the streets, the educational institution functions largely through the school system, including public and private schools, teachers, school boards, and parent organizations (Bidwell and Friedkin 1988). Education can be measured as a density (teacher/student ratios), and input (dollars expended per student), and an output (percentage of high school seniors graduating). Changes in the educational system directly impact other components of the social system (such as the timing of leisure activities, distribution of knowledge, availability of skilled labor). Dramatic changes in the institution (such as school consolidation) can have significant effects on the entire human ecosystem.

Leisure (recreation). Leisure (the culturally influenced ways we use our nonwork time) is an important institution in all but the most harsh human ecosystems (Cheek and Burch 1976). Several studies suggest that industrialized societies have less leisure time per capita than agricultural or pastoral ones (Burch and DeLuca 1984; Schor 1992). In industrialized societies, the recreation institution includes formally managed leisure opportunities (bowling alleys, wilderness areas, moviegoing, hunting, and fishing) as well as less formal pursuits (socializing, sexual behavior or courtship, resting) and specialized activities (holidays, festivals, and so forth). Leisure can be measured as an amount (hours per day per capita), as a level of participation (percentage of adults with hunting permits), or as a range (number of festivals or special events). Changes in leisure can impact human ecosystems in several ways, as through direct impacts on commerce (a boom or bust in the tourist industry) and by changing social norms (a decline in festival attendance or a change in gender participation).

Government (politics). The political subsystem is at once a central component of human ecosystems and a result of numerous other components (such as organization, myths, and legal institutions [Shell 1969]). Politics as an institution is a collective solution to the need for decision making at scales larger than clan or caste. It includes the modes of interaction between political units (such as states and counties), the processes of decision making within political units (such as elections and legislative action), and the participation of citizens in political action (campaigns, party activity, referendum, and so forth). Government can be measured by its resources (tax receipts, authorized expenditures, and employees are examples) or its actions (laws passed, hearings held, and so forth). As governments at several scales control critical natural resources (such as the federal government's forestland), changes in government action or process (revision to the Endangered Species Act) can have a significant influence on human ecosystems.

Sustenance (agriculture and resource management). The provision of sustenance (food, potable water, energy, shelter, and other critical resources) is a central and collective challenge facing all social systems (Hawley 1950). The management of that challenge and the production of necessary supplies require agricultural and resource management institutions of some complexity (Field and Burch 1988). Irrigation districts, farmer's cooperatives, timber companies, tree farm associations, extension offices, federal management agencies, and environmentally oriented interest groups are all components of the sustenance institution. Measures include organizational capacity (number of agents/farm, acres in production), output (measured in dollar values or crop tonnage), and range of sustenance products (number of crops or timber types). As agriculture and resource management are the chief methods for transforming critical resources into necessary social system supplies, their importance to human ecosystem functioning is key. Changes in production, efficiency, or distribution can have effects throughout human ecosystems.

Social Cycles — patrones temporales para la distribución de la actividad humana e influyen sobre la distribución de los recursos

Physiological cycles. Homo sapiens has evolved a series of physiological cycles that deeply influence human behavior. For example, diurnal cycles of night and day create peaks of labor and leisure activity; menstrual cycles control reproduction patterns. The life cycle is roughly similar across cultures: birth, childhood, labor, marriage, child rearing, retirement from labor, and death. Each stage of the life cycle creates expectations and norms for behavior (including the use of resources [see Burch and DeLuca 1984]). Measurement can include the proportion of the population at each stage of the life cycle. These cycles create predictable patterns of activity within the human ecosystem: park-going during daylight hours, increases in energy demands during early morning hours (for showering, cooking, heating, and so forth), rituals at each juncture of life cycle stages (such as weddings and funerals). While physiological cycles rarely may change, they may substantively impact human ecosystem functioning at several scales.

Individual cycles. Beyond physiological cycles, individuals may follow time cycles that are personal and idiosyncratic. Examples are graveyard shifts for certain workers (such as bakers or police), part-time or seasonal work (such as agricultural field labor or lumbering), and personal patterns of recreation activity (weekend hiking or camping). These cycles impact social institutions and the use of natural resources. They can be measured by such indicators as employment patterns (for example, the proportion of part-time to full-time workers). Changes in individual cycles can reflect alterations in labor needs, social institutions, or hierarchies of wealth. For example, displaced mill workers may have to travel farther from home for employment, changing family time budgets.

Institutional cycles. Each of the social institutions described above have (or create) social cycles that control the flow of relevant activities (Burch and DeLuca 1984). The legal institution, for example, creates court seasons and trial days; the leisure and sustenance institutions create hunting and fishing seasons. These institutional cycles are critical to human ecosystem functioning, for they provide guidance and predictability to the ebb and flow of human action. Institutional cycles can be measured in terms of frequency (the number of times that persons or groups participate), duration (such as the length of a hunting season), proportion (the percentage of the population involved), or intensity (the depth of the meaning assigned to the cycle, such as the funeral of a national leader). Changes in institutional cycles may directly impact the use of natural resources (for example, a year-round school calendar diversifying park-going patterns), and importantly, the conduct of commerce (such as fishing seasons, field-burning periods, or fiscal year cycles of funding).

Environmental cycles. Not all cycles are socially constructed: environmental cycles are natural patterns that can significantly influence the human ecosystem (Bormann and Likens 1979; Turner et al. 1990). Environmental cycles include seasons, drought periods, El Niño patterns, biogeochemical cycles, short-term successional stages, and long-term climatological change. Drought cycles in the western United States, for example, impact natural resources such as wildlife and forests, the capital needs for dams, reservoirs, and other storage devices, agricultural institutions, litigation over water rights, and many other components of the human ecosystem. The cycles can be measured by duration (such as length of growing season) or occurrence (the proportion of years in a decade with low precipitation). Changes in environmental cycles, such as the end of a drought or the movement of the seasons, can alter ecosystem and social system responses, often significantly.

Social Order → patrones culturales para organizar la interacción entre personas y grupos

I. *Identity.* One of the key ways that social systems maintain coherence and the ability to function is through the use of identity. In sociological terms, identity is often ascriptive—it is assigned by society based on birth or circumstances rather than through the individual's actions or achievements. Caste or race, for example, is ascriptive: One is born into a racial category which then follows the individual throughout the life course. These identities are used (often through stereotyping or other generalizations) to differentiate people and manage interactions: African Americans claim affinity to one another (by the ascription of race), Chinese make similar claims to each other, both groups identify differences between them, and so forth. Other identities are less ascriptive, such as class: Individuals can alter their class through changes in wealth, education, occupation, and so forth.

Several forms of identity are critical to human ecosystems. *Age* is important, for much of human activity is age-dependent (Eisenstadt 1956): Certain occupations (such as mining) are mainly for the young; certain recreation activities (such as white-water sports) likewise are often specialized by age. *Gender* (the socially constructed masculine and feminine roles) is important, both for its crucial impact on social norms and for its differential effects on social institutions—women and men having different access to capital, health care, wealth, power, and other features of the social systems (Weitz 1977). *Class* is important, though its definition is problematic (Abercrombie et al. 1988). Some social scientists define class in purely economic terms (based on occupation or income); others include sociocultural concerns (such as education or social norms). *Caste* (an anthropological term for race and ethnic groupings) is significant for reasons described above. Finally, *clan* (the extended family or tribal group) is crucial, both as a predictor of interaction (most recreation, for example, takes place with family members) and as a source of support. Clans routinely provide health care, financial assistance, even natural resources (such as food or other supplies) to members in need.

These identities can be measured in terms of diversity (the range of ethnic or age groups in a community) and distribution (the proportion of non-Caucasians within a population, the ratio of working-age individuals to dependents). Changes in identity usually impact social systems through an alteration in social norms; an influx of young people, Jews, women, and blue-collar workers leads to shifts in what is expected as well as what people do; these shifts further alter the human ecosystem.

II. *Social norms.* Norms are rules for behavior, what Abercrombie et al. (1988) called the "guidelines for social action." *Informal norms* are administered through community or social group disapproval: Deviating from the norm is noticed, but sanctions are slight. Speaking too loud in a museum or too soft at a football game are examples (as are norms for behavior in campgrounds, along trails, or on fishing boats). The full range of etiquettes for eating, socializing, courtship, and so forth also are informal norms. *Formal norms* are more serious and institutionalized; they usually are codified in laws that not only prohibit certain actions but proscribe punishments for breaking such norms (Wrong 1994). Misdemeanor and felony laws are examples. Sometimes a community's informal norms may conflict with its formal (legal) norms. The results are "folk crimes," that is, activities that are against the law but not considered harmful by the population. Some kinds of wildlife poaching or illegal woodcutting are folk crimes (Scialfa 1992).

Norms can be measured by both their adherence (the proportion of a population following a social convention, such as marriage before childbirth) and deviance (the number of felonies per capita). Changes in social norms can impact social institutions (divorce directly impacts health and justice for women) and alter resource use.

Hierarchy. An important mechanism for social differentiation, and for managing the social order, is hierarchy. In almost all social systems, hierarchy is ubiquitous; inequality of access is a consistent fact across communities, regions, nations, and civilizations. Five sociocultural hierarchies seem critical to ecosystem functioning: wealth, power, status, knowledge, and territory.

Wealth is access to material resources, in the form of natural resources, capital (money), and credit. The distribution of wealth is a central feature of social inequality and has human ecosystem impacts; the rich have more life opportunities than the poor. *Power* is the ability to alter the behavior of others, either by coercion or deference (Mann 1984; Wrong 1988). The powerful (often elites with political or economic power) can have access to resources denied the powerless; an example is politicians who make land use decisions and personally profit from these decisions at the expense of other citizens. *Status* is access to honor and prestige (Goode 1978; Lenski 1984); it is the relative position of an individual (or group) on an informal hierarchy of social worth. Cultures may vary as to whom is granted high status (for example, teachers are given high status in China, modest status in the United States). Status is distributed unequally, even within small communities, and high-status individuals (such as ministers) may not necessarily have access to wealth or power.

Knowledge is access to specialized information (technical, scientific, religious, and so forth); not all within a social system have such access. Knowledge provides advantages in terms of access to critical resources and the services of social institutions. Finally, *territory* is access to property rights (such as land tenure and water rights). Hierarchies of territory are created when some have strong land tenure (large tracts with secure ownership) and others weak tenure or are landless. This can vary by region. For example, in the arid U.S. West, water rights (granted by historical priority) may be especially crucial, as it is water that limits development (Reisner 1986).

These critical hierarchies can be measured in several ways. Wealth can be measured by indicators such as the range of incomes or the proportion of the population that is below the poverty line. The distribution of power can be indirectly measured by certain decision-making activities, such as elections. It also can be measured by levels of domination and subordination—the disproportion of Blacks and Latinos in prison or on death row, "glass ceilings" faced by women workers, the persistence of spousal abuse, and the relationship between timber workers and company executives. Status can be measured by public polling techniques that capture public opinion; knowledge can be indicated by educational attainment. Territory can be measured by ownership patterns, the distribution of land by size (that is, the proportion of landholders with large tracts), or the distribution of water rights (by acre-feet). Changes in hierarchies, by altering who has access to critical resources and social institutions, can dramatically alter the human ecosystem.

Potential Applications of the Human Ecosystem Model

This human ecosystem model, we hope, is neither an oversimplification or caricature of the complexity that undergirds the human ecosystems occurring in the world. Parts of the model are orthodox to specific disciplines: There is little new in attributing importance to energy or capital as necessary resources. Other portions of the model are less commonplace to resource managers (though still not original)—myth as a cultural resource, justice as a critical institution, and others. We believe the model is a reasonably coherent whole, and a useful organizing concept for ecosystem management. There are several potential applications.

First, the model could be employed as an organizing framework for social impact assessments (SIAs) associated with ecosystem management plans. Such plans will be more broad and multiscaled than the traditional development projects that have been subject to SIAs, and the model may guide resource managers and their social science partners in capturing a full range of possible impacts. For example, changes in land use (such as a shift from timbering to recreation) may impact a full range of social institutions in ways that ecosystem managers and citizens need to anticipate.

Second, the model could serve as a guide for the development of social indicators for ecosystem management. Social indicators have a long tradition in the social sciences and in social policy decisions; at present, their use in natural resource management is experimental. Yet, there is both precedent and potential in constructing a set of social indicators for human ecosystems. Resource managers already employ biophysical indicators of stream quality, tree growth, soil erosion, and so forth. They use these indicators to guide decision making and to monitor the effects of on-the-ground actions, and when done in a systematic way, define the result as "adaptive management." In an accompanying article in this issue (Force and Machlis 1997), we describe how this human ecosystem model was used to select a set of social indicators for monitoring ecosystem management in the Upper Columbia River Basin. Similar efforts have utility for other critical regions, from South Florida to Chesapeake Bay to the Mississippi Delta to Puget Sound.

Third, and an extension of the application described above, is the use of the human ecosystem model as a basis for monitoring other programs directly tied into the activities of natural resource agencies. By collecting and learning from data related to the model's variables, management alternatives that meet local needs for sustenance and long-term requirements for sustainability may be devised. For example, the emphasized role of social institutions in ecosystem order (from health to business to faith) suggests that the inclusion of local leaders beyond the typical political and special interest representatives may have significant benefits for public planning. Human ecosystems with weak or sound institutions may respond very differently to a manager's plan for altered timber harvests, special management zones, wilderness areas, and other forms of ecosystem manipulations. Predicting such variation is an important ecosystem management skill.

Fourth, the model could serve as an introduction to the human ecological sciences for current and future ecosystem managers. Current resource managers, often trained in the postwar disciplines of wildlife, recreation, or forest management, must struggle to overcome their professional concentrations and "trained incapacities." Future ecosystem managers now in the professional schools are being told that a new paradigm for resource management is being developed. Yet, they are being shown that the traditional faculties and departments are not suitable for mastering and synthesizing the broad range of technical and sociopolitical skills needed to enact this new paradigm. The human ecosystem model could function as a basic teaching tool—its description, analysis, application, and critique providing a bridge between the courses, departments, and faculties involved in ecosystem management education.

Fifth, the human ecosystem concept offers an intellectual crossroads for social scientists working on issues related to ecosystem management. Because it is derived from numerous disciplines and explicitly multiscaled, there is opportunity for economists, anthropologists, geographers, political scientists, sociologists, and others to link their work and findings in order to contribute to the model's overall improvement.

Even further, the human ecosystem as an organizing concept is an invitation to cooperation with biophysical scientists, for many of the model's critical variables function in

ways being discovered and described by landscape ecologists, botanists, hydrologists, and others. Golley noted:

> It is not clear to me where ecology ends and the study of the ethics of nature begins, nor is it clear to me where biological ecology ends and human ecology begins. These divisions become less and less useful. Clearly, the ecosystem, for some at least, has provided a basis for moving beyond strictly scientific questions to deeper questions of how humans should live with each other and the environment. In that sense, the ecosystem concept continues to grow and develop as it serves a larger purpose. (Golley 1993, 205)

From our own experience, we suspect such efforts at interdisciplinary, mutual learning to be simultaneously difficult and exhilarating.

Conclusion

The human ecosystem has great potential as an organizing concept for ecosystem management. Our model of the human ecosystem, and our selection of variables and the importance we place on them, are of course, preliminary. The model must be tested, applied, revised; that is, it must go through the same "adaptive management" cycles required of the ecosystem management techniques being applied to the nation's forests, grasslands, parks, and preserves.

But, more broadly, the human ecosystem is a necessary building block in a true life science—one that attempts to grasp the full complexity of the earth's dominant species. Such a life science is difficult to distinguish at this time. It is doubtful that it will spring from the determinist arguments currently joined in academe, from genes to gender. It is also doubtful that it will be discovered in the specialized researches of the wildlife ecologist or the zoologist. More likely, it will evolve—in advances and retreats—in response to the great necessity of our species to come to an accommodation with our powers, desires, weaknesses, and limits. For the fate of human ecosystems is our own.

Notes

1. There are numerous definitions of ecosystem management, as well as vigorous debate (see, for example, the August 1994 issue of *The Journal of Forestry*). Moote et al., synthesizing the literature, provided a serviceable, if generalized, working definition.

> Ecosystem management is a management philosophy which focuses on desired status, rather than system outputs, and which recognizes the need to protect or restore critical ecological components, functions, and structures in order to sustain resources in perpetuity. (Moote et al. 1994, 1)

Definitions describe five principles central to ecosystem management: (1) socially defined goals and management objectives, (2) integrated holistic science, (3) broad spatial and temporal scales, (4) adaptable institutions, and (5) collaborative decision making. The actual practice of ecosystem management may be considerably less inclusive.

2. There is some irony in the historical evidence that early ecologists freely borrowed from the social sciences to construct key concepts. H. F. Cowles described "plant societies." A. G. Tansley borrowed from Herbert Spencer to create his "organism-complex"; he in fact left ecology to study psychology with Sigmund Freud. A. Kerner reasoned from human communities to "plant-species communities"; Forbes to "communities of interest" between predator and prey. F. E. Clements was influenced by Spencer and sociologist Lester Ward. Both H. T. and E. P. Odum were influenced by

their father, H. W. Odum, whose sociological study of the American South (1936) was prescient in human ecology. For a review, see Golley (1993) and Hagen (1992).

3. Tansley's definition was exceptionally holistic and hierarchical.

> But the more fundamental conception is, as it seems to me, the whole *system* (in the sense of physics), including not only the organism-complex, but also the whole complex of physical factors forming what we call the environment of the biome—the habitat factors in the widest sense.
>
> It is the systems so formed which, from the point of view of the ecologist, are the basic units of nature on the face of the earth.
>
> These *ecosystems*, as we may call them, are of the most various kinds and sizes. They form one category of the multitudinous physical systems of the universe, which range from the universe as a whole down to the atom. (Tansley 1935, 299)

E. P. Odum's definition was similar, though it included the proscription of human needs that

> any entity or natural unit that includes living and nonliving parts interacting to produce a stable system in which the exchange of materials between the living and nonliving parts follows circular paths is an ecological system or ecosystem. The ecosystem is the largest functional unit in ecology, since it includes both organismal (biotic communities) and abiotic environment, each influencing the properties of the other and both necessary for maintenance of life as we have it on the earth. A lake is an example of an ecosystem. (Odum 1953, 9)

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