not focus primarily on resources but rather on the sustainability of ecosystem processes necessary to provide these resources. Only then can we evaluate the products that emerge from these processes over

time and space. Timber, shrubs, herbs, mushrooms, animals, birds, and bacteria all have their own distributions in time and space relative to disturbance. For example, fireweed (*Epilobium angustifolium* L.) occurs in the early years following a disturbance, ginseng (*Panax quinquefolius* L.) is found under mature forest canopies, while highbush cranberry (*Viburnum trilobum* L.) often occurs along riverbanks disturbed periodically by spring flooding. Fireweed and ginseng have both been used as medicines while highbush cranberry is an edible berry. Ecosystem-based management requires that we consider ecological processes first and then link production to those processes—not the other way around.

A shift in priority from product to process opens up a whole new set of research questions. For instance, if we are interested in shortening the period between timber harvests, we need to consider both the ecological and social implications of such a management decision. In Indonesia the *pekarangan* reflects a similar decision to intensify forest management. One of the implications is that with intensification comes the need to recognize private property rights. However, we need to be aware that this is not the only possible alternative. If intensification is an option but not a requirement, then it may be possible to examine the ecological processes and the value of the products that flow from the ecological processes of a forest ecosystem.

What would such a multiple-species management system look like across the landscape and over time? What are the production/technological constraints for such a system of production? What is the distribution of products in space and time? What is the value of these products? What institutional changes would be required? A focus on non-timber forest products opens up a whole new set of questions that science and ecosystem-based forest management are only beginning to consider. These questions, however, have been considered within traditional ecological knowledge and traditional management systems.

The study of non-timber forest products opens up an area of research that can contribute to ecosystem-based forest management through a focus on ecosystems and traditional ecological knowledge. There is a potential for dialogue and mutual learning between scientists, resource managers, and traditional resource harvesters/managers through the establishment of cooperative research projects to answer research questions of mutual interest. However, this will require scientists and resource managers who are not just interested in mining information from traditional harvesters/managers but who are also willing to re-think the whole paradigm of resource management along with traditional harvesters/managers: scientists and resource managers who are able to envision the linkages between livelihoods and ecosystems, and able to imagine healthy forest ecosystems as vibrant places where people live, work, play, and visit. The linkages between ecosystem studies, traditional ecological knowledge, ecosystem-based forest management, livelihoods, and non-timber forest products provide a new direction for research and application that will lead us toward the vision of the Canadian Council of Forest Ministers to manage Canada's forests as ecosystems.

LITERATURE CITED

Agrawal, Arun. 1995. Dismantling the divide between indigenous and scientific knowledge. Development and Change. 26(3): 413-439.

Alcorn, Janis. 1990. Indigenous agroforestry strategies meeting farmers' needs. In: Anderson, A.B., ed. Alternatives to deforestation. New York, NY: Columbia University Press.

Baines, G.B.K. 1989. Traditional resource management in the Melanesian South Pacific: a development dilemma. In: Berkes, F., ed. Common property resources: ecology and community-based sustainable development. London: Belhaven: 273-295.

Berkes, Fikret. 1999. Sacred ecology: traditional ecological knowledge and resource management. Philadelphia, PA: Taylor and Francis.

Berkes, Fikret; Folke, Carl, eds. 1998. Linking social and ecological systems: management practices and social mechanisms for building resilience. Cambridge: Cambridge University Press. 459 p.

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

Berkes, Fikret; Davidson-Hunt, Iain; Davidson-Hunt, Kerril. 1998b. Diversity of common property resource use and diversity of social interests in the Western Indian Himalaya. Mountain Research and Development. 18(1): 19-33.

Berkes, Fikret; Folke, Carl; Gadgil, Madhav. 1995. Traditional ecological knowledge, biodiversity, resilience and sustainability. In: Perrings, C.A.; Mäler, K.-G.; Folke, C.; Holling, C.S.; Jansson, B.-O. Biodiversity conservation: problems and policies. Dordrecht: Kluwer Academic Publishers: 281-300.

Canadian Council of Forest Ministers. 1997. Criteria and indicators of sustainable forest management in Canada. Tech. Rep. 1997. Ottawa: Natural Resources Canada-Canadian Forest Service.

Canadian Council of Forest Ministers. 1998a. National forest strategy (1998-2003) — sustainable forests: a Canadian commitment. Ottawa: Natural Resources Canada-Canadian Forest Service.

Canadian Council of Forest Ministers. 1998b. Canada forest accord. Ottawa: Natural Resources Canada-Canadian Forest Service.

Christianty, L.; Abdoellah, O.S.; Marten, G.G.; Iskandar, J. 1986. Traditional agroforestry in West Java: the pekarangan (homegarden) and kebun-talun (annual-perennial rotation) cropping systems. In: Marten, G.G., ed. Traditional Agriculture in Southeast Asia. Boulder, CO: Westview: 132-158.

Costa-Pierce, B.A. 1987. Aquaculture in ancient Hawaii. BioScience. 37: 320-330.

Costa-Pierce, B.A. 1988. Traditional fisheries and dualism in Indonesia. Naga. 11(2): 34.

ESA. 1995. The report of the ecological society of America committee on the scientific basis for ecosystem management. Ecological Society of America homepage.

Gunderson L.H.; Holling, C.S.; Light, S.S., eds. 1995. Barriers and bridges to the renewal of ecosystems and institutions. New York, NY: Columbia University Press.

Holling, C.S. 1986. Resilience of ecosystem: local surprise and global change. In: Clark, W.C.; Munn, R.E., eds. Sustainable development of the biosphere. Cambridge: Cambridge University Press: 292-317.

Holling, Crawford S.; Berkes, Fikret; Folke, Carl. 1998. Science, sustainability and resource management. In: Berkes, Fikret; Folke, Carl, eds. Linking social and ecological systems: management practices and social mechanisms for building resilience. Cambridge: Cambridge University Press: 342-362.

Johannes, R.E.; Lasserre, P.; Nixon, S.W.; Pliya, J.; Ruddle, K. 1983. Traditional knowledge and management of marine coastal systems. Biology International, Special Issue 4.

Jordan, C.F. 1986. Local effects of tropical deforestation. In: Soulé, M., ed. Conservation biology. Sunderland, MA: Sinauer: 410-426.

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

Lugo, A. 1995. Management of tropical biodiversity. Ecological Applications. 5: 956-961.

Moorehead, R. 1989. Changes taking place in common-property resource management in the Inland Niger Delta of Mali. In: Berkes, F., ed. Common property resources: ecology and community-based sustainable development. London: Belhaven: 256-272.

Posey, D.A. 1985. Indigenous management of tropical forest ecosystems: the case of the Kayapo Indians of the Brazilian Amazon. Agroforestry Systems. 3: 139-158.

Robinson, George R.; Handel, Steven N. 2000. Directing spatial patterns of recruitment during an experimental urban woodland reclamation. Ecological Applications. 10(1): 174-188.

Ruddle, K.; Akimichi, T., eds. 1984. Maritime institutions in Western Pacific. Senri Ethnological Studies 17. Osaka, Japan: National Museum of Ethnology.

Stevenson, Marc G. 1998. Traditional knowledge in environmental management? From commodity to process. Working Pap. 1998-14. Edmonton: Sustainable Forest Management Network. 15 p.

Swezey, S.L.; Heizer, R.F. 1993. Ritual management of salmonid fish resources in California. In: Blackburn, T.C.; Anderson, K., eds. Before the wilderness: environmental management by native Californians. Menlo Park, CA: Ballena Press: 299-327.

Turner, Nancy. 2001. "Keeping it living": traditional land and resource management of British Columbia First Peoples and implications for management of non-timber forest products. In: Davidson-Hunt, I.; Duchesne, L.; Zasada, J., eds. Forest communities in the third millennium: linking research, business, and policy toward a sustainable non-timber forest product sector;1999 October 1-4; Kenora, Ontario. Gen Tech. Rep. NC-217. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station.

Usher, Peter J. 2000. Traditional ecological knowledge in environmental assessment and management. Arctic. 53: 183-193..

Watanabe, H. 1973. The Ainu ecosystem, environment and group structure. Seattle, WA: University of Washington Press.

Williams, N.M.; Hunn, E.S., eds. 1982. Resource managers: North American and Australian hunter-gatherers. Washington, DC: American Association for the Advancement of Science.