Invited Feature

Traditional Ecological Knowledge, Ecosystem Science, and Environmental Management[1]

As the pace of ecological change increases, so too does the need for baseline information with which to direct conservation and restoration activities. Often, however, data are scarce. The premise of this Invited Feature is that there are complementary sources of knowledge about local ecosystems held by people whose lives are interwoven in complex ways with particular lands and waters. Local knowledge is richest when it has accumulated over generations, embedding observations and corresponding cultural adaptations within a context of long-term ecological change.

This Invited Feature focuses on Traditional Ecological Knowledge (TEK), a term used to describe the knowledge held by indigenous cultures about their immediate environments and the cultural (management) practices that build on that knowledge. Most Western ecologists are unfamiliar with the many ways in which renewed interest in TEK is adding to the common store of knowledge about extant ecosystems and are unaware of the increasing number of international mandates for the inclusion of TEK in ecological restoration and conservation. This Invited Feature is intended as an introduction to these important subjects.

The language of Traditional Ecological Knowledge is not the language of scientific discourse. Mutual understanding requires mutual respect, an investment of time, and a willingness on the part of Western scientists to accept that TEK is grounded in moral, ethical, and spiritual world views. It is a common misperception that, because of this grounding, TEK is somehow mystical or out of touch with reality. This set of papers makes a different case: that, on the contrary, TEK is eminently practical. Far from being a static body of knowledge, TEK must be highly adaptive if it is to serve the needs of human populations over long periods of time. Some TEK practitioners have observed that knowledge or information by itself is subject to serious misapplication if not informed by wisdom. Because of this, TEK is often referred to as Traditional Ecological Knowledge and Wisdom (TEKW). It is largely this latter component that reflects the moral, ethical, and spiritual dimensions of TEKW with which practitioners of rationalist scientific traditions are most uncomfortable.

This Invited Feature will be a venture into new territory for most ecologists. Some of the papers may be difficult because they cross scientific disciplines and/or cultural epistemologies. However, it is precisely these interfaces that provide the creative tension from which new insights and advances may spring. Much of the literature related to TEKW has been the province of cultural anthropology, which has a different style of discourse and different rules of evidence than papers typically found in this journal. For this project, we accept those differences. Further, because TEKW flows from epistemologies so different from Western science, faithful representation of underlying concepts are at best approximate. Attempts to reframe these approximations to fit standard scientific discourse would miss the point. Instead, we have asked authors to illustrate their points using case studies whenever possible, to help ground unfamiliar concepts in more familiar contexts. Finally, discerning readers of this entire feature may discover divergent and sometimes contradictory TEKW views on specific issues. In this sense, TEKW is perhaps not so different from Western science.

The first three papers in this Invited Feature lay the foundation for TEKW as a credible source of environmental knowledge. The introductory paper by Berkes et al. is a comprehensive review of the literature on TEK. The second paper by Mauro and Hardison discusses the policy context

[1] Reprints of this 92-page Invited Feature are available for $13.75 each. Prepayment is required. Order reprints from the Ecological Society of America, Attention: Reprint Department, 1707 H Street, N.W., Suite 400, Washington, DC 20006.

and emerging mandates for the incorporation of TEKW into scientific research and environmental management. Next, Huntington discusses some of the sources of resistance on the part of the scientific community to TEKW and also addresses practical issues encountered by ecologists interested in TEKW but unsure of how to proceed in collecting and applying this information.

The next five papers illustrate the potential of TEKW in ecological research, conservation, and restoration. Turner et al. describe characteristics of TEKW among selected peoples in British Columbia, with particular attention to sustainable harvest of traditional root vegetables. Nabhan builds on this theme by discussing ecological interactions recognized by O'odham and Comcáac foragers of the Sonoran Desert, emphasizing the importance of local language as a carrier of such knowledge. This discussion lends disturbing dimensions to the observation that languages are currently disappearing much faster than species. Klubnikin et al. document the contributions of Altaian TEKW in illuminating the value of the Katun River headwaters (Siberia, part of the complex Mongolian biogeographic province) when faced by plans for a massive hydroelectric dam. Gadgil et al. and members of the People's Biodiversity Initiative describe an ongoing project in India to document and encourage the use of local knowledge of biodiversity. Fernandez-Gimenez discusses ecological knowledge of Mongolian nomadic pastoralists, its role in modern rangeland management, and the difficult interface between TEKW and changing socioeconomic infrastructures.

This Invited Feature began by looking at TEKW from interdisciplinary Western science with a social-science perspective, and it comes full circle with an inside perspective by Salmón (Rarámuri). Salmón discusses Rarámuri TEKW, including the reciprocal relationship with nature encompassed by the concept of *iwígara*. This conceptual translation is a difficult task, and Salmón's graceful discussion is a much needed complement to the external observations of TEKW made by Western scientists. The concluding commentary by Pierotti (Comanche) and Wildcat (Euchee) summarizes their perception of the principal elements common to much of TEKW, and how they differ from the spectrum of ideas about nature that flow from Eurocentric tradition.

We hope that this set of papers encourages discussion of TEKW. Many important topics are conspicuous by their absence in this collection, including intellectual property rights, collaborative TEKW/Western comanagement practices, and why indigenous sovereignty issues are important components of both conservation and restoration ecology. North America is overrepresented, and none of the case studies relates to primarily maritime cultures/environments. Nor are there papers that report on current progress in First Nations fisheries and wildlife management, existing TEKW/Western science collaborations in ecological restoration, and so forth. Perhaps some of these gaps can be addressed in future issues.

We believe that as a community of ecologists living in times of unprecedented ecological change, we can no longer afford the questionable luxury of working solely within our own traditions if we are to learn to live sustainably. Conserving our options means, in part, conserving the diversity of ways of thinking about problems. It is our hope that this Invited Feature will provide nourishing food for thought, open lines of communication, and inspire future research and collaborations.

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We dedicate this Invited Feature to those who come after.

—Jesse Ford
Editor
Oregon State University
—Dennis Martinez (O'odham/Chicano)
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REDISCOVERY OF TRADITIONAL ECOLOGICAL KNOWLEDGE AS ADAPTIVE MANAGEMENT

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Abstract. Indigenous groups offer alternative knowledge and perspectives based on their own locally developed practices of resource use. We surveyed the international literature to focus on the role of Traditional Ecological Knowledge in monitoring, responding to, and managing ecosystem processes and functions, with special attention to ecological resilience. Case studies revealed that there exists a diversity of local or traditional practices for ecosystem management. These include multiple species management, resource rotation, succession management, landscape patchiness management, and other ways of responding to and managing pulses and ecological surprises. Social mechanisms behind these traditional practices include a number of adaptations for the generation, accumulation, and transmission of knowledge; the use of local institutions to provide leaders/stewards and rules for social regulation; mechanisms for cultural internalization of traditional practices; and the development of appropriate world views and cultural values. Some traditional knowledge and management systems were characterized by the use of local ecological knowledge to interpret and respond to feedbacks from the environment to guide the direction of resource management. These traditional systems had certain similarities to adaptive management with its emphasis on feedback learning, and its treatment of uncertainty and unpredictability intrinsic to all ecosystems.

Key words: adaptive management; human ecology; resilience; resource management; social learning; Traditional Ecological Knowledge.

INTRODUCTION

Traditional knowledge, as a way of knowing, is similar to Western science in that it is based on an accumulation of observations, but it is different from science in some fundamental ways. The anthropologist Claude Levi-Strauss (1962:269) argued that these two ways of knowing are two parallel modes of acquiring knowledge about the universe; the two sciences were fundamentally distinct in that ‘‘the physical world is approached from opposite ends in the two cases: one is supremely concrete, the other supremely abstract.’’ Similarly, the philosopher Paul Feyerabend (1987) distinguished between two different traditions of thought: abstract traditions (to which scientific ecology belongs) and historical traditions, which include systems of knowledge possessed by people outside Western science, knowledge that often becomes encoded in rituals and in the cultural practices of everyday life. Other scholars have cautioned against overemphasizing the differences between Western science and traditional knowledge and questioned if the dichotomy is real (Agrawal 1995).

Interest in Traditional Ecological Knowledge has been growing in recent years, partly due to a recognition that such knowledge can contribute to the conservation of biodiversity (Gadgil et al. 1993), rare species (Colding 1998), protected areas (Johannes 1998), ecological processes (Alcorn 1989), and to sustainable resource use in general (Schmink et al. 1992, Berkes 1999). Conservation biologists, ecological anthropologists, ethnobiologists, other scholars, and the pharmaceutical industry all share an interest in traditional knowledge for scientific, social, or economic reasons.

For a long time, ‘‘tradition’’ was a problematic word for researchers in development and anthropology because, as Warren (1995) put it, ‘‘‘traditional’ denoted the 19th-century attitudes of simple, savage and static.’’ For this reason, some scholars favor the less value-laden term ‘‘indigenous knowledge’’ (Warren 1995). Nevertheless, the use of the term ‘‘Traditional Ecological Knowledge’’ has become established, among others, through the work of the International Conservation Union (IUCN) working group by that name (Johannes 1989, Williams and Baines 1993).

In the course of the development of the field, the

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study of Traditional Ecological Knowledge began with the study of species identifications and classification (ethnobiology), and proceeded to considerations of peoples' understandings of ecological processes and their relationships with the environment (Williams and Baines 1993, Berkes 1999). The analysis of many Traditional Ecological Knowledge systems shows that there is a component of local observational knowledge of species and other environmental phenomena, a component of practice in the way people carry out their resource use activities, and further, a component of belief regarding how people fit into or relate to ecosystems. In short, traditional knowledge is a knowledge–practice–belief complex (Berkes 1999). We have therefore developed 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 with their environment. This definition, evolving from our earlier work (Gadgil et al. 1993, Berkes et al. 1995), further recognizes that Traditional Ecological Knowledge is an attribute of societies with historical continuity in resource use practice (Dei 1993, Williams and Baines 1993). By and large, these are nonindustrial or less technologically advanced societies, many but not all of them indigenous or tribal.

Traditional knowledge may be holistic in outlook and adaptive by nature, gathered over generations by observers whose lives depended on this information and its use. It often accumulates incrementally, tested by trial-and-error and transmitted to future generations orally or by shared practical experiences (Ohmagari and Berkes 1997). Obviously, not all traditional practice and belief systems were ecologically adaptive in the first place; some became maladaptive over time due to changing conditions. Not all traditional practice is ecologically wise. For example, Diamond (1993) notes that even though New Guinea natives possess detailed knowledge of plants and animals, some of the groups had, and continue to have, a heavy impact on their native biota. We do not wish to enter into the debate over aboriginal conservation, but suffice to say, exaggerated claims on behalf of traditional ecological wisdom require a reality check (Chapin 1988, Redford and Stearman 1993). In any case, indigenous notions of conservation are fundamentally different from those of Western conservationists (Alcorn 1993, Dwyer 1994, Roberts et al. 1995).

Nevertheless, growing interest in traditional knowledge since the 1980s is indicative of the need to gain further insights into indigenous and/or local practices of resource use from an ecological perspective, which is the objective of this paper. We explore a diversity of traditional knowledge systems and discuss the usefulness of Traditional Ecological Knowledge in terms of providing understanding and information complementary to scientific ecology. The synthesis is partly based on the findings of a project on linked social–ecological systems (Berkes and Folke 1998), which sought to mobilize a wider range of considerations and sources of information than those used in conventional resource management (which we define as resource management based on Newtonian science and on the expertise of government managers). The overall objective of the project was to learn from a diversity of locally evolved management systems and their dynamics for improved ecosystem management. Some of the cases came from traditional societies and some from modern societies with locally evolved management systems, as in Maine (Acheson et al. 1998, Hanna 1998). Such nonindigenous examples help emphasize the point that probably none of the examples is purely traditional but incorporate both Western science and local practice. Whether a practice is traditional or contemporary is not the key issue. The important aspect is whether or not there exists local knowledge that helps monitor, interpret, and respond to dynamic changes in ecosystems and the resources and services that they generate.

In this paper, the emphasis is on the role of local or indigenous communities in using Traditional Ecological Knowledge to respond to and manage processes and functions of complex systems. Of special interest are practices by which ecosystems and biological diversity are managed to secure a flow of natural resources and ecological services on which people depend. First, we identify a selection of management practices based on local ecological knowledge. These practices range from monitoring specific resources to ecologically sophisticated practices that respond to and manage disturbance and build resilience (sensu Holling 1973, 1986) across temporal and spatial scales. Resilience in this context refers to the capacity to recover after disturbance, absorb stress, internalize it, and transcend it. Resilience is thought to conserve options and opportunity for renewal and novelty (Holling et al. 1995, Gunderson et al. 1997).

Second, we identify a number of social mechanisms behind these practices and organize them sequentially from the generation of knowledge, to the underlying world view and values of the culture in which that knowledge is embedded. We do not address in any detail, the belief or spiritual component of traditional knowledge, as this is largely outside the realm of ecology (but see the discussion on the ecological role of sanctions and taboos by Colding and Folke 1997). Third, we evaluate traditional knowledge systems for the insights they provide for the qualitative (as opposed to quantitative) management of resources and ecosystems (Lugo 1995), and for parallels to adaptive management (Holling 1978, Gunderson et al. 1995).

TABLE 1. Social-ecological practices and mechanisms in traditional knowledge and practice (adapted from Folke et al. 1998).

Management practices based on ecological knowledge		
	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
	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
	Practices related to the dynamics of complex systems, seldom found in conventional resource management but found in some traditional societies	
		Management of landscape patchiness
		Watershed-based management
		Managing ecological processes at multiple scales
		Responding to and managing pulses and surprises
		Nurturing sources of ecosystem renewal
Social mechanisms behind management practices		
	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
	Structure and dynamics of institutions	
		Roles of stewards/wise people
		Cross-scale institutions
		Community assessments
		Taboos and regulations
		Social and religious sanctions
	Mechanisms for cultural internalization	
		Rituals, ceremonies, and other traditions
		Cultural frameworks for resource management
	World view and cultural values	
		A world view that provides appropriate environmental ethics
		Cultural values of respect, sharing, reciprocity, humility, and other

PRACTICES BASED ON TRADITIONAL ECOLOGICAL KNOWLEDGE

It is often difficult to identify and generalize about indigenous practices that function in resource and ecosystem management. A given practice may be documented from one social group but not the next, or from one time period but not another. As well, researchers who are not trained ecologists may not recognize a practice as having an ecological function or may even misinterpret them. In fact, many of the management practices listed in Table 1 were not previously identified specifically for their role in resource and ecosystem management (Folke et al. 1998). When identifying these practices, we make no claim about their existing use; nor do we make any claims that the people who practiced them would necessarily interpret or explain them as we do. Similar complications apply also to the identification of *social mechanisms* behind management practices.

Practices and mechanisms listed in Table 1 are not considered separate phenomena but interlinked with one another and coevolving. (Coevolution is interpreted here as a trial-and-error process of self-organization through mutual feedback, see Colding and Folke 1997.) The list is by no means exhaustive but merely a starting point for the further identification of social–ecological linkages and their contribution to the use of locally based ecological knowledge. For analytical purposes, we have clustered these practices into three groups: those found both in conventional resource management and in some local and traditional societies; those largely abandoned by conventional resource management but still found in some local and traditional societies; and those related to the dynamics of complex systems, seldom found in conventional resource management but found in some local and traditional societies.

Table 1 does not list some well known ecological practices, such as territoriality, which can limit the size of local human populations to resource availability

(Dyson-Hudson and Smith 1978) as in other species. Instead, Table 1 deals with variations of territoriality, such as resource rotation and watershed-based management, that may serve different functions. As well, biodiversity conservation is not identified as a practice as such. Many traditional management systems contribute to the conservation of biodiversity through a number of practices, including the use of more varieties, species, and landscape patches than do modern agricultural and food production systems (Nabhan 1985, Warren et al. 1995, Sporrong 1998), and by monitoring and responding to ecosystem change (Berkes et al. 1995). In such cases, biodiversity conservation is not necessarily the objective of the practice but a consequence of it.

Practices found both in conventional resource management and in some traditional societies

Monitoring the status of the resource is a common practice among many groups of traditional users, and is often accompanied with the monitoring of change in ecosystems. The proximity of users to the resource confers an ability to observe day-to-day changes, either by the whole community or by selected individuals, such as community stewards and elders. For example, shamans of the Tukano people of Colombia monitor species abundance by random scheduling of hunting excursions. Thus, shamans determine the number of animals to be hunted and the species that need to be protected, based on field observations (Reichel-Dolmatoff 1976). Many of the cases in Berkes and Folke (1998) provide examples of such monitoring across a range of locally evolved management systems from traditional to modern. For example, herders of the Sahel monitor grazing pressure and the state of the pasture to make decisions about rotating or relocating herds (Niamir-Fuller 1998), Icelandic fishers spend a great deal of time and effort communicating about fish distributions and abundance (Palsson 1998), and coastal communities in Maine monitor clam populations to help determine the areas requiring enhancement (Hanna 1998).

Total protection of certain species is common in some areas. Such practices may vary from avoiding species that are poisonous or are used for medicinal purposes (Begossi 1998) to preserving keystone species in the ecosystem (Colding and Folke 1997). Several practices involve the protection of vulnerable life-history stages of species (Johannes 1978). For example, there are local prohibitions against catching lobsters with eggs in the Maine fisheries (Acheson et al. 1998). In south India, many wading birds are hunted outside the breeding season; they are not hunted in heronries that offer year-round sanctuaries and that may be on trees in the middle of a village (Gadgil et al. 1993).

Sacred groves may serve for the protection of specific habitats, and continue to be important in many areas, for example in Africa, but have been disappearing as a result of change of rural economies and denigration of local traditions (Dei 1993). Habitats protected by sacred locales may be recruitment areas, for example, for populations of seed-dispersing birds and bats, that are of importance for renewal of surrounding ecosystems (Gadgil et al. 1993). They are also important for birds controlling insect outbreaks on adjacent crop fields, and may serve as seed banks for locally adapted crop varieties and medicinal plants. Even small sacred groves may be surprisingly effective in conserving biodiversity. A botanical survey in a Nigerian sacred grove yielded 330 plant species as compared to only 23 in surrounding nonprotected areas (Warren and Pinkston 1998). Sacred groves are not the only example of culturally protected habitat. Niamir-Fuller (1998) describes the use of buffer areas of Sahelian rangelands, which are normally protected from grazing except in the case of emergencies. Gadgil et al. (1998) suggest that traditional conservation practices in relation to refugia might have originated to serve secular functions, even though they are associated with religious practice.

Temporal restriction of harvest is a common practice in conventional fish and wildlife management, and it is also used in some traditional management systems, for example, among African herders (Niamir-Fuller 1998) and groups of Canadian Amerindian hunters, whose hunting, fishing, and trapping areas are periodically ‘‘rested’’ (Berkes 1999). In the Hindu-Kush Himalayas, there were traditional seasonal and periodic restrictions on gathering from the village commons (Jodha 1998). Zerner (1994) describes how prohibitions on entry, harvest, or hunting in community-controlled areas of many Maluku Islands of Indonesia, are regulated through the practice of *sasi*, a long-standing social institution for restricting access to certain resources.

Practices largely abandoned by conventional resource management but still found in some local and traditional societies

These include practices that have fallen out of favor in government resource management, presumably because of production inefficiency. But many of them are being rediscovered, as reflected for example in the growing emphasis on agroecology, integrated farming and aquaculture, and polyculture. Explicitly or implicitly, these rediscoveries continue to be inspired by traditional practices. Many traditional systems use multiple species management, for example, through integrated farming and cultivation systems. A Nigerian case study (Warren and Pinkston 1998) identifies an agroforestry system combining food crops and domesticated trees as the oldest farming practice in the area. Since the beginning of the 20th century, this system has taken the form of a perennial mixed plantation that includes cash crops such as cocoa, oil palm, and coffee. Many multiple species management approaches result in soil fertility improvement and crop protection through the integration of trees, animals, and crops (Altieri 1994). For example, the Bisnois of the Thar desert of India maintain their resource base through managing a keystone process tree species, *Prosopis cinerarea.* This leguminous tree helps fix free nitrogen and enrich the soil, creating ideal conditions for crops that are planted under the shade of these trees. The leaves provide fodder, branches provide fencing material and firewood, and pods are eaten by both cattle and humans (Sankhala 1993).

Many of these systems serve the purpose of maintaining ecosystem process and function. For example, indigenous-inspired forestry practices in northern coastal British Columbia serve to conserve the structure and function of forest ecosystems by the maintenance of both hardwood and coniferous trees, so that species such as alder can help fix nitrogen for the conifers (Pinkerton 1998). Ramakrishnan (1992), Jodha (1998), and Alcorn and Toledo (1998) describe mixed cultivation systems in which some of the species help maintain ecosystem structure and function. For example, *milpa* and *jhum* systems, which are two regional variations of shifting cultivation (swidden) systems found throughout world's tropical forests (Brookfield and Padoch 1994), use tools and techniques that support the processes and functions of the agroforest ecosystem.

The practice of resource rotation, once used in agriculture worldwide, is one of the most widespread tools of traditional resource management systems from the arctic to the tropics. For example, James Bay Cree hunters rotate trapping areas on a four-year cycle (ideally) to allow populations of beaver to recover. They use a similar rotation technique for fishing areas, using the declining catch per unit of effort as the feedback that informs decision-making, basically an optimum foraging model (Berkes 1998). In semiarid regions such as the fringe of Sahel, plant productivity oscillates seasonally and follows the rains. Many of the larger herbivores, as well as the traditional cattle herders, have adapted to this pattern by migrating seasonally. This yearly cycle provides a rotational management system, enabling the recovery of heavily grazed rangelands. In some cases, adjacent grazing areas are rotated in the same season as well (Niamir-Fuller 1998). Variations of this pattern, involving the rotation of herd animal enclosures, may result in landscape-level management in the long term through the production of islands of *Acacia*, a keystone species, by providing nutrient-rich microhabitats suitable for the growth of this tree species (Reid and Ellis 1995).

Appreciated by ecologists only relatively recently (Denevan et al. 1984), succession management is exemplified by the shifting cultivation system, *milpa*, as used in tropical Mexico. This system is well adapted to the multiple use of the tropical moist forest. While crops are growing, the regenerating vegetation is renewing the site for the next *milpa* cycle, and many of the regrowth species will eventually become trees that provide firewood, construction materials, dyes, craft materials, canoe bodies, medicine, and other resources. Agriculture becomes a sequential harvesting system of crops and nonfood crops (Alcorn and Toledo 1998). There are many variations of this succession management system among different South American groups (e.g., Irvine 1989).

Practices related to the dynamics of complex systems seldom found in conventional resource management

Some of the above-mentioned practices also address the management of complex systems (Costanza et al. 1993), but there seems to exist a class of indigenous practices that may be best appreciated by ecologists with an interest in ecosystem dynamics, adaptive management, and nonequilibrium systems, practices seldom found in the repertory of conventional resource management.

Management of landscape patchiness is practiced by many groups in the African Sahel (Niamir-Fuller 1998). The small-scale movements of Sahelian herders are adapted to the variability and unpredictability of the landscape. In a contemporary adaptation of traditional herding rules, the Maasai of Kenya progressively widen the radius of grazing around wells as the wet season advances, so as to leave enough forage around the wells for the dry season. Sporrong (1998) argues that the scattered agricultural plots of 18th century Swedish farmers of Delacarlia was an adaptation for the use of multiple ecological zones in the landscape. In the Eastern Himalayas, tribal groups are intimately familiar with and utilize landscape patchiness by elevation zones to grow different crops (Ramakrishnan 1992).

Watershed-based management systems use biogeographic boundaries to delineate areas controlled and managed by specific groups of people (Berkes et al. 1998). Southeast Asia and Oceania had, and to some extent still have, a wealth of these prescientific ecosystem management practices. Examples include ancient Hawaiian *ahupua'a* (Costa-Pierce 1987), the Yap *tabinau*, the Fijian *vanua*, and the Solomon Islands *puava* (Ruddle et al. 1992). These four terms refer to generically similar watershed-based management systems. In ancient Hawaii, valleys within watersheds were used for integrated farming. The ecosystem unit extended from upland forests protected by taboo, 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). 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.

There is some evidence that locally devised systems may be useful in managing ecological processes at multiple scales. *Milpa* is the indigenous Mexican term for shifting cultivation. *Milpa* succession, as described by Alcorn and Toledo (1998), manages food crops on a 1–3 year scale, and some tree crops and products on a 30-year scale. Based on ethnohistorical information and current practice, James Bay Cree hunters seem to be simultaneously managing beaver populations on a 4–6 year scale, lake fish on a 5–10 year scale, and caribou on a 80–100 year scale (Berkes 1998). The holistic forestry described by Pinkerton (1998) is concerned not only with the production of fiber over several square kilometers, but also with the maintenance of ecological processes involving soil bacteria at the spatial scale of a few square meters. In the case of African herders, Niamir-Fuller (1998) recognizes two different sets of practices and rules for the larger scale movements (macro-mobility) and the smaller scale movements (micro-mobility).

An example of responding to and managing pulses and surprises is the establishment of range reserves within the annual grazing areas of African herders. These reserves provide an emergency supply of forage that functions to maintain the resilience of both the ecosystem and the social system of the herders, and serve as buffer when disturbance, such as drought, challenges the dryland ecosystem (Niamir-Fuller 1998). Such practices may be considered ecological adaptations to unpredictable, low-rainfall environments. Livestock gather up energy from the low-production environment, and serve as relatively drought-resistant packages of concentrated energy to buffer against variability (Coughenour et al. 1985). Sacred groves in India absorb disturbance by serving as firebreaks for cultivated areas and villages (Gadgil et al. 1998). The Warlis of India control pests by placing certain kinds of tree branches in their paddy fields. This practice serves to attract birds for insect control, and buffers against outbreaks of various pest populations (Pereira 1992).

Disturbances triggered by events such as fire, hurricanes, pest outbreaks, and heavy grazing are inherent to the internal dynamics of ecosystems, and often set the timing of ecosystem renewal processes (Holling et al. 1995). Many traditional societies seem to nurture sources of ecosystem renewal by creating small-scale disturbances. Traditional agroforestry, such as *milpa* and *jhum*, create forest gaps and enable people to produce crops or enhance wild foods without disrupting natural renewal processes (Ramakrishnan 1992, Turner 1994). Lewis and Ferguson (1988) show that aboriginal use of fire in as geographically diverse areas as Canada, Australia, and California had many elements and principles in common. It was used effectively to improve habitat for game and to assist in the hunt itself. Herders in Niamir-Fuller (1998) behave like a disturbance by following the migratory cycles of the herbivores from one area to another. The pulses of grazing by herbivores contribute to the capacity of the semiarid grasslands of Africa to function under a wide range of climatic conditions. If this capacity of the ecosystem to deal with pulses is reduced, an event that previously could be absorbed can flip the grassland ecosystem into a relatively unproductive state, which is dominated and controlled by woody plants for several decades (Walker 1993).

Social Mechanisms Behind Traditional Practices

The practice of Traditional Ecological Knowledge differs from that of scientific ecological knowledge in that it is largely dependent on local social mechanisms. These social mechanisms may be thought of as a hierarchy that proceeds from local ecological knowledge to social institutions, to mechanisms for cultural internalization, and to world views. Institutions, in the sense of rules-in-use, provide the means by which societies can act on their local knowledge and use it to produce a livelihood from the environment (Berkes 1989). Both knowledge and institutions require mechanisms for cultural internalization, so that learning can be encoded and remembered by the social group. World view or cosmology gives shape to cultural values, ethics, and the basic norms and rules of a society. Fig. 1 illustrates the idea of Traditional Ecological Knowledge as a knowledge–practice–belief complex. Local observational knowledge of the land, resource management systems, social institutions (or rules-in-use), and the world view can be represented as a hierarchical system. Such a representation falls short of showing the feedbacks among the ellipses, and the close coupling of some parts of the system, especially management systems and social institutions. However, it does convey the idea of embeddedness of local knowledge and rules/norms in the world view of a particular culture.

Generation, accumulation, and transmission of knowledge

The generation, accumulation, and transmission of Traditional Ecological Knowledge proceeds along very different lines than those in scientific ecology. The response of the Cree caribou hunting system, following a resource crisis, illustrates how a society can reinterpret ecological signals for learning, consistent with the model proposed by Gunderson et al. (1995). The disappearance of caribou in the 1910s, following what the Cree themselves considered a wasteful slaughter, became a lesson that later led to a more conservationist approach (Berkes 1999). The redesigned management

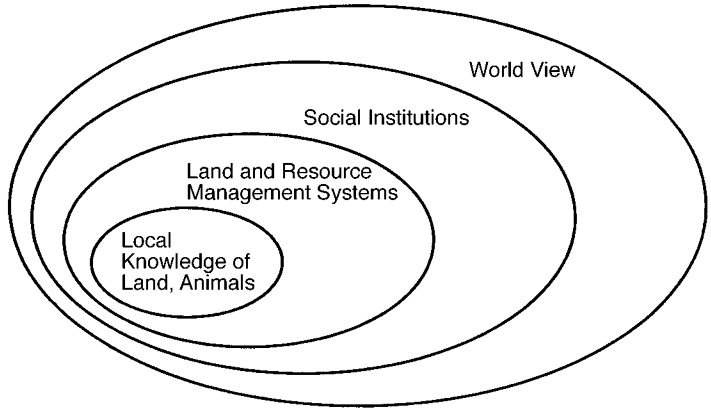

FIG. 1. Levels of analysis in traditional knowledge and management systems (adapted from Berkes 1999).

system, encoded in ethical and cultural beliefs of the Cree, was enforced by elders two generations later in the 1980s (Berkes 1999). Another example of such social learning is provided by Finlayson and McCay (1998) in Newfoundland's cod fisheries. Inshore fishers, who had traditionally seen fishery depletions as a natural and transient event, began to realize with the escalation of the offshore fishery, that stock failure could be caused by fishing itself. The irony of the case is that the inshore fishers were unable to convince the resource managers of the impending crisis. The managers were preoccupied with the offshore fishery and missed the signals that the inshore fishers were monitoring and learning from—until the entire stock collapsed (Hutchings et al. 1997).

The reestablishment of beaver management rules by the James Bay Cree provides an example of the revival of local ecological knowledge for restoring a population. Local Cree ethics for beaver conservation were suspended when their territory was overrun by outsiders in the 1920s. The ethics and the territorial management system itself were revived in the 1950s with the departure of the intruders and government protection of Cree land tenure (Feit 1986, Berkes 1998). Such revival requires the presence of strong traditions and institutions, as experienced in some Central American cases (Chapin 1991). In the absence of strong traditions and institutions, other kinds of incentives, including community economic benefits, may become necessary. For example, the redevelopment of ecological refugia in some parts of India has required monetary incentives (Gadgil et al. 1998).

Folklore and knowledge carriers help maintain ecologically sound management practices. These carriers may be local stewards and leaders (Pinkerton 1998), elders (Berkes 1998), or mythical figures in the local culture. For example, tales of the ''maize culture hero'' are associated with all stages of the *milpa* agroforestry system. The hero warns people of impending doom if people stop making *milpa* properly (Alcorn and Toledo 1998). The hunters' guild among the Yoruba functions as a knowledge carrier to maintain ancient traditions and indigenous knowledge (Warren and Pinkston 1998); Icelandic fishers serve as carriers of practical knowledge (Palsson 1998); and among the Gitksan of British Columbia, traditional values and knowledge are carried, and revived, by elders and chiefs (Pinkerton 1998).

Social mechanisms often play a role in the integration of ecological knowledge of different kinds. Maine's soft shell clam fishery is characterized by the integration of informal local knowledge and formal scientific information generated locally (Hanna 1998). Begossi (1998) argues that the mix of traditional and new knowledge of the *caiçaras* and *caboclos* (two groups of mixed-race rural people) of Brazil increases the resilience of their social–ecological systems by combining adaptations from two different cultural traditions, Amerindian and European.

Mechanisms for the intergenerational transmission of knowledge are embedded in social systems. An example of such transmission is the *milpa* script, which is passed on to children and sustained by cultural beliefs, mythologies, and yearly festivals (Alcorn and Toledo 1998). Among the James Bay Cree, successful transmission of bush skills and knowledge depends on the amount of time families spend on the land because of apprenticeship-based knowledge transmission, and the amount of time required for hands-on learning (Ohmagari and Berkes 1997).

Wide-ranging information exchange on rangeland conditions among different pastoralist groups (Niamir-Fuller 1998) illustrates the process of geographical diffusion of ecological knowledge. The similarity of the basic management design in some 30 traditional fishing societies throughout the world suggests geographic transfer of knowledge of marine coastal management systems (Acheson et al. 1998). Similarities become more obvious when regional systems are considered. Johannes' (1978) detailed study of fishery management in Oceania shows the pervasiveness of knowledge diffusion inferred through striking similarities across island groups in the basic design of the reef and lagoon tenure system.

Structure and dynamics of institutions for implementation of knowledge

Ecological knowledge does not function in isolation. It is embedded in institutions and local social norms (North 1990). The structure and dynamics of institutions are critical for implementation of management practices based on ecological understanding in any society (Hanna et al. 1996). The coordination of appropriate resource use practices is often entrusted with traditional leaders. For example, the collective leadership of stewards of different hunting areas is the key common-property resource management institution among the Cree. A hunting leader may act as the steward of resources on behalf of the community, as well as a social leader (Berkes 1998). Similarly, senior Ara hunters are custodians of their sacred areas as well as communal areas. The traditional guild of Ara hunters is headed by the chief of the hunters, and guided by an Ogun priest who performs ritual duties (Warren and Pinkston 1998). Pinkerton (1998) describes how a clan chief developed and pursued his vision of the future Gitksan forest, a telling case of the key role of stewards/wise people in bringing about a revival of local knowledge.

Several examples are available of cross-scale institutions, those that operate at more than one temporal or spatial scale. In the Maine soft shell clam fisheries, management rights held at different levels, from the citizen to the state, are nested in ascending levels of authority, providing for a cross-scale management institution appropriate for comanagement or the sharing of resource management power and responsibility (Hanna 1998). The ‘‘tenurial shell’’ created by the Mexican state that supports the traditional belief structure of the Huastec, which in turn supports ecologically sustainable land use (Alcorn and Toledo 1998), and the nested territorial rights of tribes, sub-tribes, and clans in south-central Sudan are other examples of institutions that operate cross-scale (Niamir-Fuller 1998).

Many tribal task groups engage once a year in a large-scale communal hunt, a group-level or community assessment of available resources. Such a group exercise may serve the purpose of monitoring or evaluating the status of prey populations and their habitats; this in turn may help adjust resource harvesting strategies (Gadgil et al. 1993). In the Maine clam fishery, the time and effort needed to develop and implement management plans are proportionally shared by the major beneficiaries of the resource through the inclusion of users in resource surveys and other assessments, and through rotating membership on shellfish conservation committees (Hanna 1998).

Taboos and other regulations are critical social mechanisms for resource conservation, and have the potential of building resilience in ecosystems (e.g., Johannes 1978, Chapman 1985, Colding and Folke 1997, Colding 1998). Food taboos on game and fish are part of *caboclos* and *caiçaras* cultures, in which species are avoided due to toxic, medicinal, or ecological reasons (Begossi 1998). In pre-colonial Ara, Nigeria, there were sacred forests and sacred trees of various types, as in India (Gadgil et al. 1998) and elsewhere. Such trees and forests were believed to be occupied by spirits, and their use was forbidden by taboos (Warren and Pinkston 1998).

Taboos are merely one form of a larger set of social and religious sanctions, which may be used in conservation and resource management. The Gitksan of British Columbia sanction those who do not follow the norms and rules of the community by questioning their right to use their Gitksan name and social status (Pinkerton 1998). Acheson et al. (1998) provide a contemporary application of sanctions in the Maine lobster fishery: one must be a member of a ‘‘harbor gang’’ to participate. Members are expected to obey local rules, and a person who violates them will be sanctioned. Territories are held by ‘‘harbor gangs’’; this limits the number of fishers in each territory and helps conserve the lobster resource.

Other institution-related social mechanisms not listed in Table 1, include coping mechanisms or short-term responses to environmental surprises and other unexpected events; institutional flexibility or the ability to reorganize under changing circumstances, which may involve discontinuities in the status of the resource or in user populations; and incipient institutions that may ‘‘kick in’’ following certain kinds of stresses (Berkes and Folke 1998).

Mechanisms for cultural internalization

A third category of social mechanisms concerns mechanisms for cultural internalization, which include rituals, ceremonies, and other traditions. Rituals help people remember the rules and appropriately interpret signals from ecosystem change. Chapin (1991) argues that where traditions remain strong, people see no need to make special efforts to preserve knowledge; they simply practice their culture. Alcorn and Toledo (1998) show how religious institutions reinforce community cohesion in indigenous and mestizo communities across Mexico. Ritual obligations, rights to community resources, and management obligations are all interlinked. Other examples of management systems with interlinked rituals concern the tribes of the Pacific Northwest, among whom the ‘‘first-salmon ceremony’’ provided the means to internalize proper management practices (Child and Child 1993).

An example of cultural frameworks for resource management is the *milpa* shifting cultivation system in Mexico. Alcorn and Toledo (1998) characterize *milpa* as a ‘‘cultural script,’’ an internalized plan consisting of a series of routine steps with alternative subroutines, decision nodes, and room for experimentation. Ecological knowledge is encoded in the local variation of the *milpa* script, derived from experiences and experiments of farmers over generations. Cultural support buffers the script from disruption by new economic demands, introduction of new technologies, or other changes (Alcorn and Toledo 1998). The *sasi* system is another example of cultural frameworks for managing resources. Zerner (1994) has described how improved resource management has been achieved in contemporary Maluku Islands of Indonesia, through the reestablishment and adjustment of *sasi* institutions. Local support for the institution was high because people saw *sasi* as providing historical and cultural continuity and understanding.

World views and cultural values

A fourth category of social mechanisms concerns world views and cultural values. World view or cosmology includes basic beliefs pertaining to religion and ethics, and structures observations that produce knowledge and understanding. It rounds out the knowledge–practice–belief complex that describes traditional knowledge (Fig. 1). Thus, an essential component for traditional knowledge and practice for ecologically sustainable outcomes is a worldview that provides appropriate environmental ethics. The pervasive cosmology of traditional societies may be characterized as a ''community of beings'' world view in which humans are part of an interacting set of living things, a view that was also common in Europe up until Medieval times (Callicott 1994). Such a cosmology does have similarities to a holistic ecological view of the world, as opposed to the Newtonian mechanical model (Capra 1996), except that traditional world views often also have a spiritual component, which may be interpreted as a way to deal with uncertainty.

Also outside the sphere of ecology, but relevant to indigenous knowledge, are cultural values as a social mechanism behind traditional practice. Cultural values such as respect (for humans as well as for nature), sharing, reciprocity, and humility characterize a diversity of systems of traditional knowledge and practice, including those of American aboriginal groups (Alcorn and Toledo 1998), Africans (Dei 1993, Niamir-Fuller 1998), and Pacific Island peoples (Roberts et al. 1995). Some of these values, such as reciprocity, also characterize local systems of management that seem to be operating sustainably in contemporary communities (Hanna 1998).

Qualitative Approaches for Adaptive Management

The two ways of knowing, scientific ecology and Traditional Ecological Knowledge, are potentially complementary. Here we focus on two areas, and evaluate traditional knowledge systems for the insights they provide for the qualitative (as opposed to quantitative) management of resources and ecosystems, and for parallels to adaptive management.

Conventional resource management has come under criticism because it is equilibrium-based or has an underlying assumption of ecological stability (Holling 1986, Gunderson et al. 1995, Holling et al. 1998). Resource management from a stability point of view may be characterized in terms of rules and regulations made by technical experts, often from a central bureaucracy, and enforced by agents who are not themselves resource users; emphasis on steady states and the maintenance of predictable yields, such as maximum sustainable yield; focus on controlling the resource to increase the predictability of yields; and the use of primarily quantitative techniques, such as stock assessment. Such management appears to cause a gradual loss of resilience as well as reduction of variability and opportunity, thus moving the ecosystem toward thresholds and surprises (e.g., Regier and Baskerville 1986, Ludwig et al. 1993). Loss of resilience is often masked by the development of fossil-fuel-dependent technologies to maintain yields, such as bigger fishing vessels or synthetic fertilizers. It can also be masked through support from socioeconomic infrastructures that make it possible to maintain a business-as-usual strategy when faced with ecological disturbance. Examples include capital markets that provide loans and financial insurance to fishermen and farmers in periods of resource crisis, thereby removing incentives for building an ecological knowledge base.

By contrast, there are lessons from systems of Traditional Ecological Knowledge and practice that may be characterized as ''resource management from a resilience point of view,'' such as: (1) management may be carried out using rules that are locally crafted and socially enforced by the users themselves; (2) resource use tends to be flexible, using area rotations, species-switching, and other practices summarized in Table 1; (3) the users have accumulated an ecological knowledge base that helps respond to environmental feedbacks, such as changes in the catch per unit of effort that help monitor the status of the resource; (4) a diversity of resources are used for livelihood security, keeping options open and minimizing risk; and (5) it is carried out using qualitative management wherein feedbacks of resource and ecosystem change indicate the direction in which management should move (more exploitation/less exploitation) rather than toward a quantitative yield target.

Such qualitative management is not a result of indigenous managers being more ''noble'' than conventional resource managers. We have argued elsewhere that it is a consequence of historical experience with disturbance and ecological surprise, and of not having access to modern technology and socioeconomic infrastructures with which disturbance can be exported in time and space (Holling et al. 1998). Traditional Ecological Knowledge can be viewed as a ''library of information'' on how to cope with dynamic change in complex systems. It may help connect the present to the past and reestablish resilience (Gunderson et al. 1997). Building ecological knowledge to understand qualitative changes in complex systems has been a means for improving a group's chances of survival.

Such a qualitative management approach is consistent with a number of emergent alternative management models. For example, Lugo (1995) has suggested that if the objective is to conserve tropical forests, a strategy of focusing on resilience, through a knowledge of regeneration cycles and ecological processes such as plant succession, may be the key to tropical forest sustainability, adding that ''management does not require a precise capacity to predict the future, but only a qualitative capacity to devise systems that can absorb and accommodate future events.''

Many of the prescriptions of traditional knowledge and practice are generally consistent with adaptive management as an integrated method for resource and ecosystem management (Holling 1978, Gunderson et al. 1995). It is adaptive because it acknowledges that environmental conditions will always change, requiring societies to respond by adjusting and evolving. Adaptive management, like some traditional knowledge systems, emphasizes processes (including resource use) that are part of ecological cycles of renewability. As well, adaptive management, like many traditional knowledge systems, assumes that nature cannot be controlled and yields cannot be predicted. Uncertainty and unpredictability are characteristics of all ecosystems, including managed ones. In both cases, social learning appears to be the way in which societies respond to uncertainty. Often this involves learning not at the level of the individual but social learning at the level of society or institutions; adaptive management is designed to improve on trial-and-error learning.

In this sense, adaptive management can be seen as a rediscovery of traditional systems of knowledge and management. Even though there are no doubt major differences between the two, adaptive management may be viewed as the scientific analogue of Traditional Ecological Knowledge because of its integration of uncertainly into management strategies and its emphasis on practices that confer resilience. By responding to and managing feedbacks from ecosystems, instead of blocking them out, adaptive management seeks to avoid ecological thresholds at scales that threaten the existence of social and economic activities, as do some traditional knowledge systems. Drawing on management practices based on Traditional Ecological Knowledge, and understanding the social mechanisms behind them, may speed up the process of designing alternative resource management systems.

Among the cases considered in this paper, one can identify a number of promising examples of Traditional Ecological Knowledge that can inspire adaptive management solutions. These include the monitoring of pasture status and initiating small- and large-scale movements of cattle herds in semiarid ecosystems, to respond to spatial and temporal variations in rangeland productivity (Niamir-Fuller 1998). A second example is the maintenance of multiple reproductive year classes in James Bay Cree fisheries, by the thinning out of the full size range of adult fish. This practice conserves reproductive resilience and contrasts with the conventional commercial fishery management practice in Northern Canada of harvesting only the largest fish, thus truncating the year class structure of the population (Berkes 1998). A third example is the maintenance of multiple tree species and age classes by maintaining a diversity of uses of the forest ecosystem, rather than clear-cutting large areas or selectively removing only the most economically valuable species (Pinkerton 1998).

In some cases, circumstances dictate the greater use of local ecological knowledge, and adaptive management can provide a framework for its use. For example, given the pressing needs for inshore fisheries management in Oceania and the scarcity of resources, alternative management models have been proposed in which traditional knowledge, in combination with information from marine protected areas, substitutes for stock assessment data (Johannes 1998). More generally, fishers' knowledge can complement limited scientific information for small-scale fishery management in developing countries (Mahon 1997).

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TRADITIONAL KNOWLEDGE OF INDIGENOUS AND LOCAL COMMUNITIES: INTERNATIONAL DEBATE AND POLICY INITIATIVES

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Abstract. This paper reviews international law and policy regarding the rights of indigenous peoples and local communities that are defining the role of traditional and indigenous knowledge in the management and conservation of biodiversity. The most influential forums occur within the United Nations system, particularly the Working Group on Indigenous Populations and the Convention on Biological Diversity. We discuss the ''soft-law'' context of declarations, regional agreements, ethical guidelines, research protocols, and policy frameworks, which reinforce indigenous entitlements. The elaboration of these rights will increasingly impinge upon scientific research by regulating access to the knowledge and resources of indigenous and local communities, and by requiring that policy and management be made with their full participation. Scientists should respond by following these developments, institutionalizing this participation at all levels of scientific activity, and respecting the value of indigenous knowledge.

Key words: biodiversity; conservation and sustainable use; Convention on Biological Diversity; indigenous knowledge; indigenous peoples and communities; local communities; sustainable development; Traditional Ecological Knowledge.

Introduction

Recent reviews of research and policy for the conservation of biological diversity identify needs to expand taxonomic knowledge; to incorporate conservation biology, ecology, and ecological economics; and to use bioregional planning and ecosystem management approaches (Pickett et al. 1997). Other reviews, emphasizing sustainable use and social contexts, have advocated decentralization, integrated conservation and development planning, and community-based conservation sensitive to local cultural values and institutions (Warren et al., 1995, Hanna et al., 1996, UNEP, 1998*a*).

Indigenous peoples and local communities have an important role in the management of biodiversity. The value of indigenous knowledge (IK) is becoming recognized by scientists, managers, and policy-makers, and is an evolving subject of national and international law (Anaya 1996). Scientists are often skeptical of the value of IK unless it has been recast in scientific terms, and may lump IK with superstition, irrationalism, and tribalism (Scott 1998). Scientists' arguments for preserving IK tend to emphasize intellectual and economic benefits to non-native societies by providing leads to drug discovery and raw materials for biotechnology and agricultural innovation.

Indigenous peoples themselves have repeatedly claimed that they have fundamental rights to IK because it is necessary to their cultural survival, and this principle is increasingly being recognized in international law. These rights include many nonmaterial and material values bundled into ''traditional resource rights'' (Posey 1996). When benefits are gained outside indigenous communities, they are entitled to have control over the process and to benefit from the use of their knowledge and traditions.

IK is also becoming recognized as a form of rational and reliable knowledge developed through generations of intimate contact by native peoples with their lands that has equal status with scientific knowledge (UNEP 1998*c*). While indigenous peoples have sometimes caused extinctions and degraded environments, they have often persisted for millennia in their territories by using detailed adaptive knowledge (Krech 1999). They have in many cases increased local biodiversity in widespread ''ecocultural'' landscapes, and have developed the majority of the global diversity in domesticated plants and animals (Blackburn and Anderson 1993, Harlan 1995, Nabhan 1997). Their ways of conceptualizing and acting in the environment are expressions of how to invest the world with meaning and self-fulfillment that provide alternatives to the dominant consumptive values of Western societies (Hunn 1999).

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Who Are the Indigenous?

Given the complexity of human history and social organization, there can be no single definition for being indigenous. Sometimes there is a clear history of colonization, conquest, genocide, and ethnocide, as happened in the Americas, New Zealand (Aotearoa), and Australia (Churchill, 1997, Maybury-Lewis, 1997). In Africa, Asia, and Europe, the histories often involve conquest or marginalization from within by other indigenous societies. Some indigenous peoples form unified nations, while others consist of loose bands or isolated communities.

The current definition of indigenous peoples most accepted in the international framework includes parts or all of the following elements: self-identification as indigenous; descent from the occupants of a territory prior to an act of conquest; possession of a common history, language, and culture regulated by customary laws that are distinct from national cultures; possession of a common land; exclusion or marginalization from political decision-making; and claims for collective and sovereign rights that are unrecognized by the dominating and governing group(s) of the state. Of these, self-identification is central (Anaya 1996).

It is estimated there are 5000–7000 distinct indigenous groups making up ~5% of the world's population (Maybury-Lewis 1997). Languages provide a good index of the current global threat to indigenous peoples, as distinct cultures disappear with their languages (Nabhan 1997). Of approximately 6000 distinct languages, 300 are spoken by ~95% of the world's people; one-half are spoken by communities of less than 10 000 individuals (Maffi 1998). One recent estimate suggests that 90% of the world's languages will be extinct or moribund in the next 100 years, making culture loss of equal or greater magnitude to the ongoing mass extinction of species (Cox 1997, Stork, 1999).

Indigenous Rights in International Law

Indigenous peoples have petitioned for the recognition of cultural and sovereignty rights since the creation of nation-states and their imposition of exclusive authority (Dickason 1989). Although Roman jurists and European common law accepted the natural law concept that title and sovereignty can arise from continuous use and possession of land ''from time immemorial,'' this principle was denied in colonized lands (Dickason 1989).

The unique status of indigenous peoples in the United States was recognized during the treaty-making years of 1778–1868. The powers granted in the U.S. Constitution to make treaties were recognized as powers to conduct foreign relations (Prucha 1994). Treaties often referred to tribes as ''nations,'' established peace between the Indian nations and the United States, created boundaries for tribal lands, and granted a degree of autonomy within those lands. Prior residency and distinct languages, cultures, laws, and governance were considered to grant tribes sovereign status (Prucha 1994).

Most indigenous peoples outside the United States have not gained this kind of status, and even in the United States sovereignty provisions have been greatly diminished by the assertion of federal plenary power and a long effort to extinguish tribes (Lyons et al. 1992). Frustrated by failures to secure sufficient rights in their own homelands, Indian nations petitioned for international recognition. Both the League of Nations and the United Nations (UN) upon their establishment received indigenous delegations requesting to be recognized as nonmember states. These petitions were rejected as interfering with state sovereignty (Lepage 1994).

The UN Charter (1948) recognizes the ''free-pursuit'' and ''self-determination'' of ''non-self-governing territories,'' and this led to a period of decolonization in which many nation-states divested themselves of their external colonies. The UN interpreted the obligations to extend only to the external colonies, and not to indigenous peoples living in internal enclaves (Lepage 1994). The rights embedded in the UN Charter were based on universal human rights, and it was thought that no special group-related rights were needed to protect indigenous peoples.

The UN in the late 1950s recognized that the universal human rights provisions were not enough to protect ethnic minorities and indigenous peoples from persecution, assimilation, and genocide. The UN International Labor Organization (ILO) in 1957 adopted ILO Convention 107, which recognized indigenous rights to customary law, social organization, land tenure, collective land ownership, and customary practices. However, these were conceived as individual rather than sovereign rights, and were promoted primarily to integrate indigenous peoples into the labor pools of the modern nation-state (Lepage 1994). The convention did not receive wide support, and has been ratified by only 27 countries.

Other UN declarations and conventions concern cultural and language rights. The most influential of these was the Declaration and International Convention on the Elimination of Any Form of Racial Discrimination that authorized the ''Study of the Problem of Discrimination against Indigenous Populations'' (Lepage 1994). The report concluded that: states should respect traditional laws and customs; indigenous peoples should have control over their own lands and resources, with the right to communal land ownership and to manage land according to their own traditions; and such ownership and rights should be protected by national and international laws.

Following the recommendation of the report, the UN Commission on Human Rights established the Working Group on Indigenous Populations (WGIP). The WGIP reviews the evolution of standards concerning the rights of indigenous peoples, provides a forum where they can express grievances, and promotes the protection of their rights. The Draft Declaration on the Rights of Indigenous Peoples, begun in 1988, stipulates rights to self-determination, collective rights, cultural and intellectual property rights, and obligates states to observe treaties (Anaya 1996). Though still in draft, this has been extremely influential in framing indigenous rights at the international level, and its provisions have been incorporated into other instruments. The WGIP has also produced a global study of treaties between states and indigenous peoples, and is currently investigating options for protecting their cultural and intellectual property (Daes 1999). These initiatives are important to recognize because they are UN instruments that construct indigenous rights and link rights to culture, language, religion, land, and resources, including biodiversity.

The Convention on Biological Diversity

The Preamble of the Convention on Biological Diversity (CBD), which came into force in 1993, recognizes the ''close and traditional dependence of indigenous and local communities . . . on biological resources and the desirability of sharing in the benefits derived from the use of traditional knowledge, innovations and practices.'' National obligations toward indigenous and local communities occur in Articles 8 (In-situ Conservation), 10 (Sustainable Use of Components of Biodiversity), 17 (Exchange of Information), and 18 (Technical and Scientific Cooperation) (UNEP 1992).

Article 8(j) has been the focus of most of the discussions to date. This Article states that each party will:

> Subject to its national legislation, respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge, innovations and practices.

The interpretation of this complex article is incomplete and ongoing. The initial part recognizes that the article will have to be implemented in national legislation, and encourages countries without compatible legislation to develop it (A. Campeau, *personal communication* to P. Hardison 23 July 1999). Obligations are created both to ''indigenous communities'' and ''local communities,'' but these do not have equivalent bundles of rights in human rights law (Posey and Dutfield 1996).

Decision IV/9 of the Conference of the Parties (COP) interprets ''respect'' to mean that ''traditional knowledge should be given the same respect as any other form of knowledge . . . ,'' including scientific knowledge (UNEP 1998*c*). Countries that have acceded to international conventions through national ratification, acceptance, or approval are known as Parties. As of January 1999, there were 175 Parties to the CBD. The United States has signed, but not ratified, the convention. Indigenous peoples are observers within the CBD, which has made some steps to accommodate them in negotiations on indigenous issues. The Parties have established a working group on Article 8(j), but it is unclear whether this body will operate after a meeting in February 2000. Since the third meeting of the CBD, indigenous representatives have been able to make interventions, and participate in some negotiating sessions, but this has been limited and the final decisions rest with the Parties. Indigenous peoples have argued this system does not give them ''unfiltered access'' or ''full and effective participation'' in the convention, and indigenous standing is an intense area of debate.

The extent of the obligations to ''. . . preserve and maintain . . . '' have not been well explored, and the positions of parties and indigenous observers often diverge. The parties have concentrated on access and benefits sharing, or the ''terms of trade,'' because these issues are closest to the economic use of IK. Indigenous representatives have argued that in order to preserve and maintain IK, parties must respect broader rights to lands, languages, religions, and cultures, as has been argued in the WGIP (Coombe 1998). Many parties have acted to deny or circumscribe these rights in the CBD, citing the principle of state sovereignty recognized in the Convention.

Parties are obliged to promote the use of IK outside of native communities, but only with their involvement and approval, or ''prior informed consent'' (PIC, Article 15[5]). Sharing benefits on ''mutually agreeable terms'' requires a method for obtaining this approval and mechanisms of indigenous control over the flow of information (Glowka 1998, Lesser 1998).

This radically changes older concepts of IK as the ''common heritage of mankind,'' often acquired through personal agreements between individuals. These informal transfers of knowledge will increasingly be regulated. Because systems of IK vary so widely—knowledge may be held by a guild, a clan, only by men or women, by a family group, each with their own rules for divulging knowledge—national and local implementation of PIC will also vary. In some cases it is possible to use contracts or material transfer agreements (MTAs) negotiated individually with tribal authorities (Mugabe et al. 1997). Other nations are experimenting with other policies, such as the People's Biodiversity Registers (PBRs) developed for working with indigenous communities by the World Wide Fund for Nature of India (Gadgil 1996). Many believe that the current individual-based forms of intellectual property rights cannot adequately protect IK, and argue there is a need for novel or sui generis legal regimes, which are flexible enough to deal with community rights and the diversity of customary law and tribal organization (Brush and Stabinsky 1996, Lianchamroon and Vellvé 1998, King and Eyzaguirre 1999).

The CBD works primarily through implementation of its principles and directives in national law, policy, research, and management. The meetings of the Conference of Parties (COP) result in decisions that provide instructions and guidance for parties on implementing the convention in their national activities. Article 8(j) and related articles provide a basis for indigenous participation in all activities of the convention that touch on indigenous issues (UNEP 1998*b*). This includes participation in work plans for the various ecosystems, implementing the ecosystem approach, controlling alien species, carrying out impact assessment and monitoring, and building the Clearing-House Mechanism (CHM). The Clearinghouse Mechanism was established under Article 17 of the CBD to develop methods to effectively communicate the aims of the convention, and provide a means for monitoring national progress in the implementation of the convention, and is playing an increasing role in aiding the coordination of scientific and technical input into the thematic areas of the convention. As of September 1999, indigenous peoples have been almost entirely absent in the development of national clearinghouse mechanisms, excepting Canada and the Secretariat to the CBD.

Other Global Conventions and ''Soft-Law''

The CBD maintains formal liason with other conventions that touch on biodiversity issues, which all contain decisions to harmonize their overlapping mandates, including provisions on indigenous and local communities. The International Convention to Combat Desertification (UN 1994) requires parties to ''. . . protect, integrate, enhance and validate traditional and local knowledge, know-how and practices . . . '' and that ''. . . owners of that knowledge will directly benefit on an equitable basis and on mutually agreed terms'' (Article 17[c]), and to ''. . . protect, promote and use in particular relevant tradition and local technology. . . '' (Article 18[a]) (CCD 1994). The UN Human Rights Commission is also deliberating on establishing a Permanent Forum on Indigenous Peoples' Affairs within the UN system, as recommended by the World Conference on Human Rights in Vienna in 1993. The World Intellectual Property Organization (WIPO) has established a program on Global Intellectual Property Issues, which includes exploring the legal needs and expectations of holders of traditional knowledge (WIPO 1998).

Soft-law, or declarations of principles reflecting aspirations that are not subject to national ratification, has been used extensively in setting international norms (Shelton 1999). Governments work with these informally, and drop or elevate their status as experience suggests.

The Rio Declaration, a nonbinding statement of principles produced at the 1992 Earth Summit, recognizes a ''vital role'' for indigenous peoples, and urges states to ''recognize and duly support their identity, culture and interests and enable their effective participation in the achievement of sustainable development.'' Methods for achieving recognition and support are detailed in Agenda 21, the action plan underlying the Rio Declaration.

The Intergovernmental Forum on Forests (IFF), administered by the UN Commission on Sustainable Development (CSD), has reviewed traditional forest-related practices of indigenous peoples, and has adopted many of the elements of the Leticia Declaration and Plan of Action developed by a global group of indigenous experts in Colombia in 1996 (IAITPTF and EAIP 1997).

The UN Food and Agriculture Organization (FAO) for over two decades has sponsored the ''International Undertaking on Plant Genetic Resources'' (Esquinas-Alcazar 1993, 1996). Over 1.4 billion people still farm on small plots and often use traditional technologies for farming and agricultural innovation, sharing varieties and knowledge. Recognizing that the knowledge and innovations are collective, the Undertaking is working to define a system of ''farmers' rights'' to provide compensation where individual-based intellectual property regimes fail, and these considerations have been expanded to include IK (FAO 1996, 1999).

Regional agreements are another source of important IK provisions. The Arctic Environmental Protection Strategy (AEPS), signed in 1991 by eight Arctic nations, has developed guidelines and protocols regulating research under the Conservation of Flora and Fauna Programme (CAFF). When working with communities, scientists are requested to register themselves, obtain formal permission for the use and distribution of information, and allow community oversight of their research.

Indigenous peoples have also made their positions known in many declarations, such as the ''Kari-Oka Declaration'' from the Earth Summit in 1992 and the ''Mataatua Declaration on Cultural and Intellectual Property Rights of Indigenous Peoples'' in 1993. They have developed their own policies for using IK, such as the ''Principles for Negotiating Research Relationships in the North'' of the Inuit Tapirisat in Canada.

Indigenous communities are increasingly using these protocols and declarations to regulate scientists working in their territories. Though taken very seriously by the communities, scientists have often either been ignorant of them or ignored them. The Kuna Indians of Panama in 1997 closed down a research station of the

Smithsonian Tropical Research Institute in San Blas (Kuna Yala) that had been collecting long-term data on behavior, ecology, and evolution because they claimed scientists had repeatedly violated published guidelines for research developed by the Kuna, and had failed to show the Kuna respect in their negotiations (A. Lopez. Kuna lawyer, *personal communication* to P. Hardison, May 1998 at CoP4, Bratislava, Slovakia).

Conclusions

Indigenous peoples have an evolving status in international law and policy, and many of the rights contained in draft declarations are not secured. Many indigenous peoples claim international and national legal instruments are invalid because they do not have to be granted rights they have always possessed (Venne 1998). Regardless, they are participating in defining their rights in international law and visibly impacting national laws and policies. There will be an ongoing tension as they pressure governments to recognize fundamental rights of self-determination and sovereignty, while nation-states seek to limit these rights according to national interest.

Scientists will be affected by the incorporation of indigenous and local community rights into policies and laws that regulate access to knowledge and resources and benefits sharing on mutually agreeable terms. Recent examples are statutes developed by the Republic of the Philippines and the Organization of African Unity, and under the Andean Pact (Mugabe et al. 1997, Grajal 1999). Similar laws are being drafted in Brazil and Australia that regulate bioprospecting and require scientists to negotiate research with indigenous communities (Goering 1999).

Implementing equitable principles for indigenous and local community participation in biodiversity management need not wait on legislation. Scientists and scientific societies could increase support for IK research in partnership with communities; aid the development of indigenous institutions; provide for their their full and effective participation in policy, research, and management; ensure transparency in research, and data management and support cultural revitalization efforts and the continued use of IK (IUCN ICTFIP 1997, Posey 1999). Indigenous peoples should not be treated as clients or mere stakeholders in the process, but should be invited to participate in all levels of decision-making and management, finding representation on steering committees, planning boards, advisory bodies, and similar organizations. Comanagement rights to resources on lands ceded by tribes to national governments, as recognized in Canadian and U.S. treaties to hunt, fish, and gather in ''usual and accustomed places,'' should also be fully recognized, and this includes participation in policy and planning.

Scientists should also be particularly aware of information issues regarding IK. The ability to control benefit sharing under the CBD requires that information not be placed in the public domain, and there may be data in scientific IK databases considered to be sacred or privileged information by indigenous peoples, which should have oversight. For previously published and databased information, scientists should make a strong effort to make the data available to the communities of origin, and provide capacity-building to help them manage their own information.

Some examples include the Pilot Project on Access to Genetic Resources and Benefit Sharing for botanical gardens and arboreta, and the ethical guidelines developed by the International Society of Ethnobiology, the Society for Economic Botany, and the Pew Conservation Fellows Biodiversity and Ethics Working Group (Posey and Dutfield 1996: K. ten Kate, *unpublished manuscript*). These principles have been clearly stated in the UNESCO sponsored Declaration on Science and the use of Scientific Knowledge and the Science Agenda-Framework for Action, which calls upon the International Council of Scientific Unions (ICSU) and other professional science bodies to incorporate them into their operations (UNESCO 1999).

Decisions of the COP of the CBD contain recommendations on IK that should be integrated into scientific policy and programs at all levels (available online on the CBD web site).[4] Indigenous participation has been virtually nonexistent in the development of the U.S. National Biological Information Infrastructure (NBII) and similar biodiversity information networks (e.g., BIN21, IABIN, NABIN, CHM). Participation has also been absent in programs such as Species 2000, the Global Taxonomy Initiative, the Organization for Economic Co-operation and Development Global Biodiversity Information Facility (GBIF), and the Global Invasive Species Program (GISP). Each of these initiatives contains significant issues of monitoring, valuation, benefits-sharing, and technical capacity building for indigenous peoples.

Respect for cultural diversity and the treatment of IK as coequal and complementary to Western scientific knowledge is fundamental to these policies. Indigenous peoples are asking for this respect and support from scientists because the use of their traditional knowledge is necessary for cultural survival, and it is through their cultures that healthy ecosystems are maintained. Much of the world's biodiversity occurs on or adjacent to traditional indigenous territories, and it will only be protected if the close interdependence between culture and ecosystems is maintained (Nabhan 1997). It is not wise, or right, to save pages from the book of life while recklessly discarding pages from the book of culture, especially when these contain vital lessons for us all.

[4] URL = ⟨http://www.biodiv.org/⟩

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USING TRADITIONAL ECOLOGICAL KNOWLEDGE IN SCIENCE: METHODS AND APPLICATIONS

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Abstract. Advocates of Traditional Ecological Knowledge (TEK) have promoted its use in scientific research, impact assessment, and ecological understanding. While several examples illustrate the utility of applying TEK in these contexts, wider application of TEK-derived information remains elusive. In part, this is due to continued inertia in favor of established scientific practices and the need to describe TEK in Western scientific terms. In part, it is also due to the difficulty of accessing TEK, which is rarely written down and must in most cases be documented as a project on its own prior to its incorporation into another scientific undertaking. This formidable practical obstacle is exacerbated by the need to use social science methods to gather biological data, so that TEK research and application becomes a multidisciplinary undertaking. By examining case studies involving bowhead whales, beluga whales, and herring, this paper describes some of the benefits of using TEK in scientific and management contexts. It also reviews some of the methods that are available to do so, including semi-directive interviews, questionnaires, facilitated workshops, and collaborative field projects.

Key words: beluga whales; bowhead whales; collaborative field work; herring; impact assessment; semi-directive interview; social science; Traditional Ecological Knowledge.

INTRODUCTION

Various advocates of Traditional Ecological Knowledge (TEK) promote its benefits on one or more of several fronts: improvements to scientific research and management through more and sometimes better information (Freeman and Carbyn 1988, Johnson 1992, Brooke 1993, Inglis 1993, Mailhot 1993, Hansen 1994); identification of new paradigms by which we can understand the natural world and our relation to it (Colorado 1988, Kawagley 1995, Deloria 1996); and broad societal change away from the positivist and amoral and toward the holistic and ethical (Colorado 1996, Kremer 1996). Amid the rhetoric, there are opportunities for practical and productive collaboration (Agrawal 1995).

For the purposes of this paper, I use TEK to mean the knowledge and insights acquired through extensive observation of an area or a species. This may include knowledge passed down in an oral tradition, or shared among users of a resource. The holders of TEK need not be indigenous, as shown below in the example on herring. While there are important differences between the structure and purpose of TEK and those of scientific knowledge (e.g., Berkes 1993, Deloria 1996, Stevenson 1996), we must recognize that TEK has an empirical basis and is used to understand and predict environmental events upon which the livelihood or even survival of the individual depends.

For ecologists, TEK offers a means to improve research and also to improve resource management and environmental impact assessment (Brooke 1993, Inglis 1993, Stevenson 1996). Much has been written about the potential benefits of documenting and applying TEK, but it is frequently in the future tense: ''TEK *will* be of use,'' somewhere, sometime. This tendency is unfortunate in that it often obscures real and practical contributions made by TEK in various fields and areas. In this paper, I review four methods by which TEK can be documented and otherwise accessed, three cases from Alaska in which I have been involved to some degree, and possible reasons that TEK has not been used or credited more widely. The paper is not intended as a review of TEK, but as an introduction to the topic and some of the important issues surrounding it.

METHODS FOR DOCUMENTING TEK

The methods for documenting TEK derive from the social sciences. Ecologists may prefer to engage social scientists to conduct actual research documenting TEK, but they should be aware of the variety of methods available and their strengths and weaknesses for promoting substantive interchange between local experts and outside scientists.

The four methods described below are not mutually exclusive, but are starting points from which a particular method can be developed that best meets the needs

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of the researchers and communities and best fits the circumstances of the research. These methods may involve the use of maps and other items to spur the memory or upon which to locate observations. Tape and video recordings can also be useful, in addition to accurate note taking. When designing a research project and selecting methods for gathering data, it is especially important to consider the cultural context in which the interactions take place (Briggs 1986, Johnson and Ruttan 1993). In addition, appropriate ethical principles must be followed in the conduct of TEK research so that community and individual rights are respected (IARPC 1992).

An additional consideration that applies to all four methods is the selection of participants. In the absence of personal experience with the pool of potential participants in a community or an area, the most practical option is peer selection. In nearly all cases of TEK research, the researcher will want to identify key informants rather than select a random sampling of the community. If appropriate, the community council can be asked to help select the most knowledgeable persons. Chain referrals, with each participant suggesting the name or names of further experts, are also a useful technique, and allow the researcher to evaluate the completeness of the selections since eventually few or no new names will come up. While evaluations of the reliability of a particular participant will depend in part on the judgment of the researcher, group reviews and other sources of local feedback can help minimize the role of the researcher in resolving conflicting statements from different participants.

Semi-directive interview

In this method (see Nakashima and Murray 1988, Nakashima 1990, Huntington 1998), participants are guided in the discussions by the interviewer, but the direction and scope of the interview are allowed to follow the participants' train of thought. There is neither a fixed questionnaire, nor a preset limit on the time for discussions or the topics to be covered. The interviewer may have a list of topics to discuss, which can be useful for prompting further discussions when there is a lull, but the interviewer must also be prepared for unanticipated associations made by the participants.

The semi-directive interview is more a conversation than a question-and-answer session. This is especially useful in cases where the participants are not comfortable with direct questions, or in which the researcher cannot be sure that the questions are understood as intended. Even simple questions often include assumptions that may not be universally valid, such as equating ''north'' with ''up,'' or that do not take into account local idioms. In a conversation about herring, one might ask the question, ''Where do the fish enter the bay?'' In the local idiom, ''fish'' may mean ''salmon'' rather than ''herring,'' and so the answer may appear valid but actually be referring to a different species than the researcher believes (see also Briggs 1986).

An example of the power of this method comes from my research on beluga TEK. Discussions in one group interview suddenly turned to the increasing population of beaver in the region. I was caught off guard, and as I listened to the conversation, I wondered whether it was time to exercise the ''directive'' part of the method. Seeing my confusion, one of the elders then explained why beaver were relevant to beluga: the beaver dam streams where some salmon spawn, reducing salmon habitat, and thus potentially affecting the abundance and distribution of the salmon on which beluga feed. This type of information is unlikely to be anticipated in advance, and the strength of the semi-directive interview method lies in providing an opportunity for such information to be discussed, while still providing enough structure that other useful information is not missed.

Questionnaire

This method is useful when the interviewer knows in advance what he or she is seeking, and also simplifies comparisons between respondents. Quantification, if desired and appropriate, is often simpler with a well-designed questionnaire. Depending on the cultural context, this may be more comfortable to some respondents than the more free-form semi-directive interview. When quantification is not necessary for all responses, some questions can be left open-ended, giving the respondent a chance to add more detail or make associations beyond those anticipated in the questions. While this is unlikely to produce as thorough a discussion as the semi-directive interview, it can be useful in providing new ideas and insights beyond the scope of the initial inquiry.

Analytical workshop

In some cases, collecting additional data is not as desirable as trying to interpret what is already known. Just as a workshop among scientists can help spur new ideas and challenge old assumptions, a workshop that brings together scientists and the holders of TEK can allow both groups to better understand the other's perspective, and to offer fresh insights. By cooperating in the analysis of data, the two groups may also find common understanding and jointly develop priorities for management and future research. Comanagement settings like the Alaska Beluga Whale Committee (ABWC) are examples of de facto analytical workshops. In the absence of a formal cooperative body, ad hoc workshops can be convened to address particular topics of interest.

Collaborative field work

Applying TEK to scientific research need not take place exclusively in an interview or meeting room. Collaborative field work offers an excellent means of interacting for an extended period. As shown by the examples of the use of TEK below, TEK has often been used to locate study sites, obtain specimens, and interpret field results. Locally hired field assistants have often contributed far more to research than mere logistical support (e.g., Dowler 1996), though this contribution is often not acknowledged.

Examples of the Use of TEK

The bowhead whale census

In 1977, the International Whaling Commission imposed a ban on the harvest of bowhead whales (*Balaena mysticetus*), curtailing a traditional activity of Alaska Eskimos (this section is based on Huntington [1989, 1992], Albert [1996, 1997], and T. Albert *personal communication*). In response, the whalers formed the Alaska Eskimo Whaling Commission (AEWC), composed of one representative of each bowhead-hunting community in Alaska. The eventually successful fight against the ban was a political one, and led to the creation of a quota for the harvest. Establishing the quota and getting it increased to a more tolerable level became a scientific battle, centered on the bowhead whale census conducted along the north coast of Alaska.

The census started with visual counts of migrating bowheads, made from sites on high cliffs or pressure ridges in the shorefast ice along the open lead through which the migratory path led. Early census counts produced population estimates of 2000–3000 bowheads. The Eskimo whalers felt that this was not an accurate figure, and that the assumptions upon which the census count was based were not valid. In particular, the visual census assumed that all migrating bowheads passed within sight of the census location, and also that when the lead was closed (i.e., the pack ice had moved in toward shore and no lane of open water remained) the bowheads stopped migrating past. The whalers, however, travel on the ice when the lead is closed and go by boat to the pack ice across the lead. At these times and in these places they see whales.

In the early 1980s, as a result of interactions between whalers and scientists similar to collaborative field work and analytical workshops, the census was expanded to include both acoustic and aerial components. The acoustic component allowed the researchers to detect bowheads migrating when the lead was closed (during which times the whales breathed through cracks in the pack ice or forced their blowholes through relatively thinner ice), and to provide a check on the completeness of the visual count. The aerial component, by flying transects perpendicular to shore and well beyond the visual range of the surface location, showed that the bowheads do in fact migrate on a front broader than the confines of the nearshore lead. Thus, in both instances the Eskimo whalers' knowledge proved accurate. The use of this knowledge had the tangible and, to the whalers, beneficial result that the population estimates increased to 6000–8000 bowheads.

The Alaska Beluga Whale Committee

In 1988, Alaska Native American hunters of beluga whales (*Delphinapterus leucas*) and government agency biologists and managers established the Alaska Beluga Whale Committee (this section is based on Huntington [1992, 1998], Adams et al. [1993], Frost [1996], Huntington and Mymrin [1996], and K. Frost, *personal communication*). The ABWC's founders reasoned that good information on beluga populations, stock identity, and harvest levels together with a sound management plan would forestall, or at least minimize the impact of, sudden action by the International Whaling Commission like that taken on the bowhead hunt.

Unlike the AEWC with its hunter-only representation, the ABWC members include government agency personnel as well as beluga hunters from around the state. (The one limitation to the government role is that only hunters can vote on hunting matters.) These biologists and managers also conduct or assist with much of the current research on belugas. Thus, the ABWC plays a substantial role in identifying data needs and in establishing research priorities and methods. In addition to allowing hunters to bring TEK into these discussions, the ABWC has established broad support for research including studies on mitochondrial DNA, studies to determine stock identity and discreteness, and satellite tagging of belugas to determine migratory and behavioral patterns.

Similarly designed studies using intrusive or invasive techniques such as satellite tag implants or radio collars have in other parts of Alaska generated considerable opposition from Native American residents who view such procedures as cruel or disrespectful (T. Brelsford 1996, *personal communication*; J. Spaeder 1997, *personal communication*). The ABWC's research, developed at meetings similar to an analytical workshop and including collaborative field work, has avoided such opposition by establishing close collaboration between hunters and scientists, based on common understanding of the ecological problems to be addressed, and mutual respect for each other's expertise.

In 1995, I began a research project to document TEK about belugas in three areas of Alaska and four areas in Chukotka, Russia, using the semi-directive interview method. The ABWC was supportive of this effort, and at the conclusion of the field work participated in a seminar to review current understanding about the documentation and application of TEK. While the TEK information documented was for the most part already known to them, the ABWC's members felt that it was valuable to have it recorded in an accessible form and identified as the knowledge of the hunters. The ABWC continues to promote the coordinated development of

TEK and biological research to better understand beluga ecology and to better manage Alaska's stocks of belugas.

Herring and the Exxon Valdez oil spill

The 1989 Exxon Valdez oil spill in Prince William Sound, Alaska, released 41.6×10^6 L of crude oil, which flowed through the sound and the Gulf of Alaska, reaching as far as Kodiak Island and the Alaska Peninsula (this section is based on Exxon Valdez Oil Spill Trustee Council 1993–1999, Brown et al. 1996, Holloway 1996; J. Seitz 1997, *personal communication*; see also Lethcoe and Nurnberger 1989, Piper 1993). Currently, the Exxon Valdez Oil Spill Trustee Council administers settlement funds from the civil lawsuit against Exxon, some of which are used for a restoration science program to study injured resources.

Among these resources is the Pacific herring (*Clupea pallasi*), which has been harvested commercially in Prince William Sound for much of this century. In 1993, the herring population crashed due to viral hemorrhagic septicemia. Whether an indirect result of the oil spill or part of a natural fluctuation, the crash has had severe economic repercussions. Residents of the area believe that the crash has also affected the distribution of predators such as seabirds and seals. Current research on herring includes examination of its life history and ecology throughout the sound and Gulf of Alaska.

This effort is hindered to an extent by the lack of documented historical data concerning distribution of herring in the region, particularly for spawn, juveniles, and the winter distribution of adults. Promoted by a researcher familiar with the communities of the Sound and one of the herring researchers, a study of the local knowledge of the region's fishermen and pilots and the TEK of native residents is currently underway to record long-time residents' observations and understanding of herring ecology. This study uses a questionnaire as well as some aspects of a semi-directive interview. The results to date include geographically and temporally extensive observations of juvenile herring and other forage fish, dating from the 1930s to the present, adding a great deal of information to the documented record on distribution of juvenile herring and the significance of certain areas as nurseries.

Discussion and Conclusions

As noted above, TEK has made a demonstrable difference in many research projects and management strategies. Why, then, does it not enjoy broader acceptance, and why is it not used more often and in more places? McDonald (1988), Johannes (1993), Nakashima (1993), and others have offered various critiques and explanations in which two factors predominate: inertia and inflexibility. The former, inertia, is merely a general resistance to change because it upsets the familiar and comfortable. Working within an established paradigm is simpler than adapting to a new one. With continued pressure from advocates and holders of TEK, more collaborative research, and a growing mass of evidence from studies documenting and incorporating TEK, this resistance may be overcome.

Inflexibility, on the other hand, is resistance specifically to TEK and the changes required by its use. It relies on more subtle arguments, questioning the reliability of TEK, or expressing concern about ''political correctness'' replacing scientific rigor. Such resistance may be due to concerns about funding priorities and about power over management decisions. Inflexibility may also include an unwillingness to work with nonscientists, indigenous or otherwise. While one would hope that evidence of the utility of TEK would help overcome this resistance as well as inertia, the positions here are more entrenched.

There are, of course, more than two reasons why TEK has not been more widely accepted. Many wildlife managers and researchers are unfamiliar with social science methods and are not prepared to attempt to use these methods to gain access to information that otherwise remains out of reach. They may also be uncomfortable in cross-cultural interactions. The holders of TEK, for their part, are sometimes reluctant to share information, and issues of ownership and control over use of TEK sometimes arise. The combination of obstacles presents a more complex problem than a simple lack of recognition of the merit of TEK.

While the validity and relevance of the reasons behind the various forms of resistance are perhaps debatable, they are an appropriate caution against the overselling of TEK. TEK, like other forms of knowledge (including science), is sometimes wrong. Such errors may be due to misinterpretations made both by observers (e.g., informants) or by collectors of information (e.g., managers and researchers). Documenting TEK can be a long process, and the effort is not always justifiable by either the applicability of the results or by the involvement of residents from the area of the study in question. Insistence on a TEK component of every ecological research and management activity will only succeed in reducing TEK to a token, to be included in a paragraph or two, and then ignored. Unquestioning acceptance of TEK is as foolish as its unquestioning rejection.

Instead, TEK should be promoted on its merits, scrutinized as other information is scrutinized, and applied in those instances where it makes a difference in the quality of research, the effectiveness of management, and the involvement of resource users in decisions that affect them. On this basis, there is ample evidence of the utility of TEK. What is needed is a broader willingness to consider its relevance, to attend to the information it offers, and to incorporate the expertise that is available.

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TRADITIONAL ECOLOGICAL KNOWLEDGE AND WISDOM OF ABORIGINAL PEOPLES IN BRITISH COLUMBIA

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Abstract. This paper discusses the characteristics and application of Traditional Ecological Knowledge and Wisdom (TEKW) of aboriginal peoples in British Columbia, Canada. Examples are provided from various groups, most notably, the Secwepemc (Shuswap) Interior Salish and Kwakwaka'wakw and Nuu-Chah-Nulth peoples of the Northwest Coast, covering a range of features comprising TEKW: knowledge of ecological principles, such as succession and interrelatedness of all components of the environment; use of ecological indicators; adaptive strategies for monitoring, enhancing, and sustainably harvesting resources; effective systems of knowledge acquisition and transfer; respectful and interactive attitudes and philosophies; close identification with ancestral lands; and beliefs that recognize the power and spirituality of nature. These characteristics, taken in totality, have enabled many groups of aboriginal peoples to live sustainably within their local environments for many thousands of years. In order for TEKW to be incorporated appropriately into current ecosystem-based management strategies, the complete context of TEKW, including its philosophical bases, must be recognized and respected. A case study of ecological and cultural knowledge of the traditional root vegetables yellow avalanche lily (*Erythronium grandiflorum*) and balsamroot (*Balsamorhiza sagittata*) illustrates ways in which these components can be integrated.

Key words: Balsamorhiza sagittata*; Balsamroot; British Columbia Plateau;* Erythronium grandiflorum*; indigenous peoples; Northwest Coast; sustainable resource use; Traditional Ecological Knowledge and Wisdom; traditional land management; yellow avalanche lily.*

INTRODUCTION

We were born there and raised there and we understand the area.

—(Stanley Sam, Nuu-Chah-Nulth Elder from Ahousaht, and member of the Scientific Panel for Sustainable Forest Practices in Clayoquot Sound, British Columbia)

Traditional ecological knowledge and wisdom (TEKW) of indigenous peoples has become a major focus of attention within the past decade (Freeman and Carbyn 1988, Johnson 1992, Berkes 1993, Doubleday 1993, Inglis 1993, Williams and Baines 1993). TEKW is acknowledged as having fundamental importance in the management of local resources, in the husbanding of the world's biodiversity, and in providing locally valid models for sustainable living. It has received major recognition as being complementary to, equivalent with, and applicable to scientific knowledge (Colorado and Collins 1987, Colorado 1988, Schultes 1988, Posey 1990, Gadgil et al. 1993, Hunn 1993, Corsiglia and Snively 1995, Salmón 1996, Richards 1997). On the international front, the Brundtland Report, *Our Common Future*, notes, ''. . . the larger society . . . could learn a great deal from their [indigenous peoples'] traditional skills in sustainably managing very complex ecological systems'' (World Commission on Environment and Development 1987:115). Recent international agreements following from the 1992 United Nations Conference on Environment and Development (UNCED) meeting in Brazil, including the *Convention on Biological Diversity, Agenda 21,* and *Guiding Principles on Forests,* specifically recognize the important knowledge of indigenous and other long-resident peoples.

In this article, we examine characteristics of TEKW that pertain to the strategies for sustainable resource use of aboriginal peoples of British Columbia and neighboring areas. In particular, knowledge about plants and their cultural importance is exemplified as a major component and reflection of TEKW. Based on data from the Secwepemc (Shuswap) and other Northwestern peoples, we propose a model for analysis of

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TEKW systems, provide examples of their various features, and make recommendations about potential applications of TEKW. We contend that TEKW can enhance resource management practices, including ecological restoration, that currently are directed largely by scientific knowledge and westernized worldviews. The emerging holistic or ecosystem-based management of forestry and fisheries will particularly benefit from its input.

Indigenous peoples have resided in a particular locality for a long period of time, depending on the resources of their homelands. Many have become marginalized within nation states, although most have remained distinct linguistically and culturally, and continue to define themselves in relation to their home environment. Their concept of guardianship over their lands requires careful management and conservation by the present generation for the benefit of future generations: ''We have to preserve and maintain our lands for the generations to come'' (Mary Thomas, Secwepemc elder, *personal communication* to N. Turner, 1996). Indigenous peoples also connect their continuing guardianship and use of their ancestral lands to inherent aboriginal rights to those places. The concept of ''Mother Earth'' thus takes on local, as well as global, relevance.

Indigenous peoples are uniquely positioned in their close and long-standing environmental relationships, yet the survival of many indigenous cultures is severely threatened by insensitive economic development, by coersive education systems, by assimilation into the modes of production and inexorable movement toward market economies of the dominant society, and by the escalating ecological destruction of peoples' homelands and resources. Indeed, worldwide, the knowledge base for TEKW is threatened, and so are the possibilities for continued expression and reproduction of this knowledge and the mode of production that it engenders.

Indigenous peoples are diverse, and cannot be treated as a single entity, in opposition to industrial or post-industrial society. Each indigenous people has its own unique economic, practical, spiritual, political, and historical relationships to its homeland. Within indigenous societies, too, knowledge is not homogeneous. For example, differential knowledge among women and men in areas of plant and animal resource management is common. The degree of assimilation with the dominant society has also varied, and along with it, retention of traditions regarding resource management techniques and knowledge systems. However, traditional knowledge among younger generations, in most indigenous groups, has inevitably diminished as assimilation and environmental change have escalated.

The widely held anthropological distinction between food gatherers (''foragers'') and food producers (''pastoralists/agriculturalists/horticulturalists'') has created an artifical gap in the classification of resource management techniques between the former and the latter. As recent data on sustainable plant management among so-called gatherers from northwestern North America show (Blackburn and Anderson 1993, Anderson 1998, Loewen 1998, Peacock 1998, Peacock and Turner 2000; N. J. Turner and S. Peacock, *unpublished manuscript*), these peoples practiced a range of techniques of plant propagation, habitat management and enhancement, and soil fertilization that maximized the productivity of plant foods and materials. These management practices blur the division between foragers and horticulturalists, and challenge us to reexamine our own conceptual schemes regarding both hunter–gatherers and the respective roles of men and women in the production and reproduction of TEKW.

Traditional Ecological Knowledge and Wisdom of Indigenous Peoples of Northwestern North America

Fig. 1 provides a framework from which to present TEKW. Its general characteristics, as reflected in traditional cultures of our region, are categorized within three broad themes: practices and strategies for resource use and sustainability; philosophy or worldview; and communication and exchange of knowledge and information. These themes are complex and not subject to simple characterization, but each is developed as a general concept, and examples are provided from various cultural groups and experiences. In this paper, we focus not so much on *which* resources were (and are) used, as on the concepts surrounding their use: the attitudes about resources, the techniques and strategies applied to their use and the underlying rationales, and the formulation of these as ''traditions'' in the context of resource management. TEKW is recognized as holistic and not easily subject to fragmentation; the themes presented here are inextricably linked and interrelated. We close by discussing a case study of the use of avalanche lily and balsamroot.

Information in this study is drawn from many sources, including published ethnobotanical writings, ethnographies, ethnohistorical writings (as cited in Turner 1995*a*), and, most importantly, from accounts of aboriginal elders.

Practices and strategies for sustainable living

Practices of aboriginal peoples to maintain and enhance their lands, waters, and living resources are derived from generations of experimentation and observation, leading to an understanding of complex ecological and physical principles. In fact, aboriginal practices represent a dialectic relationship between those practices and peoples' belief systems. Management of plant resources is manifested in at least three levels: *populations,* as in harvesting and maintaining individual stands or patches of a plant species; *habitats,* as

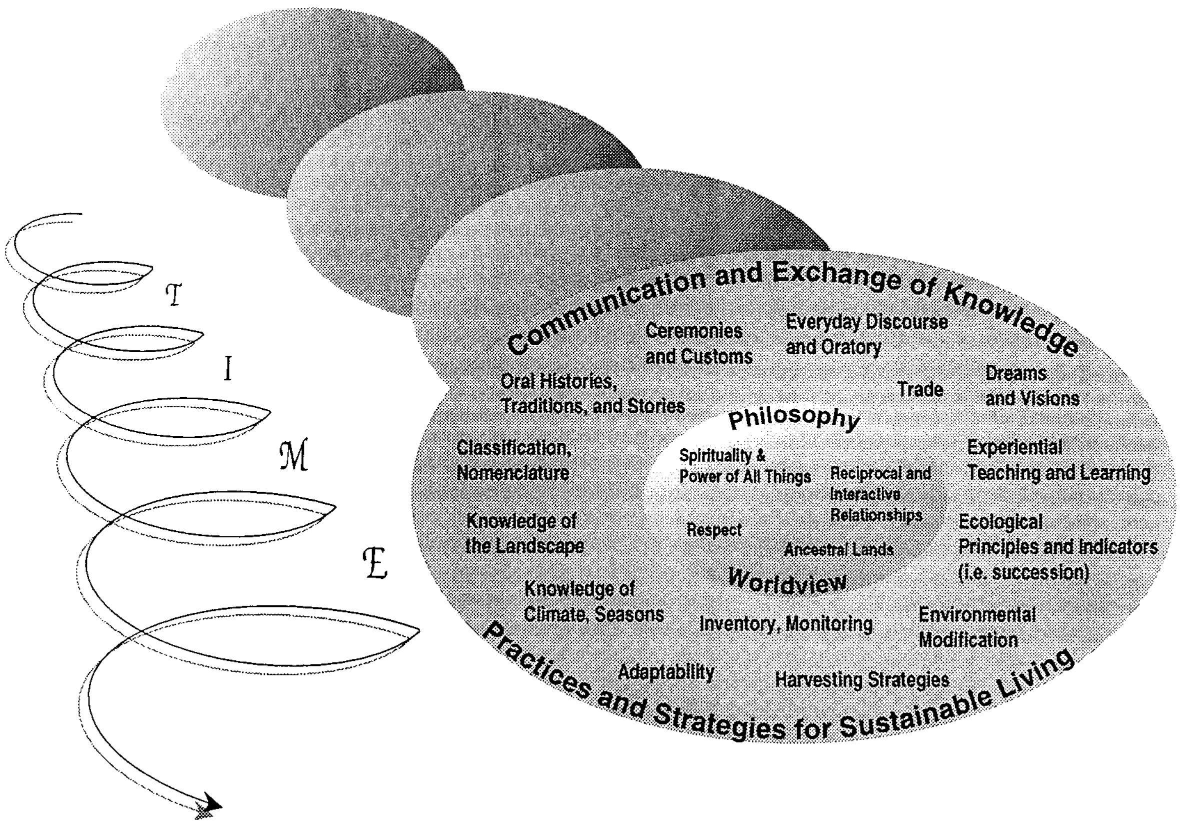

FIG. 1. Components of traditional ecological knowledge and wisdom of aboriginal peoples of northwestern North America.

with the use of fire to create and maintain particular successional stages conducive to the productivity of a complex of plant species; and *landscapes,* in which a host of strategies, including seasonal rounds leading to variable harvesting regimes, conventions relating to ownership and authority over resources, and culturally mediated prescriptions for humans' relationships to plants and animals, influence landscape development (see Peacock and Turner 2000).

Many of the techniques used by people to sustain the productivity of their plant resources are based on the fact that virtually all resource plant species in northwestern North America are perennials. Therefore, for example, unless an entire tree is required for construction or canoe making, individual plants are not generally destroyed. Instead, required parts are harvested from living plants having the capacity to regenerate. Thus, the inner bark of western red-cedar and yellow cedar was (and still is) harvested in quantity by Northwest Coast peoples for use in basketry, mats, cordage, and clothing (Turner 1998). However, seldom is bark of more than one-third of a tree's circumference removed, and the tree continues to live. Such living Culturally Modified Trees (CMTs) are a common sight in British Columbia's forests (Stryd 1997). They include not only cedars and birch trees used for their bark, but also trees with house planks split from them, various trees accessed for their edible cambium tissues, and trees and shrubs whose branches and boughs were taken for various purposes, from pit-cooking to use in the sweat house. Harvesting of bark for medicine is also done by cutting narrow strips from the trunk or by pruning branches (Turner and Hebda 1992). Even if, as in the case of harvesting root vegetables, an entire bulb or corm is removed, the harvesting is highly selective. Often, careful harvesting can lead to increased capacity for propagation. Even when large quantities of a plant product are harvested, the productivity of the plant populations can be maintained. Table 1 provides examples of various strategies used to maintain productivity of plant resources.

The efficacy and sustainability of these strategies is borne out in the quantities of resources that people consistently harvested over many, many generations. For example, root vegetables, such as spring beauty and avalanche lily for the Interior Salish St'at'imc and Nlaka'pamux, blue camas for the Straits and Halkomelem of southern Vancouver Island, and bitterroot for the Okanagan people, were harvested in immense quantities (Turner et al. 1990). Even a conservative accounting would have led to severe depletion of such resources unless they were in some way managed and

TABLE 1. Plant resources harvested and sustained by aboriginal peoples in northwestern North America.

Type of resource	Species examples	Sustainable harvesting method	References
Fibrous tree bark	western red-cedar, *Thuja plicata*; birch, *Betula papyrifera*	strip pulled off partial circumference of trunk; only outer birch bark harvested	Boas (1921), Stryd (1997), Turner (1998), Mary Thomas, *personal communication* to N. Turner, 1997
Wooden planks	western red-cedar	planks split from standing trees	Stewart (1984), Stryd (1997)
Bark for medicinal use	red alder, *Alnus rubra*; cascara, *Rhamnus purshiana*	narrow strip cut from four different trees	Turner and Hebda (1992)
Roots for basketry	red-cedar; Sitka spruce, *Picea sitchensis*	only a few roots taken from each tree	Turner (1998)
Fibrous stems and leaves for mats, cordage or baskets	cattail, *Typha latifolia*; tule, *Scirpus acutus*; stinging nettle, *Urtica dioica*; Indian-hemp, *Apocynum cannabinum*; slough sedge, *Carex obnupta*	cut from perennial plants at end of growing season; often only vegetative plants taken; plants regenerate next season	Turner (1998)
Withes and branches for basketry, rope, fish traps	saskatoon berry, *Amelanchier alnifolia*; hazelnut, *Corylus cornuta*; red-cedar; willow, *Salix* spp.	pruned from growing trees or bushes	Turner (1998)
Pitch for medicine, adhesives	western hemlock, *Tsuga heterophylla*; lodgepole pine, *Pinus contorta*; Sitka spruce; subalpine fir, *Abies lasiocarpa*; and other conifers	collected from natural human-made wounds in trees, or pitch blisters; not permanently damaging	Turner et al. (1990), Turner (1998); Christine Joseph, *personal communication* to N. Turner, 1999
Medicinal plants and roots	mountain valerian, *Valeriana sitchensis*; Indian hellebore, *Veratrum viride*	selectively harvested; often regenerated from fragments left in the ground (like a pulled-up dandelion in one's lawn)	Mary Thomas, *personal communication* to N. Turner, 1997
Edible berries, fruits and nuts	salmonberry, *Rubus spectabilis*; highbush cranberry, *Viburnum edule*; salal, *Gaultheria shallon*; hazelnut, *Corylus cornuta*; huckleberries, *Vaccinium* spp.; soapberries, *Shepherdia canadensis*	picked from bushes or from branches broken off from main bushes; sometimes bushes burned or pruned to renew their growth	Turner (1995, 1997, 1999)
Green leaves, shoots as vegetables	cow-parsnip, *Heracleum lanatum*; fireweed, *Epilobium angustifolium*; Indian celery, *Lomatium nudicaule*	picked selectively in spring from patches; plants perennial, and soon regenerate (e.g., like asparagus)	Turner (1995, 1997), Kuhnlein and Turner (1983)
Seaweed	red laver, *Porphyra perforata*	picked from rocks when young; plants allowed to regenerate	Turner (1995)
Root vegetables	blue camas, *Camassia* spp.; yellow avalanche lily, *Erythronium grandiflorum*; spring beauty, *Claytonia lanceolata*; balsamroot, *Balsamorhiza sagittata*; rice-root, *Fritillaria* spp.; springbank clover, *Trifolium wormskjoldii*; silverweed, *Potentilla anserina* ssp. *pacifica*	harvested selectively by size; smaller ''roots'' and propagules replanted; enhanced with tilling soil, sometimes weeding; burning said to enhance growth	Turner (1995, 1997, 1999), Turner and Kuhnlein (1982, 1983)
Edible tree cambium	western hemlock, Sitka spruce, black cottonwood, *Populus balsamifera* ssp. *trichocarpa*; pines, *Pinus* spp.	patch of bark removed, but trees not girdled	Stryd (1997), Turner (1987, 1995, 1997)
Edible mushrooms	pine mushroom, *Tricholoma magnivelare*; cottonwood mushroom, *T. populinum*	mature individuals cut at base; soil carefully replaced to protect those still growing	Turner et al. (1985), Turner (1997)

enhanced. Conversations with contemporary elders such as Mary Thomas and Kwakwaka'wakw Hereditary Chief Adam Dick confirm that these strategies were refined and intentional (N. J. Turner and S. Peacock, *unpublished manuscript*; see also the case study reported here).

Even when entire plants were removed, as in cutting trees, it was done in the context of ecological understanding. The trees cut down for house construction around the village of Skangwaii, on Haida Gwaii, for example, provided habitat on their stumps for growing salal, trailing currant, red huckleberries, and blueberries, and thus the area became a berry garden for the people of the village (Captain Gold, *personal communication* to N. Turner, 1996). Trees were almost always harvested selectively, with standing forest cover being maintained. Mary Thomas was told long ago that her people usually waited until trees had died or were blown down in winter storms before they were taken for use in house construction (*personal communication* to N. Turner, 1995).

Plant resource use was (and is) imbued with ecological knowledge and wisdom that take many forms. Contemporaneous life cycles of different species; seasonal signals such as position and size of snow patches on the mountains, or the arrival of the first snow in the fall; relative numbers of particular birds in a given location; flowering of certain plants; and productivity of certain berries: all of these provide indicators for people to know when to expect a salmon run, when the clams are ready to be dug, or when particular roots are ready for harvesting (Turner 1997*b*). Regeneration of individual plants also has been widely recognized. Pruning or burning of certain berry bushes, for example, was formerly a common practice, and resulted in long-term enhanced yields. Basketry materials, too, were and are managed and enhanced by focused cutting, pruning, and burning (Turner 1996).

Ecological succession was and is also recognized by aboriginal peoples, as shown by their practice of landscape burning and the resultant enhancement of successional species (Gottesfeld 1994, Turner 1999). They also had an intimate understanding of the prime habitats for various cultural species, the conditions under which they were most productive, and the best methods for processing and storing them for the optimal utilization. Similar strategies were applied to the monitoring, management, and harvesting of salmon, shellfish, and game, where seasonal, age, and gender selection, and use of ecological indicators for population health was paramount.

Monitoring and control of specific resources was often undertaken by designated individuals, such as chiefs, and by families within a given territory. These people had the direct authority to manage specific fish stocks, plants, or shellfish beds, and if they noted populations in jeopardy, they could pronounce a harvesting moratorium until the situation improved (Richardson 1982; Chief Adam Dick and Daisy Sewid-Smith, *personal communication* to N. Turner, 1996). Surveying and observations were also carried out by hunters, as they traveled through the territory, and communicated the stage of plant growth (e.g., berry ripening, availability of root plants) to their partners or wives. Likewise, wives would exchange knowledge about animal resources with their husbands or other relatives as they gathered plants.

Philosophy and worldview

For traditionally schooled aboriginal people in many regions, the environment is seen as a whole; all the parts are interconnected in a seamless web of causes and effects, actions and outcomes, behaviors and consequences. People, animals, plants, natural objects, and supernatural entities are not separate and distinct. Rather, they are all linked to each other and to the places where they reside through cultural traditions and interactive, reciprocal relationships. Because of the integration of the secular with the spiritual, of the past with the present, and of all parts of the living universe, people have a sense of spiritual and practical respect for their lands, waters, and all the environmental components that they recognize. The spirituality of these elements, and their power to influence the success and well-being of humans, has been an integral part of traditional cultures. Ancient relationships tie all beings together in communities (Anderson 1996, Turner and Atleo 1998).

Indeed, more than any other single concept, it is the notion of *respect* for all life-forms and the land itself that characterizes North American belief systems. Resource management was carried out through a value system that enforced practices of sustainability, expressed as respect for all life-forms, and sanctioned individuals who were wasteful or ''stingy.'' Notions of resource management sustained through forms of knowledge have been an integral part of the entire belief system, which stipulates spiritual connections among humans, animals, plants, and nature in general. Therefore, specific practices of resource management have expressed the ''respect'' that humans must show for all living things. Lack of respect was seen as resulting in spiritual sanctions from nature itself. Thus, aboriginal elders recall being told never to ''play with'' (i.e., playfully waste) animals or plants, which were perceived as giving themselves up for the benefit of humans. As Secwepemc elder Ida Matthew recalls, ''It was pitiful enough that we had to kill them. [My mother] instilled in us that we were not to waste the food, that we had to kill the poor animal. With any kinds of animal that we would hunt and eat, you have to respect them.'' (*personal communication* to M. B. Ignace).

The essence of this attitude is revealed in part by the words of Charles Hill-Tout in his observations on the Lillooet First Salmon ceremony (Maud 1978:117):

> Nothing that the Indian of this region eats is regarded by him as mere food and nothing more. Not a single plant, animal, or fish, or other object upon which he feeds, is looked upon in this light, or as something he has secured for himself by his own wit and skill. He regards it rather as something which has been voluntarily and compassionately placed in his hands by the goodwill and consent of the ''spirit'' of the object itself, or by the intercession and magic of his culture-heroes; to be retained and used by him only upon the fulfilment of certain conditions . . . respect and reverent care in the killing or plucking of the

> animal or plant and proper treatment of the parts he has no use for. . .

Mary Thomas (*personal communication* to N. Turner, 1997) has vivid memories of her grandmother walking along the banks of the Salmon River near her home after the sockeye had spawned, and pushing the dead salmon back into the river to float away in the current. This was undertaken with a combined sense of respect for the salmon and to nourish all the other life in the river. It was done all along the river by different people. The children, including Mary herself, were taught to do this and to respect the dead and dying salmon.

Many other indications of this respectful and interactive relationship between people and the resources they use are provided directly from elders' experiences and in the literature, for example, in the prescriptions for harvesting and using foods, materials, and medicines, in descriptions of the First Foods ceremonies, and in people's creation stories (Boas 1921, 1930, Charles Hill-Tout in Maud 1978:117, Turner 1997*b*, Sewid-Smith and Dick 1998, Turner and Atleo 1998). For example, the portrayal of the earth as having been created from a woman in the Nlaka'pamux story, ''The Creation of the Earth by Old-One,'' and its variants (Teit 1912:321–322), supports the respectful and appreciative attitude towards the earth that is part of TEKW. The precarious relationship to the land and the need to respect it is also expressed by the Haida proverb: ''The earth (land) is the same as the edge of a knife. When you are walking, watch your steps. If you don't watch your steps, you will fall off the earth'' (from Boelscher 1989).

As noted previously, the practical strategies that people developed for maintaining their resources are inextricably linked with peoples' worldviews and philosophies. Thus, the care taken by a cedar-bark gatherer not to girdle the tree yielding the bark is drawn from the knowledge that the tree would die if all the bark were peeled off, and also reflects the recognition of the power and spirituality of the tree itself:

> Even when the young cedar-tree is quite smooth, they do not take all of the cedar-bark, for the people of the olden times said that if they should peel off all the cedar-bark . . . the young cedar would die, and then another cedar-tree near by would curse the bark-peeler so that he would also die. Therefore, the bark-peelers never take all of the bark off a young tree.
>
> —(Boas 1921:616–617; see also Schlick 1994)

All kinds of skills and practices have their foundations in such beliefs. At least part of peoples' care in fostering and caring for their lands and resources relates directly to the notions of the spirituality and influential powers in all things, including the earth, as exemplified in the Nlaka'pamux notion of ''The Earth's Blanket'': ''[F]lowers, plants and grass especially the latter are the covering or blanket of the earth. If too much plucked or ruthlessly destroyed [the] earth [is] sorry and weeps[.] It rains or is angry & makes rain, fog & bad weather.'' (James Teit, ethnographer, *unpublished notes* on Nlaka'pamux [or Thompson] plant knowledge, around 1900, cited from Turner et al. 1990: 54). This general indigenous sense of respect for the Earth as ''Mother'' in our opinion does not contradict the fact that particular aboriginal peoples had particular guardianship relations, ideological bonds, and rights to their own ancestral lands. It is important to distinguish this relationship with particular aboriginal territories from the more widely mentioned guardianship of ''Mother Earth'' often invoked by contemporary environmentalists.

Communication and exchange of knowledge and wisdom

Integral to the systems of TEKW are the processes by which knowledge is communicated and transmitted among people, and from one generation to the next. Knowledge transfer occurs in many ways, and through many culturally mediated venues, beginning with the instruction of children by parents and grandparents, and by children's participation in and observation of management activities. Language is integral to the process of knowledge transfer, and one of the most serious and insidious obstacles to the perpetuation of TEKW in our region was the imposition of the Residential School system for indigenous children over the last century, in which their languages were forcibly suppressed and effectively eliminated. The widespread loss of specialized vocabulary (such as names for plants, animals, and places) and discourse associated with peoples' relationships to the land and the various life-forms is a major tragedy; yet the concepts are at least partially retained to the present day.

Although banned through federal Canadian legislation for several decades, major cultural institutions such as potlatches, feasts, first foods ceremonies, and systems of designated authority have been, and continue to be, vitally important in TEKW. For example, the Nuu-Chah-Nulth concept of HaaHuulhi, in which the recognized authority and responsibility over specific lands and resources is designated through hereditary prescription to individual chiefs, leads to intimate knowledge of specific places by individuals. They are instructed about these places and resources, and how to care for them, from the time that they are very young. They are taught the philosophies associated with the use of the land and specific practical strategies, such as maintaining and caring for salmon spawning beds and pools in a particular river (Scientific Panel for Sustainable Forest Practices in Clayoquot Sound, 1995*a*). Comparable systems of stewardship and proprietorship over lands and resources were in place throughout the region.

Children's participation in harvesting and management of traditional foods and materials is crucial; children gain practical knowledge and experience through observation and assisting their elders, parents, and grandparents. Mary Thomas and her siblings gathered up the avalanche lily and riceroot bulbs from the turf their grandmother turned over with her digging stick. Then, they watched as she examined the ''roots'' they had put into the basket, picking out the smaller ones and replacing them in the soil to grow for the future years. This is how they learned to manage the root resources. As a child, Chief Adam Dick learned similar skills and knowledge as he helped to harvest his family's riceroot patches at Kingcome Inlet (*personal communication* to N. Turner, 1997).

Narratives, told over and over again to children and adults alike, were another highly important mode of communicating TEKW. Stories such as ''Coyote Juggles His Eyes'' and the ''Star Husband Tales'' are imbued with lessons in ecology and proper ways of relating to others. A good example is the story told to Mary Thomas by her grandmother about trembling aspen (*Populus tremuloides*). When all the trees were created, Trembling Aspen would not bow down and recognize Mother Nature, its creator. As a punishment for this lack of respect, Aspen was made to tremble and shake its leaves continuously, which it still does. This story emphasized to children that they must respect their parents and their Creator (Mary Thomas, *personal communication* to N. Turner, 1997).

Many of the concepts, themes, and specific details of TEKW are widely held among different language and cultural groups in the region. Trading and other forms of intergroup communication have contributed to the commonalities of understanding (Turner and Loewen 1998). Comparisons of the names of plants and animals and associated terminology, as well as of narratives and ceremonies, can reveal some of the past ties and connections among peoples' knowledge systems (Turner et al. 1998).

Case Study: Avalanche Lily and Balsamroot

The traditional management of wild root crops in south-central British Columbia is a good example of how the many facets of TEKW are woven together to provide ecologically sustainable, nutritious, and culturally valued food sources. From this knowledge, too, ecologists and restorationists can acquire important baseline data to help in restoring degraded habitats, in gaining a better understanding of humans' role in shaping the environment, and in providing other important information, e.g., requirements for prescribed burning regimes and knowledge of feeding habits of grizzly bear and other wildlife species.

Although aboriginal peoples of the Interior Plateau are generally assumed to have derived most of their sustenance from salmon and game, plant foods have contributed to their diets in major ways, both quantitatively and qualitatively. Of the plant products eaten, roots and other underground parts were primary sources of carbohydrates, dietary fiber, and essential vitamins and minerals (Kuhnlein and Turner 1991, Hunn et al. 1998).

Recent work on yellow avalanche lily (*Erythronium grandiflorum*) and balsamroot (*Balsamorhiza sagittata*), particularly that of Loewen (1998) and Peacock (1998), has revealed complex relationships pertaining to plant ecology (harvesting practices, management, seasonality, species distribution, interspecific interactions); human health and nutrition (nutritional value, famine foods, medicine); technological innovations (processing and cooking, storage); and cultural aspects of plant use (social structure, education, language and classification, trade and exchange, narratives, and ceremonial and religious practices). In this section, we summarize briefly some of these relationships as they pertain to these two species. There are countless other such examples.

*Avalanche lily (*Erythronium grandiflorum *Pursh)*

Yellow avalanche lily, or glacier lily (Fig. 2) is widely distributed in south-central British Columbia, mostly in montane regions, but extending onto lower hillsides and valleys around Shuswap Lake. Its primary use among Plateau peoples is its edible bulbs, which formerly were harvested in large quantities, evidently ~100 kg per family per year for the Secwepemc around Chase (Palmer 1975).

The bulbs were generally harvested at their fruiting stage, when the leaves start to turn yellowish. The exact timing of this stage varied according to elevation, so that people could start harvesting the bulbs in lowland areas in May and June, and extend their harvesting into the montane meadows through July and early August. Only the largest bulbs were selected; these were determined by choosing stems with multiple fruiting capsules, indicating the most mature plants, or possibly those genetically disposed toward large size. Mary Thomas (*personal communication* to N. Turner and D. Loewen, 1997) noted that the bulbs are only good at a certain stage in their development; if dug too early, they were too soft, and after their ''ripe'' stage, they became too watery and were no longer considered edible.

Harvesting the bulbs involved prying up a section of turf, discarding the upper layer containing competing grasses and other species, then turning over the loamy soil, selecting the largest bulbs, and replanting the small ones. Because the seed capsules would have been mature, intentional or incidental scattering of seeds into the freshly tilled soil would have enhanced the propagation of the plants. As well, the small propagule attached to the lower part of the bulb was intentionally removed and replanted, or saved and later returned to the digging site, according to Mary Thomas.

FIG. 2. Left: Yellow avalanche lily, or yellow glacier lily, *Erythronium grandiflorum* (Liliaceae). Right: Dried bulbs of *E. grandiflorum.*

She also noted that people would leave the dug-over locality alone for three or four years after an intensive harvest, moving to another location in the interim. After this time, the younger bulbs would have matured and would be ready for further harvest. The continuous digging and tilling of the soil, weeding, and breaking up and spreading of clumped bulbs evidently optimized the productivity of the lilies, for the preferred harvesting grounds are those that traditionally have been dug intensively.

Sometimes people left the bulbs, once dug, to ''wilt'' out on the ground at the digging site. This was to make them easier to thread and dry, but also, according to some people, the process made them taste sweeter, apparently because more sugars were produced. The carbohydrate content of the bulbs changes considerably with life cycle stage, as well as with processing (Loewen 1998), and this undoubtedly influenced their taste, digestibility, and energy contributions.

Several other root vegetables grow together with the avalanche lily, notably spring beauty (*Claytonia lanceolata*), riceroot (*Fritillaria lanceolata*), tiger lily (*Lilium columbianum*), and nodding onion (*Allium cernuum*). Not surprisingly, peoples' seasonal movements over their territories were guided in large measure by the presence and availability of these and other plant resources. The ''roots'' were dug concurrently, and some of the management practices pertaining to avalanche lily also influenced the use and productivity of the other species. In particular, all of these species are noted to have been enhanced in quality and productivity through controlled landscape burning (Turner 1999). The roots were often stored and served together in special dishes with other ingredients such as dried saskatoon berries (*Amelanchier alnifolia*), deer fat, salmon eggs, and black tree lichen (*Bryoria fremontii*), to provide highly nutritious and well-balanced food combinations (Turner et al. 1990). Additionally, the bulbs were known to be valued as accessible, predictable food in time of food shortage, when fish and game were not available (Turner and Davis 1993).

Avalanche lily bulbs are also known to be eaten by grizzly bears and by various small rodents. People were very familiar with the foods of animals, and often used their observations to enhance their own diets. For example one St'at'imc elder from Mount Currie (A. Peters, *personal communication* to N. Turner, 1984) recalled seeing grizzly bears digging avalanche lily up in the subalpine parklands, turning over the turf to leave the bulbs exposed to the sun and air for a few days before returning to consume them:

> You've got to go pretty well up the top of a mountain for it [k'ám'ts, *Erythronium* bulbs], the summit. In a certain time of the year they pick it. . . . The old-timers used to pick it and dry it for winter use. I know the grizzly bears they dig it out too. They use their big claws like that [raking motion], and they just leave it like that in the sun, you know. I guess they must taste good when they're dry. They don't eat it right away. I've watched them. A long time, I've watched the grizzly bear, digging it out. I've seen them k'ám'ts laying like that. . . .

It is quite likely that people first learned of the edibility of these bulbs from observing the feeding habits of grizzlies, and possibly learned to ''wilt'' the bulbs from these animals as well. Sometimes, too, people availed themselves of the stored roots of small mammals from their underground storage caches, but they were always careful to leave some of the roots, or to leave a gift of

FIG. 3. Left: Balsamroot or spring sunflower, *Balsamorhiza sagittata* (Asteraceae). Right: Harvested roots of *B. sagittata,* to be peeled and pit-cooked before being eaten.

grain or other food for the rodents in return for their "gift."

*Balsamroot (*Balsamorhiza sagittata *(Pursh) Nutt)*

Balsamroot, or spring sunflower, is a member of the Asteraceae (Fig. 3) and produces multiple foods for Plateau peoples: taproots, young shoots, flower bud stalks, and achenes. The roots, little used at present, were formerly pit-cooked and eaten in quantity. This species is wide-ranging throughout the interior plateau, from the lower valley slopes into upland valleys such as Botanie Valley, near Lytton, in grasslands and open woodlands (Turner 1997*a*). Some people say that the lowland plants produce the best roots for eating (Turner et al. 1990). As with avalanche lily, however, the roots, which were usually dug in the spring before flowering, could be harvested progressively from the lowlands to farther up in the mountains as the season advanced.

The ideal size of root to harvest was from plants with 6–12 leaves and taproots about the size of carrots. The largest roots, probably several decades old, in some cases, were called the "mother" roots, and they were never dug as food. They produced up to 40 or 50 leaves and 20–30 flowerheads. These mother roots could be as large as one's forearm, and could extend half a meter into the ground. In traditional harvesting regimes, they would serve as a source of seeds for food, and also for continuing propagation of the species.

Once dug, the roots were cooked, dried, and stored. They were also used medicinally, being boiled to produce a resin that was used as a poultice for burns, cuts, and other wounds. The powdered leaves of balsamroot were also used on wounds to reduce infections (Mary Thomas, *personal communication* to N. Turner, 1996). Balsamroot is considered to have many "relatives" such as arnica (*Arnica* spp.) and brown-eyed Susan (*Gaillardia aristata*). Ecologically, it is associated with other food plants such as prickly pear (*Opuntia* spp.), mariposa lily (*Calochortus macrocarpus*), desert parsley (*Lomatium macrocarpum*), and yellowbells (*Fritillaria pudica*).

Preparation of root crops for consumption

Traditionally, both avalanche lily bulbs and balsamroots were pit-cooked, before or after being dried. Pit cooking is a complex and highly effective method for cooking and flavoring large quantities of root vegetables and other foods such as deer meat, fish, and shellfish. Various pit-cooking recipes were used throughout the Northwest Coast and the Interior Plateau (cf. Turner 1995*b*, 1997*a*, Turner et al. 1983, 1990). In cooking pits, vegetation such as Douglas-fir boughs (*Pseudotsuga menziesii*), branches of certain shrubs, or damp grass surrounded the food as it cooked. In experimental reconstruction, the pit temperature can reach 100°C after a couple of hours, and relatively high temperatures are sustained for many hours. Some foods, including both avalanche lily bulbs and balsamroots, were left to cook for 24 hours or more. Chemical conversions have been demonstrated for pit-cooked foods, in which complex carbohydrates such as inulin (a complex sugar with fructose as basic units) are significantly reduced into simpler forms, producing more digestible and probably more palatable end products (Kuhnlein and Turner 1991, Loewen 1998, Peacock 1998).

Pit-cooking practices extend well back in the archaeological record, and are apparently indicative of intensification of root use as important foods >2000 years ago (Pokotylo and Froese 1983, Peacock 1998). The use of root diggers also has ancient origins: handles of root-digging sticks dating to ~2400 years ago have been found in the Plateau region near Kamloops and Chase. The antiquity of intensive root harvesting attests to its ecological sustainability and to the success of the various practices applied in its promotion.

Cultural and linguistic context

Both avalanche lily and balsamroot, as well as other food resources, depended upon the harvesting, processing, and preparation of a number of other resources: the woods used for making the digging sticks; the birch bark (*Betula papyrifera*), red-cedar root (*Thuja plicata*), and cherry bark (*Prunus emarginata*) for the baskets needed to transport the roots; the maple bark (*Acer glabrum*) used to string the bulbs or roots for drying; the Indian hemp (*Apocynum cannabinum*) fiber, silverberry (*Elaeagnus commutata*), or other fibers used for weaving storage bags; and the fuel and vegetation used for cooking and flavoring them (Turner 1996, 1997*a*, 1998).

There are names for avalanche lily and balsamroot in all four Interior Salish languages in British Columbia, as well as in Tsilhqot'in, Carrier, and other neighboring languages. The names for avalanche lily are from two distinct linguistic lines, both apparently unanalyzable in these languages (Turner et al. 1990), indicating a probable long-term association of these peoples with the plant. For the versatile balsamroot there are, in some cases, separate and specific names for the various edible parts (see Turner et al. 1990). Conceptually, these plants are often considered together in a broad, but generally unnamed, category of ''edible roots,'' resources that share many commonalities in harvesting, management, processing, storage, and serving, and play similar roles in traditional diets.

Many places are named after these root plants around the southern Interior. For example, there is flat area in Botanie Valley (which is a famous root-harvesting valley in Nlaka'pamux territory) called *k'em'k'em'ats-útsiyem'cw* after the avalanche lily that grows there abundantly. People were also sometimes named after these plants (Turner et al. 1990).

Women were the major harvesters of root vegetables, using pointed wooden or antler digging sticks. Children also participated, learning the techniques and sizes to select from their mothers and grandmothers. Women were also the main processors and preparers of these foods, and were generally the ones to determine what quantities should be harvested, what types of processing and storage should be used, and how much might be available for trade.

Both avalanche lily and balsamroot feature in many traditional narratives, particularly those involving grizzly bears and avalanche lily (Teit 1898, 1912). Balsamroot was associated with several rituals relating to its preparation (Teit 1900, Turner et al. 1990, Peacock, 1998). For example, Nlaka'pamux women, while digging or cooking the roots, had to abstain from sexual intercourse. A man was not to come near the cooking pit while the roots were being cooked. Women often painted their faces red, or painted a large black or red spot on each cheek, when they went to dig the roots. Prayers were offered to the balsamroot plant by young people when eating the first berries, roots, or other foods of the season: ''I inform thee that I intend to eat thee. Mayest thou always help me to ascend so that I may always be able to reach the tops of mountains, and may I never be clumsy! I ask this from these, Sunflower-root. Thou are the greatest of all in mystery'' (Teit 1900:349). There were also taboos against a bereaved spouse eating balsamroot for a whole year after the bereavement (Teit 1900).

Contemporary status of traditional root vegetables

It is ironic that contemporary elders like Mary Thomas have noticed a distinct deterioration in the quality and productivity of root vegetables such as avalanche lily and balsamroot. Mary Thomas (*personal communication* to N. Turner, 1995) summarized her observations of the impacts of cattle on traditional Secwepemc root vegetables:

> Everything is deteriorating—the surface of the soil where we used to gather our food, there's about 4 to 6 inches of thick, thick sod and all introduced [plants]. And on top of that the cattle walk on it, and it's packing it to the point where there's very little air goes into the ground, very little rain, and it's choking out all the natural foods [e.g., rice-root, avalanche lily, spring beauty], and it's going deeper and deeper, and the deeper they go the smaller they're getting.

She said that her grandmothers and mother would not even consider harvesting avalanche lily bulbs that were smaller than 2.5 cm across and 7–8 cm long. Now, because of the cattle and the dense turf, and because people are not digging these roots any more, it is almost impossible to find plants with bulbs of this size. She also observed that much of the prime digging meadowlands for avalanche lily are being innundated by shrubs such as black hawthorn (*Crataegus douglasii*). This is because people are not burning the way they did formerly. Gradually, she believes, these meadows will be completely covered with bush.

She recalled, from her childhood, seeing the horses run through the fields of balsamroot in the Neskonlith Meadows near Chase; their bellies were colored yellow by the pollen of the flower heads, so high and lush-growing were the plants. Now, because of the trampling of cattle and introduced weeds, the balsamroot plants are only about 30–40 cm high, and are almost impossible to dig. Obviously, if we want to try to restore such areas, these observations are invaluable.

Summary of case studies

These descriptions of the ecological and cultural aspects of these two important root vegetables incorporate some of the complexities and interactive elements of TEKW for the Interior Salish peoples. Virtually all of the culturally important plants of British Columbia, as well as other areas of North America, are underlain by equally rich and significant traditional knowledge. If ecologists, resource managers, and restorationists are to truly understand these resources and the ecological and cultural systems that support them, they will need to recognize and rely more fully on TEKW of indigenous peoples.

Conclusions

In looking for answers and solutions to ecological dilemmas that we face, such as loss of biodiversity and imperatives for restoration of degraded lands, it is important to respect, recognize, and apply TEKW of indigenous peoples, with their full participation and collaboration. There are good models for integrating TEKW in ecosystem management decision making in ethical and effective ways (e.g., Osherenko 1988, Pinkerton 1989, Scientific Panel for Sustainable Forest Practices in Clayoquot Sound 1995*a*, *b*), but more need to be developed. All of us, scientists and nonscientists alike, are looking for a more complete understanding of ecosystems, so that we can better care for them and alleviate some of the damage that we have done. TEKW provides answers, not only in terms of detailed observations of particular localities and resources, but also in terms of philosophies and methods of acquiring and communicating knowledge that can enrich our lives and help us to achieve a better, more sustainable relationship with our environment.

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