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ECOSYSTEMS

MINIREVIEWS

Exploring the Basic Ecological Unit: Ecosystem-like Concepts in Traditional Societies

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ABSTRACT

Ancient conceptualizations of ecosystems exist in several Amerindian, Asia-Pacific, European, and African cultures. The rediscovery by scientists of ecosystem-like concepts among traditional peoples has been important in the appreciation of traditional ecological knowledge among ecologists, anthropologists, and interdisciplinary scholars. Two key characteristics of these systems are that (a) the unit of nature is often defined in terms of a geographical boundary, such as a watershed, and (b) abiotic components, plants, animals, and humans within this unit are considered to be interlinked. Many traditional ecological knowledge systems are compatible with the emerging view of ecosystems as unpredictable and uncontrollable, and of ecosystem processes as nonlinear, multiequilibrium, and full of surprises. Traditional knowledge may complement scientific knowledge by providing practical experience in living within ecosystems and responding to ecosystem change. However, the "language" of traditional ecology is different from the scientific and usually includes metaphorical imagery and spiritual expression, signifying differences in context, motive, and conceptual underpinnings.

Key words: traditional ecological knowledge; human ecology; ecological anthropology; ecosystem; watershed.

INTRODUCTION

In his history of the ecosystem concept, Golley (1993, p 1) identifies "an exact moment of birth" in referring to the definition of Tansley (1935) and discusses some of the early ecosystem ideas pioneered in Europe in the first part of the 20th century. He notes that the concept of holism, but not specifically that of ecosystem, "was an extension of the Mother Earth idea in modern guise" (Golley 1993, p 3). In this minireview, we bring to the attention of ecologists that ecosystem-like concepts existed in a number of ancient societies in various parts of the world and continue to exist in some contemporary non-Western cultures (Gadgil and Berkes 1991; Berkes and others 1995). We explore the ways in which some traditional ("premodern") societies viewed physical and biological components of the environment and the human population as being linked together in a web of relationships. We are not interested in the "noble savage" (Buege 1996) but in possible insights that may be obtained from the experience and adaptations of ancient societies.

A review that integrates topics in ecology and anthropology goes beyond the subject matter of most ecology journals. It is offered here in the spirit

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of the invitation by the editors of *Ecosystems* to break out of long-accepted and conservative ways of thinking (Carpenter and Turner 1998). Our broader objective is to contribute to the search for cross-disciplinary insights for sustainability and ecosystem management (Gunderson and others 1995; Colding and Folke 1997; Berkes and Folke 1998; Folke and Berkes 1998). The paper reviews some traditional ecosystem-like views, comparing them to the scientific ecosystem concept and highlighting some of the key similarities and differences. It notes some lessons from ancient wisdom as may be relevant to the shifting views of ecosystems in terms of their uncertainty and unpredictability, away from a mechanistic, Newtonian concept and linear models (Holling 1986; Gunderson and others 1995; Holling and others 1998). As well, the paper links traditional ecosystem-like concepts and some popular views of ecosystem management, including the notions of bioregionalism and "sense of place."

Traditional Ecosystem-like Concepts

Many indigenous peoples have local words that usually get translated into English as *land*. But *land*, as understood by them, often carries other meanings. Among the indigenous peoples of the North American Subarctic, *land* is more than a physical landscape; it encompasses the living environment, including humans. For example, the term used by the Dene groups of the Western Subarctic, such as the Dogrib, Yellowknives, and Slavey, *ndé* (*ndeh*), is usually translated as *land*. As Legat and others (1995) point out, though, its meaning is closer to *ecosystem* because it conveys a sense of relations of living and nonliving things on the land. However, it differs from the scientific concept of ecosystem in that ndé is based on the idea that everything in the environment has life and spirit.

Similarly, Cree and related groups in the Eastern and Central Subarctic use a word, *ashkii* in the case of the Eastern James Bay Cree, and *aski* in the case of the Anishnabe/Ojibwa (Berkes, field notes), which is more properly translated as *ecosystem* rather than *land* because it refers to plants, animals, and humans, as well as the physical environment. The Western James Bay Cree consider that "the Indians go with the land" as part of "land's dressing" in the sense that the presence of humans makes the land complete (Preston and others 1995). Interestingly, in the history of ecology, *land* was often used as a synonym for *ecosystem*, as in the "land ethic" of Aldo Leopold (1949).

Many ecologists use the term *ecosystem* to refer to a spatially explicit unit. In the prewar ecological tradition, these bounded ecosystems were almost always lakes because boundaries for terrestrial ecosystems were much less clear (Golley 1993). The studies by Bormann and Likens (1979) established the practice of using watershed divides as ecological boundaries. There is evidence, however, that the basic idea of watershed management goes back at least to the ancient Greeks (Hamilton 1995) and appears in the conservation wisdom of many societies, including the Swiss, Japanese, and Turks (Gadgil and Berkes 1991). For example, Hamilton (1995) refers to a 16th-century Chinese print about "tree restoration for river conservation," implying that the Chinese knew about the relationship of forests, erosion, and water quality. Written records going back to the 16th century show that Swiss communities controlled watersheds and used watershed resources in an integrated fashion (Netting 1981). Written records show that Sultan Mehmed II instituted watershed conservation measures when the Ottoman Turks captured Constantinople in 1453. The Sultan's edict included the prohibition of tree cutting ("under the pain of death") and overgrazing in the basin of the river supporting the city, and measures were undertaken for riverbank stabilization and revegetation (Kislalioglu and Berkes 1990).

Watershed units are commonly used also in traditional ecological systems. One of the most common ways in which aboriginal groups identify themselves is with reference to river systems, for example, "The people of the Big River," the Chisasibi Cree of Eastern James Bay, Quebec. This kind of use does not necessarily denote an ecological understanding of watershed boundaries; it may merely reflect the use of a river system as a canoe transportation corridor. Similarly, the watershed-based definition of family hunting territories among the Cree may merely indicate that the height of land between adjacent river systems provides a convenient and enforceable way of delimiting territorial boundaries. More fully developed traditional watershed-based management systems are found in the Pacific Northwest of North America and among a number of geographically and culturally diverse groups in Asia, Africa, and the Asia-Pacific (Table 1).

Among the Gitksan (Gitxsan) and Wet'sewet'en of the Pacific Northwest, tribal chiefs describe their land boundaries as "from mountaintop to mountaintop" and orient themselves by two directional axes within this watershed framework: vertically up and down from valley bottom to mountaintop, and horizontally, upstream and downstream (Tyler 1993). Detailed land-use maps of the kinship-based *house* groups (*wilps*) of the Gitxsan show that there is a close correspondence between watershed areas and wilps or clusters of wilps (Collier and Vegh

Table 1. Examples of Traditional Applications of the Ecosystem View

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

1998). Clearly, these are not merely territories but watershed-ecosystems-as-territories. Similarly, the Nass River area in the British Columbia–Alaska border provides an example of the use of watershed-based traditional systems in the management of Pacific salmon (Berkes 1985). The Nass River watershed was claimed as traditional land by the Nishga Indians. Within it, each Nishga community used one part of the watershed, within which specific salmon fishing sites were controlled by a chief on behalf of a *house*. Thus, resource-use rights were organized hierarchically, from the watershed level down to specific fishing sites.

In Southeast Asia, one of the better known examples of bounded ecosystems used for resource management is the *tambak* (Johannes and others 1983). The use of estuarine polyculture fish ponds (tambak) such as those in Java, Indonesia, dates back to the 15th century. Often fringed by mangrove forests, tambaks combined the cultivation of fish, vegetables, and tree crops (Costa-Pierce 1988). Tambaks were often located at the downstream end of integrated rice–fish culture systems of which Southeast and South Asia had many local variations (Johannes and others 1983). Organic-rich outflow from rice–fish systems were often directed into tambaks to fertilize them. Many estuarine polyculture systems in Southeast Asia have fallen into disuse; some have been affected by international markets and displaced by shrimp-pond monoculture. The tambaks of Java have been impacted by population growth and urbanization pressures. Nevertheless, tambaks provide lessons in the design of productive, human-dominated ecosystems, and the application of the ecological notion of the coupling of land and water systems (Hasler 1974).

In Africa, the *dina* system of Mali provides an example of sophisticated adaptions of communities to floodplain ecology (Moorehead 1989). Dina provides integrated resource management through resource specialization of different ethnic groups and their complementary activities through the flood cycle in the inland delta of the Niger River. The system was legally formalized in the 19th century by codifying the then existing resource management practice into a system of grazing, fishing, and farming territories allocated to different ethnic groups. The Bozo people specialized in shallow-water fishing, whereas the Somono people specialized in net fishing in deeper waters. The farmers consisted of four groups characterized by the use of different crops and cultivation techniques. Several groups specialized in animal herding, with the Fulani the dominant ethnic group among them. Detailed access rules governed productive activities and specified reciprocal rights for the various groups. Fishing, for example, was regulated by "masters of the water" who supervised the use of allowable techniques, set opening dates for different fisheries, had the powers to extend (for a fee) fishing rights to outsiders, and conducted ceremonies for water deities (Moorehead 1989). Resource specialization by ethnic groups appears to be a traditional adaptation found in different parts of the world, and the system in Mali superficially resembles, for example, that under the caste system in India (Gadgil and Malhotra 1983).

In Asia-Pacific, there was a wealth of ecosystem-like concepts. Perhaps the richest set of ecosystem applications were found in Oceania. Examples include the ancient Hawaiian *ahupua'a* (Lind 1938; Costa-Pierce 1987), which were wedge-shaped land units controlled by local chiefs, the *konohiki.* They encompassed entire valleys, stretching from the mountaintops to the coast and shallow waters, and included a forested mountain zone (for watershed conservation, protected by taboo), integrated farming zones in upland and coastal areas, a fringe of coconut palms along the coastline (storm and wind protection), and brackish water and seawater fish ponds. The land unit in question is clearly an ecosystem, with the height of land between adjacent valleys serving as the biophysical boundary. The Hawaiian ahupua'a disappeared with colonization, but similar systems exist in other Pacific islands and some are considered still functional in the contemporary world.

The variations of the Hawaiian system may be found in the Yap *tabinau,* the Fijian *vanua,* and the Solomon Islands *puava* (Ruddle and Akimichi 1984; Ruddle and others 1992). The common point in each is that the term refers to an intimate association of a group of people with land, reef, and lagoon and all that grows on or in them. It is the "personal ecosystem" of a specific group of people. In the Solomons, for example, a puava is a defined, named territory consisting of land and sea, and it includes all areas and resources associated with a *butubutu* or descent group (Hviding 1996). Similarly, the Fijian vanua describes the totality of a Fijian community. Depending on the context, the term may be used to refer either to a social group or the territory it occupies, thereby expressing the inseparability of land and people in the Fijian ethos. Fijian spiritual affinity with land is illustrated in expressions such as *ne qau vanua* ("the land which supports me and to which I belong") (Ravuvu 1987; Ruddle 1994).

There are several significant features of ecosystem-like concepts in Oceania. One is the extension of the bounded unit to the outer edge of the reef, indicating the ecological insight that the ecosystem does not end at the limit of dry land but includes the lagoon. A second feature, which goes hand in hand with the recognition of land and sea space as a continuum, is a lack of distinction between "ownable land" and "unownable sea," a dichotomy that is found in the Western world but not in many parts of the Asia-Pacific, for example, in Japan (Ruddle and others 1992). A third is the presence of a social and ethical mechanism for integrating humans and nature, as concepts such as puava and vanua explicitly serve the inclusion of a specific group of people as a part of the named ecological or bioregional unit.

Lessons from Traditional Knowledge

Ancient wisdom warns us to be wary of dichotomies such as nature–culture and mind–matter, inventions of the positivist science tradition and enlightenment philosophy dating back to Newton and Descartes (Capra 1996) and seen by some to be at the root of our environmental crisis (Bateson 1979). As Golley (1993, p 2) observes, the scientific concept of ecosystem that emerged in the postwar period was very much in the positivistic tradition, "a machine theory applied to nature." The dynamic response of natural systems was simplified and made deterministic, consistent with physical theory. The ecosystem was conceived as a machine and represented as a computer model (Golley 1993). Even more graphically, major ecosystem processes, such as biogeochemical cycles, were often depicted in ecology texts as gears and clockwork mechanisms powered by the sun, clearly stamping ecosystems with Newtonian mechanistic thinking.

By contrast, many traditional ecological knowledge systems depict ecosystems, not as lifeless, mechanical, and distinct from people, but as fully alive and encompassing humans. In some cases, traditional ecosystem-like concepts also incorporate spirits of animals and other natural objects (as among Dene Indians) and spirits of human ancestors, as in some African cases (Dei 1993) and among the Australian aborigines (Wilkins 1993). In Feng-shui teaching in the Taoist tradition, land is alive and full of various kinds of energies or life forces. The human form is simply a temporary "shell" that follows a life cycle and eventually disintegrates, releasing to the universe the energy encased in the "shell" (Wong 1996).

The spiritual dimensions of traditional ecological views are unlikely to be embraced by ecologists, but some of the other lessons may be relevant. Part of the reason for the growth of interest in traditional ecological knowledge since the 1980s is that the chasm between indigenous knowledge and Western science has evaporated in recent years. Some areas of science, such as chaos theory, resemble "savage thought" (Levi-Strauss 1962) more than anyone previously was willing to recognize. Traditional ecological knowledge, based on detailed observations of the dynamics of the natural environment, feedback learning, social system–ecological system linkages (Berkes and Folke 1998), and resilience-enhancing mechanisms (Folke and Berkes 1998),

seems akin to *adaptive management* (Holling 1978; Gunderson and others 1995).

Many indigenous ecological views are in line with the shifting scientific view on the nature of ecosystems. As characterized by Holling (1986), the classic view holds that ecosystem processes are linear, equilibrium centered, and therefore predictable and controllable. It is a view that is closely related to the Age of Enlightenment ideal of "mastery over nature." An alternative view of ecosystem science is that ecosystem processes are nonlinear, multiequilibrium, and full of surprises, threshold effects, and system flips (Gunderson and others 1995; Holling and others 1998). Predictability and controllability are not limited by the scientific data available but by the very nature of ecological systems [see also Ludwig and others (1993), Carpenter and Cottingham (1997), and Johannes (1998)].

All traditional ecological knowledge systems with which we are familiar are at odds with the view of linear, controllable ecosystems, but many are compatible with the alternative view. Some traditional peoples seem to have perceived the essential unpredictability of ecosystems and their nonlinear nature. How close they may have been to a multiequilibrium ecosystem understanding, we will never know. But in any case, the language used by traditional peoples is very different from that of science, with premodern views often couched in metaphorical imagery and spiritual expression. These differences serve as a warning against the *uncritical* use of traditional ecological knowledge, for example, in conservation and resource management. As Dwyer (1994) argues, forcing indigenous conservation into the mold of Western conservation is not likely to work: "The resource management systems of indigenous people often have outcomes that are analogous to those desired by Western conservationists. They differ, however, in context, motive and conceptual underpinnings. To represent indigenous management systems as being well suited to the needs of modern conservation, or as founded in the same ethic, is both facile and wrong."

For example, the Maori environmental ethic does not support the exclusion of people from a protected area and is oriented for conservation for human use. Traditional prohibitions are intended to ensure resource productivity and not to safeguard some notion of "intrinsic value"; there is no human–nature or self–other duality in Maori worldview (Roberts and others 1995). The Maori conservation is at odds with New Zealand's 1987 Conservation Act, which stipulates "preservation" and "setting aside of land" (without humans) to meet conservation objectives. From a preservationist point of view, the issue is that Maori "conservation" does not allow for land and species protection and conflicts with the Conservation Act. From the Maori point of view, the issue is that the notion of conservation rooted in human–nature dichotomy "only serves to further alienate all humans, but particularly Maori, from their land, and thus from their *kaitiaki* [land guardianship] responsibilities" (Roberts and others 1995).

Such stewardship rules are found in a diversity of traditional societies. Responsibility for the land, as enforced by elders and other wisdom holders, and conservation-through-use are common features of many traditional ecological knowledge systems in a variety of geographical areas (Berkes and Folke 1998; Gadgil and others 1993). Many of these systems have been eroded, but others have been emerging, consistent with the anthropological conceptualization of culture and tradition as not static but constantly adapting and evolving.

In conclusion, some ancient societies and contemporary non-Western cultures share with ecologists the view of connectedness of humans and nature. A number of these cultures in diverse parts of the world have notions of watershed-based ecosystems to which certain groups of humans naturally belong, presumably emphasizing their dependence on local resources. As an anonymous referee commented, "their adaptations fit the resource because they must. Groups where this was not true have gone extinct. [By contrast] ecologists have a point of view that may express connectedness, but after work . . . the ecologist drives home and reenters the modern world with all its conveniences . . ." The incentive to respond to changes in local resource abundance is removed in the modern world. Traditional peoples had, or some may continue to have, remnants of adaptations to their local resource base (Folke and others 1998).

A lesson from traditional ecological knowledge is that values and beliefs are an important part of a knowledge system if it is to lead to a moral code or ethics toward the environment. Anderson (1996, p 166) argues that "all traditional societies that have succeeded in managing resources well, over time, have done it in part through religious or ritual representation of resource management. The key point is not religion per se, but the use of emotionally powerful cultural symbols to sell particular moral codes and management systems." If this is true, movements combining values and beliefs with ecological concepts are more likely to succeed in making ecosystem a transforming concept, as compared to the use of the science of ecology alone.

A number of contemporary ecosystem applications and social movements appear to be re-creating

traditional ecological ideas. Examples include bioregionalism, with its combination of local self-reliance and sense of belonging, and the related notion of "sense of place" (Norton and Hannon 1997). "Topophilia" or love of land (Tuan 1974); biophilia or love of living beings (Wilson 1984; Kellert 1997); "ecological footprints," which provide an area-based estimate of the natural capital requirements of a defined human population (Wackernagel and Rees 1996); and Gaia, the contemporary version of the Mother Earth idea (Lovelock 1988; Golley 1993, p 3; Capra 1996) are either traceable to or consistent with ancient ecological concepts. Each provides an approach to the understanding of reciprocal ties that bind humans with the natural world, to use a phrase from Stephen Kellert (personal communication).

Traditional ecosystem-like concepts combine ecology, ethics, and culture into a worldview of humans as being part of nature. Such a worldview was also put forward by Aldo Leopold (1949): "We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect. There is no other way for land to survive the impact of mechanized man, nor for us to reap from it the esthetic harvest it is capable, under science, of contributing to culture." A major challenge in ecosystem management and conservation is to treat human societies as a part of nature, as well as a major influence on ecosystem dynamics, stressing that humanity will always depend on the life-support function of the ecosystem, irrespective of technological sophistication.

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