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Indigenous Knowledge for Biodiversity Conservation

Indigenous peoples with a historical continuity of resource-use practices often possess a broad knowledge base of the behavior of complex ecological systems in their own localities. This knowledge has accumulated through a long series of observations transmitted from generation to generation. Such "diachronic" observations can be of great value and complement the "synchronic" observations on which western science is based. Where indigenous peoples have depended, for long periods of time, on local environments for the provision of a variety of resources, they have developed a stake in conserving, and in some cases, enhancing, biodiversity. They are aware that biological diversity is a crucial factor in generating the ecological services and natural resources on which they depend. Some indigenous groups manipulate the local landscape to augment its heterogeneity, and some have been found to be motivated to restore biodiversity in degraded landscapes. Their practices for the conservation of biodiversity were grounded in a series of rules of thumb which are apparently arrived at through a trial and error process over a long historical time period. This implies that their knowledge base is indefinite and their implementation involves an intimate relationship with the belief system. Such knowledge is difficult for western science to understand. It is vital, however, that the value of the knowledge-practice-belief complex of indigenous peoples relating to conservation of biodiversity is fully recognized if ecosystems and biodiversity are to be managed sustainably. Conserving this knowledge would be most appropriately accomplished through promoting the community-based resource-management systems of indigenous peoples.

INDIGENOUS AND MODERN KNOWLEDGE

Knowledge is an outcome of model-making about the functioning of the natural world. All societies, pre-scientific and scientific strive to make sense of how the natural world behaves and to apply this knowledge to guide practices of manipulating the environment. Before the elaboration of the modern hypothetico-deductive method of systematically accumulating understanding of the functioning of the natural world, pre-scientific societies accumulated knowledge at a rather slow pace. Much of this knowledge was qualitative and based on observations on a rather restricted geographical scale. Within these bounds, reference to habitat preferences, life histories and behavior patterns of prey species such as birds, could be amazingly detailed (1, 2). Models of how the natural world functions as well as prescriptions on how to manipulate it are inevitably linked to any society's world view. However, in pre-scientific societies such models and prescriptions are much more closely integrated with moral and religous belief systems, so that knowledge, practice and beliefs co-evolve.

Modern scientific knowledge, with its accompanying world view of humans as being apart from and above the natural world has been extraordinarily successful in furthering human understanding and manipulation of simpler systems. However, neither this world view nor scientific knowledge have been particularly successful when confronted with complex ecological systems. These complex systems vary greatly on spatial and temporal scales rendering the generalizations that positivistic science has come up with of little value in furnishing practical prescriptions for sustainable resource use (3, 4). Science-based societies have tended to overuse and simplify such complex ecological systems, resulting in a whole series of problems of resource exhaustion and environmental degradation.

It is in this context that the knowledge of indigenous societies accumulated over historical time, is of significance. The view of humans as a part of the natural world and a belief system stressing respect for the rest of the natural world is of value for evolving sustainable relations with the natural-resource base (5).

Not all pre-scientific societies have necessarily lived harmoniously with the natural world, and not all indigenous peoples, outside industrial societies do so today (6). For example, some nomadic hunter-gatherers, who are not tied to any specific resource base and without well-defined territories, may gain little from prudent resource use. The same is true for agriculturists colonizing new territories with options of moving on to new localities as resources are exhausted. Rather, it is the more sedentary fishing, horticultural or subsistence agricultural societies with considerable dependence on hunting and gathering in their immediate neighborhoods that are most likely to have accumulated long series of historical observations of relevance to sustainable resource use and conservation of biodiversity. Self-regulatory mechanisms tend to evolve in such societies when they are faced with resource limitations. Among these mechanisms is a recognition and accumulation of knowledge about the important role that species play in generating ecological services and natural resources. As several major studies point out, *indigenous knowledge*, or *traditional ecological knowledge*, is of significance from a conservation perspective and an attribute of societies with continuity in resource use practices (7, 8).

Indigenous knowledge is herein defined as a cumulative body of knowledge and beliefs handed down through generations by cultural transmission about the relationship of living beings, (including humans) with one another and with their environment (9).

Many indigenous societies depended on a rather limited resource catchment of a few hundred square kilometers to provide them with a wide diversity of resources. This is not to say that they were isolated societies; many had ongoing trade and social relationships with more complex societies. However, the extent to which indigenous societies transformed local resources through manufacturing was limited, as was their ability to supplement locally available resources with imports. Thus, there were strong incentives for indigenous people to nurture and sustain diversity in their immediate environs (10). They may therefore be expected not only to conserve locally present natural biodiversity, but also to augment it by manipulating the landscape. Such manipulations could increase landscape patchiness, for instance by introducing various successional stages, thereby enhancing diversity in local resource catchments.

This paper examines local biodiversity conservation and enhancement activities of indigenous peoples, the knowledge base

A sacred *Mimusops elengi* tree believed to harbor a nature spirit, Yakshi, near Siddapur in Karnataka state in the mid Western Ghats of south India. Myriads of such sacred trees still dot the Indian countryside. Photo: M. D. Subash Chandran.

underlying it, as well as linkages to practices dealing with ecosystems and related belief systems. This accumulation of experience, knowledge and beliefs in dealing with the natural environment may be viewed as a kind of "capital". The paper also considers how this stock of "cultural capital" (11) may be retained and put to use in broader efforts to conserve biodiversity.

ENHANCING BIODIVERSITY

There is ample evidence of indigenous knowledge and practices involved in enhancing biodiversity at the landscape level.

Recent work in the Amazon basin has concentrated on longer-term changes in the forest structure, and found practices that result in the creation, for example, of forest islands, *apete*, by the Kayapo Indians of Brazil who live at the southern limit of the rainforest (12). *Apete* begin as small mounds of vegetation about 2 m in diameter (*apete-nu*). As planted crop and tree seedlings grow and the planted area expands, the taller vegetation in the center of the mound are cut to allow light. A full-grown apete has an architecture that creates zones that vary in shade and moisture (Fig. 1). The species mix includes medicinal species, palms, and vines that produce drinking water. Of a total of 120 species found in ten apete, Posey estimated that 75% may have been planted.

New apete fields peak in crop production in 2 to 3 yrs, but some species continue to be productive for a longer period: sweet potatoes for 4 to 5 yrs, yams and taro for 5 to 6 yrs, papaya and banana for 5 or more years. Contrary to common belief, old fields (*ape-ti*) are not abandoned when the primary crop species disappear; they keep producing a range of useful products. They become forest patches in the savannah-like open cerrado, managed for fruit and nut trees, and "game farms" that attract wildlife. This behavior actively promotes patchiness and heterogeneity in the landscape through a number of devices. Posey first became aware that these isolated forest patches were human-made in the seventh year of his field research (13).

Working in the Ecuador portion of the Amazon forest, Irvine (13) has also reported that Runa Indian swiddens resemble agroforestry systems rather than the slash-and-burn that merely results in temporary clearings in the forest canopy. Compared to unmanaged fallows, Irvine (14) found that management actually increased species diversity in 5-year-old fallows. Between 14 and 35% of this enhanced species diversity was attributed to direct planting and protection of secondary species. Irvine (14) characterized Runa agroforestry as a low-intensity succession management system which, nevertheless, alters forest composition and structure in the long run.

There is species diversity management also in some traditional aquaculture systems. Unlike many contemporary single-species, high-input, high-throughput aquaculture systems (15, 16), many of the ancient fish-rearing systems of China, Hawaii, Indonesia and elsewhere make use of a mix of species, taking advantage of the ecological characteristics of each, and making full use of waste recycled to provide food. Some Chinese systems combine, for example, grass carp, silver carp, bighead carp, common carp with three other aquaculture species, taking advantage of their complementary feeding specializations (17). The Chinese have also developed integrated agriculture-aquaculture systems in which agricultural waste feeds the fish, and fish waste fertilizes crops. An example is the fish-farming system integrated with mulberry-silkworm, vegetable and sugarcane production in the Zhujiang delta (18).

In Indonesia, traditional systems combined rice and fish culture, and wastes from this system often flowed downstream into brackish water aquaculture systems (*tambak*). The tambaks themselves were polyculture ponds, often combining fish, vegetables and tree crops (19). East Asia and Oceania had, and to some extent still has, a wealth of these systems. In ancient Hawaii, both freshwater and seawater fish ponds were integrated with agriculture, and river valleys were managed as integrated systems, from the upland forest (left uncut by taboo) all the way to the reef (20) (Fig. 2).

Costa-Pierce (20) provides a list of cultured species, some 10 to 20 in each of the four kinds of fish ponds. As with the Chinese carp culture systems, the number of cultivated species must have been fewer than those available in the natural environment. Nevertheless, the point is that both agriculture and aquaculture systems in these traditional societies were more diverse than contemporary food production systems. They were more "in

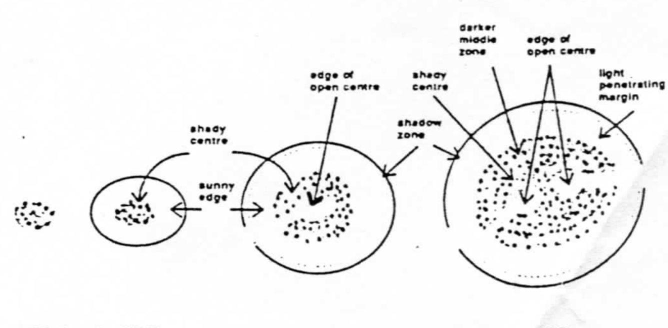

Figure 1. Enhancing biodiversity through the creation of forest islands, *apete*, by the Kayapo Indians of Brazil. Through a number of devices the behavior promotes patchiness and heterogeneity in the landscape in time and space (modified from 12).

tune" with natural ecosystem processes, and in fact one of them, the Hawaii case, may be considered an example of sustainable ecosystem management.

Habitat management by traditional agriculturalists and agroforesters is relatively well known. More controversial is habitat management by hunter-gatherers. Relatively recent work on fire management among Australian aborigines and northern Canadian Amerindians has shed new light on the controversy. Lewis and Ferguson (21) reported that Amerindians of northern Alberta, Canada, regularly used fire until the late 1940s to open up clearings (meadows and swales), corridors (trails, traplines, ridges, grass fringes of streams and lakes), and windfall forests. These clearings provided improved habitat for ungulates and waterfowl, thus, increasing hunting success, and the corridors and windfall areas improved accessibility.

Lewis' (22) work in Australia showed that aborigines possessed detailed technical knowledge of fire, and used it effectively to improve feeding habitat for game and to assist in the hunt itself. Lewis and Ferguson (21) theorized that cross-cultural comparisons of Amerindians from northwestern Canada, western Washington State and northwest California, and Australian aborigines from Tasmania, New South Wales, Western Australia and the Northern Territory indicate functionally parallel strategies in the ways that hunter-gatherers used fire.

Another widely used traditional practice, that of rotation of harvesting pressure, would similarly contribute to landscape heterogeneity. The principle of rotation in agriculture is well known: land is periodically fallowed or "rested", and often planted with species that help restore soil fertility. Less well known is the use of rotation for grazing lands and for hunting and fishing grounds. In semiarid regions such as the fringe of Sahel, plant productivity is seasonal and follows the rains. Many of the larger herbivores have adapted to this pattern by migrating seasonally, and the migrations of traditional herding peoples also follow the same adaptation. Much of the problem of the Sahel is traceable to the disruption of this adaptation by the settlement of herding peoples (23). The yearly cycle of nomads and their cattle is a rotation, providing a chance for the recovery of heavily-grazed rangelands. Throughout arid and semiarid Africa, traditional herders followed migratory cycles, rotating grazing land seasonally and, in some cases, also rotating adjacent grazing areas in the same season (24).

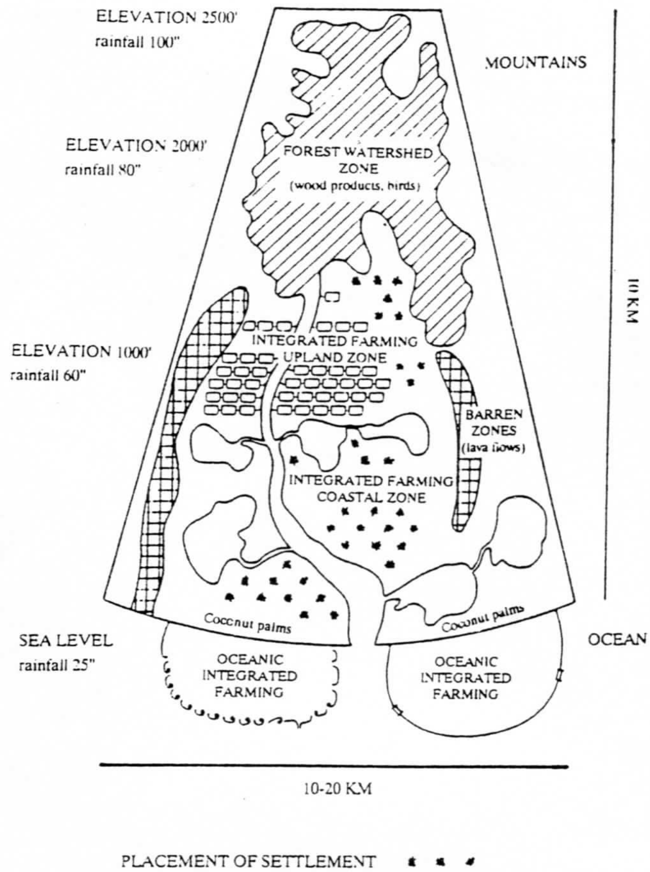

Figure 2. In the *ahupua'a* system of Hawaii, both freshwater and seawater fish ponds were integrated with agriculture, and river valleys were managed as integrated systems, from the upland forest (left uncut by taboo) all the way down to the reef (modified from 20).

Amerindians at a market in the Peruvian Andes. Photo: C. Folke.

Rotation of hunting and fishing lands of native Amerindian people have been described from eastern subarctic Canada. Feit (25) has reported on Waswanipi Cree Amerindian hunting-trapping territories in the James Bay area. The community lands of Cree groups are divided into a number of traditional hunting areas, each with a "stewart" in charge. In the ideal case, the steward divides his area into four segments, and concentrates on one segment per year, with a four-year rotation. Feit (25) found that the beaver harvest in areas rested for two or more years was significantly higher than in areas not rested. For moose, the trend was similar but statistically not significant. Berkes (26) found that Chisasibi Cree goose hunters rotated hunting areas on a 7-day cycle. In this case, the function of the rotation was to reduce disturbance to feeding and resting geese, and to harvest for subsistence needs with a minimum disruption of the large population that passes through the area.

Fish harvesting also followed rotations–rotations of different periodicities depending on the area. Remote lakes were fished on a 4 or 5 year cycle (27), a traditional pattern which has been incorporated into government fisheries management policy for remote northern lakes in Ontario and Manitoba as well. Chisasibi Cree fishermen used shorter cycles in coastal fishing near the community, fishing each cove hard until the catch per unit of effort fell below a threshold level and then moving to a different cove (26). The sustainability of the Chisasibi Cree fishery was tested and confirmed by comparing the age-frequency data for the two most important stocks, whitefish *Coregonus clupeaformis* and *C. artedii*, sampled 50 years apart (28). In each of these rotation cases, biodiversity conservation is an indirect effect of maintaining the general productivity of the habitat, whether it is grazing land or fishing area.

RESTORING BIODIVERSITY

With their interest in the availability of a wide diversity of resources within their resource catchments one expects indigenous people to contribute to restoration of biodiversity in the depleted landscapes as well. Where a stake in local resources has been created for them, indeed they do so, their detailed knowledge of succession and habitat preferences of the different species greatly contributing to such a process.

This, for example, has been the experience of village forest-protection committees in the Indian state of West Bengal (29). Over the last 10 years this state has pioneered involvement of local, mostly tribal communities of Midnapore and Purulia districts in protecting local forests to encourage natural regeneration. Once empowered and assured of a share in the produce of regenerated forest stocks, the local people have very enthusiastically nurtured regeneration of the local species-diverse forest dominated by the dipterocarp *Shorea robusta*. They have been especially motivated in this by their own immediately improved access to a wide variety of non-wood-forest-produce.

The National Wasteland Development Board (NWDB), an agency of the Government of India's Ministry of Environment and Forests, is now planning to seriously encourage such local initiatives for restoring productivity and biodiversity of degraded lands. NWDB's (30) experiment in microplanning for integrated development of wastelands now calls for preparation of a detailed land and water-management plan at a decentralized level through the agency of local village populations. It further recommends that all new plantations should include a nucleus of totally protected area, perhaps to the extent of 5% of the total, that would attempt to recreate a diverse plant community stocked by indigenous species. Such nuclei would be analogous to the traditional sacred groves or safety forests of Mizoram discussed in the next section, while the plantations would serve as supply forests. While this experiment is just being launched, the reaction of local people to the recreation of such species diverse patches appears to be entirely favorable.

CONSERVING BIODIVERSITY

That indigenous people are aware of a large variety of uses of local biodiversity including medicinal uses which have been incorporated in the modern pharmacopoeia is well known, as is their knowledge of habitat preference, life history, and behavior relevant to efficient foraging for such resources. Such knowledge is explicit and socially transmitted from one individual to another within and across generations in the same manner as scientific knowledge. The indigenous knowledge base pertaining to conservation is not as explicit. Conservation calls for restraints in resource use. The exact nature of such restraints is difficult to ascertain. Witness for example the bewildering array of fisheries regulations on mesh size, closed seasons, and quotas that may still prove insufficient to prevent the collapse of fisheries. Furthermore, resource management regulations may be difficult to implement because short-term individual interests may contradict long-term societal interests. Arriving at an appropriate set of restraints and implementing them is therefore not a simple matter of information transmission. Rather, implementation seems to be based on a complex set of "rules of thumb" arrived at through accumulated historical experience. Compliance is often facilitated through religious belief, ritual, and social conventions.

Four kinds of indigenous conservation practices are of particular relevance. They include:

(a) Total protection to many individual biological communities including pools along river courses, ponds, meadows and forests. Thus, sacred groves were once widely protected throughout the old world. They continue to be so protected even after conversion to Christianity in the tribal state of Mizoram in northeastern India, now being called "safety forest", while the village woodlot from which regulated harvests are made is called the "supply forest" (31). Ecological theory suggests that providing such absolute protection in "refugia" can be an effective way of ensuring persistence of biological populations (32).

(b) All individuals of certain species of plants and animals may be afforded total protection. Trees of all species of genus *Ficus* are protected in many parts of the old world. It is notable that *Ficus* is now considered a keystone resource significant to the conservation of overall biodiversity (33, 35). Local people seem to be aware of the importance of *Ficus* as affording food and shelter for a wide range of birds, bats and primates, and it is not difficult to imagine that such understanding was converted into widespread protection of the *Ficus* tree at some point in the distant past. It is more difficult to visualize the ecological significance of protection on a local scale, a large number of different plants and animals as being totemic.

(c) Certain particularly vulnerable stages in the life history of an organism may be given special protection. Thus, in south India fruit bats may be hunted when away foraging, but not at daytime roosts on trees that may be in the midst of villages. Many waders are hunted outside the breeding season, but not at heronaries, which may again be on trees lining village streets. The danger of overharvest and depletion of population is clearly far greater if these vulnerable stages are hunted and the protection afforded to them seems a clear case of ecological prudence (34, 35).

(d) Major events of resource harvest are often carried out as a group effort. Many tribal groups engage once a year in a large-scale communal hunt. Such a group exercise may have served the purpose of group-level assessment of the status of prey populations, and their habitats. This in turn may have helped in continually adjusting resource harvest practices so as to sustain yields and conserve diversity.

KNOWLEDGE, PRACTICE AND BELIEF

Joshi and Gadgil (32) provide a possible model of how such a complex of prescriptions and beliefs may evolve. They model an indigenous society attempting to maximize harvests from some biological population while keeping the risk of its extinction at a minimum. This is most effectively arrived at by using a decision rule involving total protection to a part of the population in a series of dispersed refugia. The optimum extent of such refugia may be arrived at by enhancing the total area under refugia whenever: (a) an increase in the area under refugia results in higher yields, or (b) a decrease in the area under refugia results in lower yields.

By the same token the total area under refugia should be reduced whenever: (a) an increase in the area under refugia leads to decreased yields, or (b) a decrease in the area under refugia leads to increased yields.

This of course holds when the harvesting effort outside refugia is constant. If the harvesting effort varies, decision rules can be appropriately amended. Joshi and Gadgil (32) found that such a system of decision rules incorporating refugia is far more likely to permit the social groups to arrive and stabilize at sustained yield levels, than a system where the level of harvesting effort is adjusted while harvesting from the entire population. Furthermore, a harvesting regime involving absolutely no harvests from refugia, while permitting harvests elsewhere is easier to implement than harvest quotas. It is also far easier to perceive and adjust the extent of refugia than levels of harvesting efforts.

As noted above, systems of refugia such as sacred ponds and groves are widely prevalent elements of indigenous resource-management systems. These systems might quite plausibly have been established through a process–involving decision rules of the kind sketched above. If so, the social group as a whole may be only vaguely aware of the rationale behind the system being implemented through religious beliefs. Such a process would inevitably result in a commingling of knowledge, practice and belief which seems to characterize conservation practices of indigenous people.

CONCLUSIONS

Resilience, the ability of the ecosystem to recover from surprises and shocks and to continue to function and provide ecological services, is probably the most critical ecosystem property to sustain (36). Generally, only a small number of species have a major role in ecosystem processes. But, when the ecosystem is stressed or perturbed, a larger number of other species perform a buffering role, in the sense that they contribute to the resilience of the system. Without these understudy species resilience is reduced, or perhaps even lost. Therefore, many ecologists argue that ecosystem resilience is promoted by biodiversity conservation. If resilience is the key property to be maintained to assure the generation of essential ecological services to human societies, then long-term historical experience of particular ecosystems is obviously of vital importance.

Indigenous people with their diachronic data, rather than western science with its reliance on synchronic data, may therefore have far more valuable knowledge relevant to biological conservation. But as indigenous knowledge is intricately linked to practice and belief, it is difficult to interpret this knowledge in the framework of western science. On the other hand, it is easier to abstract the knowledge directly related to utilization, for instance medical properties or fruiting times. Indeed, current efforts are mostly focussed on using indigenous knowledge for this purpose. Indigenous knowledge of conserving and enhancing biodiversity may be best put to use as an integrated system of knowledge, practice and beliefs. If this is to happen, then indigenous cultures must be conserved through the recovery of the right to decide their own destiny and the patterns of resource use they wish to pursue. This in turn calls for empowering communities of indigenous people to manage their own resource base.

Common property theory provides some general guidelines and policy prescriptions for the success of such indigenous peoples-based conservation (37, 38).

Eliminate open-access conditions

If access to the area to be conserved is open to any user, the commons will be degraded sooner or later. To eliminate open-access, property rights need to be defined; these can be private property or communal property rights. In areas with traditional peoples, private property is often not feasible as these peoples have social traditions of joint ownership. Controlling the access of others makes it possible for the local group to appropriate any benefits of the conservation effort. This establishes economic incentives to conserve.

Balance rights and responsibilities

Instituting resource-use rights for the local population or recognizing existing rights is only half of the solution. These rights should be balanced against responsibilities. This can be done by protecting and nurturing any existing communal property management systems. A characteristic of any well functioning communal property regime is the ability of users to limit access to the resource to members of the group, and the ability to make and enforce rules among themselves.

Legalize rights

The only way to provide long-term protection for local rights, and indirectly for local conservation, is to legalize communal resource-use rights. This may entail harmonization of national laws with local regulations, as for example in the case of appointing local leaders in charge of enforcing traditional rules, as game wardens.

Delegation of rule-making authority to the community assumes that the government is willing to share responsibilities, but remains ultimately responsible for conservation. A number of factors affect the ability of the local organization to function effectively. Internal factors include group size, social/cultural heterogeneity, and leadership; external factors include population pressure, commercialization of the resource and technology change.

Variety of consequences of restricting harvests of biological populations

Presumed consequences	Possible examples: Traditional societies	Modern societies
Save effort / avoid risk when returns are inadequate	Ban on sea fishing during the monsoon off west coast of India	Closure of whaling, as whale populations declined, by the American fleet
Enhance yields of same species in the long run	Protection to birds breeding in heronaries, or fruit bats in day time, South India	Closed seasons for hunting / fishing mesh-size regulations
Enhance yields of other species in the long run	Protection to keystone species like trees of genus *Ficus* in parts of Asia and Africa	
No discernible material benefits	Protection to all species of monkeys in many parts of India	Ban on hunting of cranes

Sharing conservation responsibility and benefits requires cooperative management (or co-management) arrangements between the local organization and the government, and the rights and benefits may be spelled out in a management plan. The biosphere reserve is one kind of conservation area that theoretically allows for joint management and compatible human activity in part of the protected area. New developments in Integrated Conservation Development Projects (ICDPs) and community-based conservation may be signalling a changing philosophy of conservation to allow for more biosphere reserve-style joint management (39). The general issue of the role which indigenous peoples should play in the management of protected areas, has come up for discussion only in recent years. There is a growing literature on this subject, but concerns have also been expressed that conservationists may be expecting too much too soon from ICBs in the absence of demonstrated success cases (40).

Furthermore, as traditional peoples are integrated into the global economy, and come under trade, acculturation and population pressures, they lose their attachment to their own restricted resource catchments. This may lead to a loss of motivation in sustainable uses of a diversity of local resources, along with the pertinent indigenous knowledge. The feedbacks between ecological carrying capacity of the local environment and social self-regulatory mechanisms, the shared values of local institutions, are cut. Thus, decoupling indigenous groups from their local resource base is likely to reduce the resilience of their social/cultural systems as well as the local ecosystems, making both more fragile.

In pace with the growing awareness that the natural capital is increasingly replacing human-made capital as the limiting factor for the development of human societies (41), there will be a growing demand for increased knowledge of the functioning of the natural environment. Much is yet to be learned about the contribution of particular species, or groups of species for the structure, functioning, resilience, and integrity of self-organizing ecosystems (42, 43). Indigenous knowledge does indeed hold valuable information on the role that species play in ecologically sustainable systems. Such knowledge is of great value for an improved use of natural resources and ecological services, and could provide invaluable insights and clues for how to redirect the behavior of the industrial world towards a path in synergy with the life-support environment on which it depends. Just as important as it is to conserve biodiversity for sustainability, it is as urgent to conserve the diversity of local cultures and the indigenous knowledge that they hold.

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