The Human Ecosystem
Part II: Social Indicators in Ecosystem Management

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The human ecosystem model presented in an accompanying article in this issue (Machlis et al. 1997) has several applications. One such application is as an organizing concept in selecting social indicators for ecosystem management. This article describes a contemporary example of such an application using the Upper Columbia River Basin (UCRB). Social indicators are statistics that can be collected over time and used for policy and management. The human ecosystem model provides a rationale for selecting specific social indicators to assess socioeconomic conditions. In the UCRB example, data were collected from 1990 U.S. Census documents and other secondary data sources for 39 indicators. In this article, two indicators are presented as examples for all 57 counties in the study area. Applications of social indicators for ecosystem management are discussed, such as (1) monitoring social conditions; (2) doing comparative studies within a region, between regions, and over time; (3) evaluating human ecosystem responses to resource management actions; and 4) providing managers and citizens with information for collaborative decision making.

Keywords ecosystem management, human ecosystem model, Idaho, Montana, social indicators, Upper Columbia River Basin

In December 1935, Howard W. Odum completed a report to the Social Science Research Council. Delayed in publication so that facts could be checked and rechecked, it was entitled *Southern Regions of the United States* (Odum, 1936). Odum's report was heroic in its conception, scope, and execution. It attempted a comprehensive inventory of conditions in the South, based on a theoretical framework taken from the emerging field of human ecology. This assessment was to serve as the foundation of regional planning that he

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hoped would create the "new South." Social science could help construct this regional strategy, and one tool it offered was the use of social indicators.

Odum (whose sons, H. T. and E. P. Odum were to become central figures in the development of ecology as a science) was a pragmatist as well as a visionary; he realized that the region was faced with dramatic change in its natural resources, economy, people, and culture. Old myths and ideologies were obsolete; a new paradigm was necessary. Odum was concerned with providing an accurate picture of the South's "reality."

> This reality is of many kinds. A part is the facing of absolute facts rather than substituting rationalizations which grow out of irrelevant comparisons or defensive explanations of how things have come to be as they are. Yet another form of reality must be found in the measurement of conditions in terms of comparison with certain selected standards and with regional and national variations. . . . Furthermore, *the greatest measure of reality can be found in the balanced picture of basic facts* rather than, and largely exclusive of, vivid extremes. (Odum 1936, 2) [Emphasis added.]

Odum described an interdisciplinary framework for guiding this inventory, organized around five key themes: (1) natural resources and agrarian culture, (2) technological deficiencies and waste, (3) industry and wealth, (4) the southern people, and (5) their institutions and folkways. He and his staff collected data from a variety of sources on nearly 700 social indicators. Additional data were collected to make comparisons with other regions of the country; the interpretation and assessment of conditions (organized around the key themes) are over 500 pages long. Yet, Odum's focus was on action, on the use of socioeconomic facts to make practical decisions:

> The main task, however, is not the catalogue of handicaps and the backward look, but to turn regional potential into regional reality and national power. There is only one main question: how achieve [*sic*] the attainable ends in view? (Odum 1936, 219)

Southern Regions became a landmark study in the fields of regional science, social indicators, and human ecology. It helped guide the South's dramatic postwar resurgence. To read it today is to realize the contemporary potential of social indicators for aiding decision making related to ecosystem management as changes in natural resources, economy, people, and culture occur. There is a significant need for "basic facts" that can help agencies and citizens assess socioeconomic conditions and achieve attainable and desired ends.

Ecosystem management is the term often used to describe current strategies for natural resource management, especially on federal lands. Definitions of ecosystem management are in flux. Some argue that ecosystem management is a paradigm shift for natural resource managers; others suggest it is an evolution, not a revolution. One definition, which is a synthesis of the current literature, states that

> ecosystem management is a management philosophy which focuses on desired states, 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)

Moote et al. (1994) presented five principles of 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 building.

People are an integral part of ecosystems, similar to other fauna, water, soil, flora, and so forth. Thus, indicators of human socioeconomic conditions are as necessary for ecosystem management as indicators of water quality, wildlife populations, and plant communities.

Defining Social Indicators

Social indicators are statistics collected for policy analysis and decision making. Numerous formal definitions exist. R. J. Rossi and K. J. Gilmartin emphasized data collection over time.

> Social indicators are time-series that allow comparison over an extended period and can be desegregated by relevant characteristics . . . they are . . . measures that allow the identification of long term trends, periodic changes, and fluctuations in rates of change. (Rossi and Gilmartin 1980, 15)

Other definitions stressed the policy relevance and social values associated with indicators. The Department of Health, Education and Welfare in 1969 defined social indicators as

> a statistic of direct normative interest which facilitates concise, comprehensive, and balanced judgments about the conditions of major aspects of society. It is in all cases a direct measure of welfare and is subject to the interpretation that, if it changes in the "right" direction, while other things remain equal, things have gotten better, or people are better off. (U.S. Department of Health, Education and Welfare 1969, 97)

In this article, social indicators for ecosystem management are defined as an integrated set of social, economic, and ecological measures available to be collected over time and primarily derived from available data sources, grounded in theory and useful to ecosystem management and decision making.

This definition has several implications. Social indicators are not merely a collection of facts or statistics, but are an integrated set of measures. Measures are the numerical values used to calculate the indicator, such as the percentage of population of a certain age or the ratio of part-time to full-time workers. Social indicators are largely developed from existing data sources and are not dependent on primary data collection. They are available over time and are repeatedly collected. They are organized around an explicit theoretical framework that provides a rationale for selecting individual indicators and their measures. The indicators reflect social, economic, and human ecological concerns, and are multidisciplinary. The indicators provide "usable knowledge," that is, they are relevant for monitoring, decision making, policy analysis, research, and other activities related to ecosystem management.

Social indicators have several strengths. They allow for systematic comparison across spatial units and over time. An example is the use of crime statistics to map high-crime neighborhoods and chart the rise or decline of certain offenses. Social indicators can provide a concise description of socioeconomic conditions, such as the proportion of people below the poverty line or the divorce rate. If they are to be used in policy analysis and decision making, social indicators should be accessible and able to be interpreted by nonexperts. An example is the widespread understanding of the Consumer Price Index (CPI). Finally, social indicators are policy relevant. An example is the use of Scholastic Aptitude Test (SAT) scores in the development of education policy. Current controversies over the construction of the CPI or the use of SAT scores emphasize their importance.

An Overview of Social Indicators Literature

Even before Odum's *Southern Regions,* social indicators were experimented with by the U.S. government. President Herbert Hoover created the President's Research Committee on Social Trends, which prepared a report using social indicators (President's Research Committee on Social Trends 1933). After Odum's work in the South of the 1930s, other government agencies (for example, the National Aeronautics and Space Administration and the Department of Health, Education and Welfare) developed their own social indicator reports for use in policy decisions and strategic planning.

In 1966, R. A. Bauer's edited volume, *Social Indicators,* represented the state of the art in social indicators research and application. It was followed by an unsuccessful effort to pass legislation requiring a system of formal social indicators. In 1972, the Social Science Research Council (SSRC) established a Center for Coordination of Research on Social Indicators to disseminate information and facilitate communication among researchers involved in social indicators research.

The social indicators "movement" declined in the 1980s, leading to the closing of the SSRC's center. Several factors appear to have contributed to this decline, including a stressed economy that had less resources for research, a change in the political atmosphere, and the lack of an overall theoretical framework from which to construct a set of social indicators (Andrews 1989; Ferriss 1989; Innes 1989).

Despite this decline, social indicators have continued to be used by a variety of organizations and professionals. A small, but significant, industry and literature has developed around the dissemination of social indicators information. Examples include *The Rating Guide to Life in America's Small Cities* (Thomas 1990), *Megatrends 2000: Ten New Directions for the 1990s* (Naisbitt and Aburdene 1990), *The Truth about Where You Live: An Atlas for Action on Toxins and Mortality* (Goldman 1991), *Where We Stand: Can America Make It in the Global Race for Wealth, Health, and Happiness?* (Wolff et al. 1992), and *The State of the USA Atlas: The Changing Face of American Life in Maps and Graphics* (Henwood 1994).

Social Indicators in Natural Resource Management

There are few examples of the actual use of social indicators in natural resource management, beyond the occasional use in developing social impact assessments as required by the National Environmental Policy Act of 1969. The U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service has published *Guidelines and Principles for Social Impact Assessment* (1994), which describes the rationale and step-by-step process of conducting a social impact assessment, including a recommendation that social indicators be used to forecast changes likely to occur as the result of a particular project. *The State of Canada's Environment* (Government of Canada 1991) is a comprehensive inventory of Canada's natural resources, which combines social and biophysical indicators to provide an assessment of the environmental integrity of the country.

W. R. Burch Jr. and D. R. DeLuca (1984) presented a human ecosystem model to guide selection of indicators and explore relationships. They provided examples of the successful integration of social indicators into natural resource management projects, such as national forest planning, water development projects, and studies of threats to national parks. G. E. Machlis and R. G. Wright (1984) proposed a system of indirect social indicators to complement biophysical monitoring to track change within biosphere reserves. Hence, the potential usefulness of social indicators to natural resource management has not yet been fully exploited. Of critical importance are issues of scale.

The Importance of Scale

One of the principles of ecosystem management calls for larger spatial and longer temporal scales than have been the postwar norm in natural resource management. Natural resource managers must simultaneously consider local concerns and national environmental and economic issues in their decision making for both short-term and long-term futures.

Appropriate spatial scales for understanding human activities range from an individual's home to the planet. However, four scales seem critical to U.S. ecosystem management: communities, counties, states, and regions. Like the scales of stand, habitat type, forest, watershed, and province in forest management, the spatial scales for human activities are hierarchical. A specific community is nested within a county which is a political division of a state. Regions include several states or portions of states. These divisions are often products of human perception and convenience, rather than natural divisions.

In the context of ecosystem management (with its emphasis on landscape), *communities* of place with specific geographic boundaries are appropriate. The definition of a human community is complex and varied (see, for example, Machlis and Force 1988; Carroll 1995). The short-term impacts of resource management decisions often are felt most keenly at the community level. Communities, even those within an individual county, may vary widely in response to management activities. Human communities, just as plant and animal communities in forest ecosystems, are fine-scale ecosystems.

Counties are the most basic subdivision of states, and are a key unit in the hierarchy of census geography (Myers 1992). They vary widely in land area, and their boundaries are not always determined by ecological features (for example, rivers, mountain ridges) or social considerations. However, they are important administrative and political units in much of the United States, and they significantly influence environmental change (McGown 1994). Counties are mid-scale human ecosystems.

States are also a unit in the hierarchy of census geography. They are useful for making comparisons across the United States. As a broad-scale human ecosystem, they give context for understanding local impacts; state law (such as water law) has significant impacts on resource management. An even broader scale unit of analysis is the *region*, such as the Interior Columbia River Basin in the Pacific Northwest. Regions have considerable influence (often indirect) on resource management (Field and Burch 1988; Odum 1936), and increasingly are being employed as key planning units. Social indicators that capture the various spatial scales of human activity are a necessary component for ecosystem management.

Theoretical Framework

The basis of a human ecological approach to social indicators for ecosystem management is a sound model. The model should be (1) derived from theory and empirical studies, (2) relevant to a wide range of resource management situations, (3) applicable at various temporal and spatial scales, and (4) able to explicitly link social and biological systems. The foundation of our model is the concept of the *human ecosystem*, defined as a coherent system of biophysical and social factors capable of adaptation and sustainability over time. While the human ecosystem is an abstract concept, specific human ecosystems are not difficult to identify. For example, a rural community is a human ecosystem—it has identifiable boundaries, resource flows, social structures, and continuity over time. For a complete development of the model, see the accompanying article in this issue (Machlis et al. 1997). Figure 1 displays the essential elements of the model, and a brief description is presented here.

A set of *critical resources* is required in order to provide the system with necessary supplies. These resources are of three kinds: (1) *natural resources* (such as energy, wood, or water), (2) *socioeconomic resources* (such as labor or capital), and (3) *cultural resources* (such as myths and beliefs). These resources are the "supplies" necessary to keep the human ecosystem functioning; their flow and distribution are critical to ecosystem sustainability.

The flow of these critical resources is regulated and used by the *social system*, which is composed of three subsystems. The first is a set of *social institutions*, defined as collec-

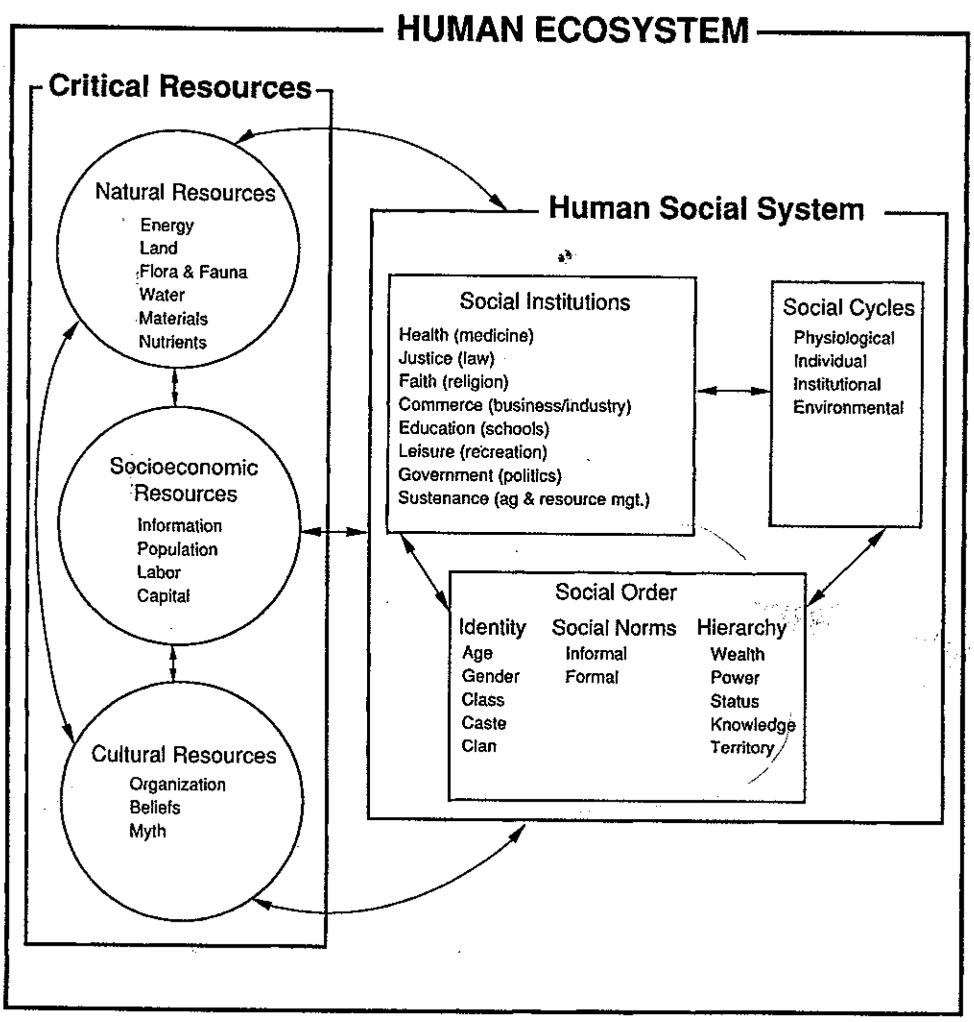

Figure 1. Working model of the human ecosystem.

tive solutions to universal social challenges or needs. For example, the collective challenge of maintaining human health leads to medical institutions, which can range from modern hospital systems to rural health cooperatives, preventive care, and traditional shamans. Other social institutions deal with other universal challenges such as justice (law), faith (religion), and sustenance (agriculture and resource management).

The second subsystem is a series of *social cycles*. Time is both a fixed resource as well as a key organizing tool for human behavior. Some cycles may be physiological (such as diurnal patterns); others institutional (such as permitted hunting seasons). Still others may be specific to the individual (such as graveyard shifts) or environment (such as climate change). Social cycles significantly influence the distribution of critical resources. An example is the set of collective rhythms within a community or culture that organize its calendar, festivals, harvests, fishing seasons, business days, and so forth.

The third subsystem is the *social order*, which is a set of cultural patterns for organizing interaction among people and groups. The social order includes three key mechanisms for ordering behavior: personal *identities* (such as age or gender), *norms* (rules for behaving), and *hierarchies* (for example, of wealth or power). Predictions about interaction are created when one can identify the age, gender, status, and power of individuals or groups, and such expectations allow the social system to function.

Taken together, social institutions, social cycles, and the social order constitute the social system. Combined with the flow of critical resources, this creates the human ecosystem and provides an organizing framework for applying social indicators to ecosystem management concerns.

An Example: The Upper Columbia River Basin

We used this theoretical framework to develop a system of social indicators that establish a baseline to use in monitoring future management actions of the Interior Columbia Basin Ecosystem Management Project (ICBEMP) in the Pacific Northwest. The basin is characterized by great diversity, both in its landscape and its people, and is the center of challenging natural resource policy debates. The ICBEMP is a joint project between the U.S. Department of Agriculture's Forest Service and the U.S. Department of the Interior's Bureau of Land Management. It involves a broad-scale and detailed scientific assessment of resources and conditions throughout the region, which includes the Columbia River drainage basin east of the crest of the Cascade Mountains—eastern Washington and Oregon, western Montana, almost all of Idaho, and small parts of Wyoming, Nevada, and Utah. Our work focused on the Upper Columbia River Basin, which includes the 44 counties of Idaho and 13 counties in western Montana.

Counties as the Level of Analysis

The county was used as the level of analysis for several reasons. First, good quality secondary data are readily available at this scale, consistently collected at regular intervals, and comparable across all counties in the United States. The county is a major unit of analysis for national census efforts, and is a stable geographic unit for time series data.

Second, counties in this region are important administrative units for government regulations and policy related to both social and biophysical aspects of ecosystem management. County governments increasingly are taking on environmental management responsibilities (remediation of Superfund landfill sites is an example), as additional discretionary authority is granted by the states and mandated by the federal government. In a study of counties in Washington, Oregon, and Idaho, a significant proportion of counties was involved in activities associated with ecosystem management, such as comprehensive planning (93%) and monitoring water quality (40%) (McGown 1994).

Third, county governments are expanding their environmental management capabilities. According to a national survey of county executives, four of the top five issues facing county governments were environmental: solid waste, land use and zoning, water supply and sewage, and toxic waste (Waugh and Hy 1988). Some counties are increasing their technical staff to deal with environmental management activities (McGown 1994).

Fourth, county boards and planning and zoning commissions have significant impacts on land use within ecosystems. These governmental units are de facto ecosystem managers, impacting human ecosystems as they develop comprehensive plans, establish zoning ordinances, and grant variances. Finally, county government is the sociopolitical unit closest to the landscape or mid-scale often discussed in ecosystem management—cities and towns are too small in area and states include too many landscape types. Hence, the use of county-level data is a plausible strategy in applying social indicators for ecosystem management throughout the Upper Columbia River Basin.

The Choice of Indicators

There is a wide variety of potential indicators for each variable in the human ecosystem model. In many cases, there are several appropriate measures for each indicator. The choice of indicators and measures was based on several criteria: (1) an extensive review of the literature, (2) close adherence to the human ecosystem model, (3) relevance to ecosystem management activities, (4) ease of understanding and interpretation by resource managers, (5) availability at the county level, and (6) accessible, good quality data. Table 1 presents the 39 social indicators that were collected for the Upper Columbia River Basin. The first column lists the variables derived from the model. The second column lists indicators chosen to represent the variables. In several instances, two indicators were selected for a given variable. The third column shows the measures for each indicator. In many cases, calculations are required to provide a measure that will allow comparison among counties. For example, it may be necessary to express a given measure (such as number of divorces) in relation to a unit of population.

The social indicators were available from a relatively few, easily accessible sources. The data were obtained from the 1990 *Decennial Census* (18 measures), the 1994 *County and City Data Book* (9 measures), and other U.S. Bureau of the Census documents and state government sources. The available data ranged from 1986 for local government finances to 1994 for the number of elected positions in local government.

Example Results

The data for the entire project were displayed in tables and in maps (see Machlis et al. 1995). The tables consisted of the values for each social indicator for each county listed in rank order from lowest to highest, with the median value in bold print. Maps were used to display each indicator in quartiles.[1] Two maps are presented here (Figure 2a and b, see color plates between pages 379–380), corresponding to the two example indicators.

The measure for the natural resource variable *land* is displayed in Figure 2a. Land is a critical resource for both its economic and cultural value. It can be characterized by ownership patterns (public or private), cover (vegetation), use (such as forestry, agricul-

Table 1
Social indicators used for the technical assessment of Idaho and Montana counties in the Interior Columbia Basin Ecosystem Management Project

Variable	Indicator	Measure (date of collection)
Natural resources[a]		
1. Energy	Occupied housing units heated with wood	% of occupied housing units heated with wood (1990)
2. Land	Federal land	% of land owned by federal government (1992)
	Population density on nonfederal land	Number of people per acre of nonfederal land (1990/92)
3. Water	Not available	
4. Materials	Material production	Dominant manufacturing or extractive industry (1987)
5. Nutrients	Agricultural product	Ratio of $ value of crop products to livestock products (1992)
Socioeconomic resources		
6. Information	Library loans	Number of books loaned by public libraries per capita per year (1993)
7. Population	Total population	Total resident population (1990)
	Rural population	% of total population residing in rural areas (1990)
8. Labor	Unemployment	% of civilian labor force unemployed (1989)
9. Capital	Bank deposits	$ value of monthly bank deposits (June 1989)
	Income	Median household income (1989)
Cultural resources		
10. Organization	Not available	
11. Beliefs	Votes by political party	% of votes cast for Republican presidential candidate (1992)
12. Myths	Major religion of family	Major religious group (1990)
Social institutions		
13. Health	Infant mortality	Number of infant deaths per 1,000 live births (1988)
	Physicians	Number of physicians per 100,000 population (1990)
14. Justice	Law enforcement	Number of police officers with arrest powers per 1,000 population (1992/90)
15. Faith	Religious adherents	% of population who claim adherence with an established religion (1990)
16. Commerce	Earnings	$ value of earnings in all industries (1988)
17. Education	High school graduates	% of adult population graduated from high school (1990)
18. Leisure	Not available	

(Table continues next page)

[a] At the time of the case study, Flora and fauna were not in the model.

ture, or urban) and economic value. One indicator of ownership pattern is the percentage of land in federal ownership. In our study region, this measure varied from 2.5% of the total land area in Lewis County, Idaho, to 93.1% in Custer County, Idaho, with a median value of 51.6% in Twin Falls County, Idaho.

Table 1 ***(continued)***
Social indicators used for the technical assessment of Idaho and Montana counties in the Interior Columbia Basin Ecosystem Management Project

Variable	Indicator	Measure (date of collection)
Social institutions (*continued*)		
19. Government	Voting rate	% of population >18 years of age participating in presidential elections (1992)
	Local government finances	$ value of local government expenditures per capita (1986–87/90)
20. Sustenance	Resource-related employment	% of labor force in agriculture, forestry, fisheries, mining (1990)
	Land use	Acres of irrigated land (1992)
Identity (social order)		
21. Age	Median age	Median age (1990)
	Dependency ratio	% of persons <18 and >64 years of age (1990)
22. Gender	Women in labor force	% of adult women in labor force (1990)
	Sex ratio	Ratio of females to males (1990)
23. Class	Professional and skilled employment	% of labor force in professional occupations (1990)
24. Caste	Ethnic/racial composition	% of total population in ethnic/racial groups (1990)
25. Clan	Household composition	% of households with children under 18 headed by single parents (1990)
Social norms (social order)		
26. Formal	Crime	Number of serious crimes known to police per 100,000 population (1991)
27. Informal	Divorce rate	Number of divorces per 1,000 population (1987/90)
Hierarchy (social order)		
28. Wealth	Poverty rate	% of persons living below poverty level (1990)
29. Power	Elected positions	Number of elected positions per 1,000 population (1994/90)
30. Status	Not available	
31. Knowledge	College graduates	% of adult population who are college graduates (1990)
32. Territory	Home ownership	% of housing units occupied by owner (1990)
Social cycles		
33. Physiological	Elderly population	% of total population who are 70 years old or older (1990)
34. Individual	Employment terms	Full-time workers (1990)
	Work days	Seasonal workers (1990)
35. Institutional	Not available	
36. Environmental	Not available	

The social order variable *wealth* represents access to material resources in the form of natural resources, capital, or credit. The distribution of wealth is a central feature of social inequality and has human ecosystem consequences: The rich have more life opportunities than the poor. One indicator is the percentage of persons below the official U.S. poverty line. Within the study area (Figure 2b), this varied from 7.1% (Caribou, Idaho) to 28.6% (Madison, Idaho), with a median value of 14.5% in Cassia County, Idaho. The complete set of 39 indicators are included in *An Atlas of Social Indicators for the Upper Columbia River Basin* (Machlis et al. 1995).

Limitations of Social Indicators

Social indicators, like other social science methodologies, have several limitations. They are dependent on accessible secondary information and may not be available at levels or periods useful to decision makers. An example is the relative lack of community-level data for several indicators. The selection of indicators is far from value-free; imbedded in the choice of an indicator (such as per capita income or library circulation rates) is the assumption that the indicator is important, and that its variation across spatial units and over time is meaningful. Hence, there is considerable debate over what constitutes appropriate indicators (Alonso and Starr 1987).

Another weakness is the potential instability of measurement criteria—indicator data may be collected differently or redefined at various times. The work in the Upper Columbia River Basin was to establish baseline data for future monitoring. If changes are made in the definition of an indicator or in the data collection methods in the coming decades, actual changes in the conditions of the human ecosystem will be more difficult to discern. For example, the number of rapes per 1,000 female population is a potential indicator of social disorder. However, if police departments, legal codes, or society change the definition of rape (for example, to include spousal rape), and if norms toward reporting rape change (more victims being willing to report), the social indicator becomes inconsistently measured, and thus, may be less useful. In addition, certain dimensions of social conditions are difficult to track with social indicators (for example, ethical values, cultural concerns, social tensions within political units).

Finally, as Odum (1936) noted, social indicators are the "basic facts." By themselves, they cannot provide explanations for *why* conditions are changing or what structural factors affect the amount of change. To carefully track an increase in population is not to be able to explain the attractiveness of place or the rationale of the migrant. Social indicators, then, are best used to provide a baseline description, and with continued collection, trends in social conditions can be monitored.

Applications of Social Indicators

There are several specific applications of social indicators for ecosystem management. The first involves comparisons across counties within ecoregions. Such comparisons can help managers identify more specific sites where it may be desirable to take (or avoid taking) certain management actions because of the potential impact on the human ecosystem, just as managers today use monitoring data on sediment loads in streams to make site-specific decisions about timber harvest. For example, using the map of federal land ownership (Figure 2a), one can identify areas where ecosystem management will require varying amounts of partnerships and collaboration with other landowners. Conditions such as the educational levels or poverty levels (Figure 2b) may affect the types of public participation activities that managers must design for collaborative decision making or may affect job retraining programs.[2]

Second, comparisons between ecoregions can help decision makers determine whether there are unique or generalized conditions within an ecoregion. Just as ponderosa pine communities share certain characteristics (for example, drier, lower elevation sites), whether in Idaho or Colorado, timber-dependent counties in forest ecoregions may have low divorce rates (an indicator of the *informal social norms*), average median incomes *(capital),* and a low percentage of college graduates *(knowledge),* compared with urban areas or other agricultural ecoregions.

If the social indicators which were collected as baseline data in this project continue to be collected over time, such comparisons can provide valuable insights into possible relationships between variables in the human ecosystem and managers' actions over both the short and long term. It may be useful to reconstruct the historical human record to better understand current trends. Historical data are available for many of the social indicators.

A fourth application is the early identification of potential problems. Social indicators can help bring attention to particular components of the human ecosystem that are of concern—those beyond the current range of human adaptability and tolerance, or the historic range of variability (if known). Social indicators can be used to identify components of the human ecosystem most at risk, indicating a particular component (for example, the health care system) that needs careful treatment and attention. Managers, decision makers, and citizens should be prepared to take action if significant undesirable change in the human ecosystem begins to occur. As Secretary of the Interior Bruce Babbitt has often stated, resource management agencies need to avoid "train wrecks"; social indicators are the tool to do so.

Fifth, ecosystem managers must be able to evaluate human ecosystem responses to resource management decisions and actions. This requires that baseline data be collected and monitored over time. There are significant data and research on certain relationships in the human ecosystem model shown in Figure 1. For example, economists have developed causal models for the relationships among labor, capital, and commerce; anthropologists have provided insights into the relationships among myths, beliefs, and social norms; and sociologists have examined relationships between material flows and social institutions. For other relationships in the model, managers must rely on correlation and professional judgment. Not all variables have direct linkages; changes in timber flows and infant mortality may be correlated, but not necessarily causally linked. Nevertheless, it is important to evaluate the responses and build an empirical database that will contribute to model development for future predictions and management decisions.

Finally, resource managers, local officials, and individual citizens must prioritize their actions. Descriptions and comparisons using social indicators of the human ecosystem can help managers set priorities. For example, if education levels are high, but local newspaper subscriptions are low, ways of communicating with local communities may have to be modified from traditional practices of official notices, articles, and letters in local newspapers. Employment and education indicators may help prioritize retraining programs and environmental education programs. There are other potential applications of social indicators in ecosystem management. These include satisfying legal requirements, rural development assistance for local communities, planning public involvement activities, education and research, regional planning, and providing information to Congress.

Conclusion

Social indicators represent an old tool from the social sciences that can prove valuable for ecosystem management. Adopting and implementing a system of social indicators for ecosystem management requires new skills and expertise for most traditionally trained natural resource managers with a limited social science background. It is likely to require a cultural change within natural resource organizations and professions; monitoring social conditions challenges the myopia of current biophysical approaches to ecosystem monitor-

Land in Federal Ownership

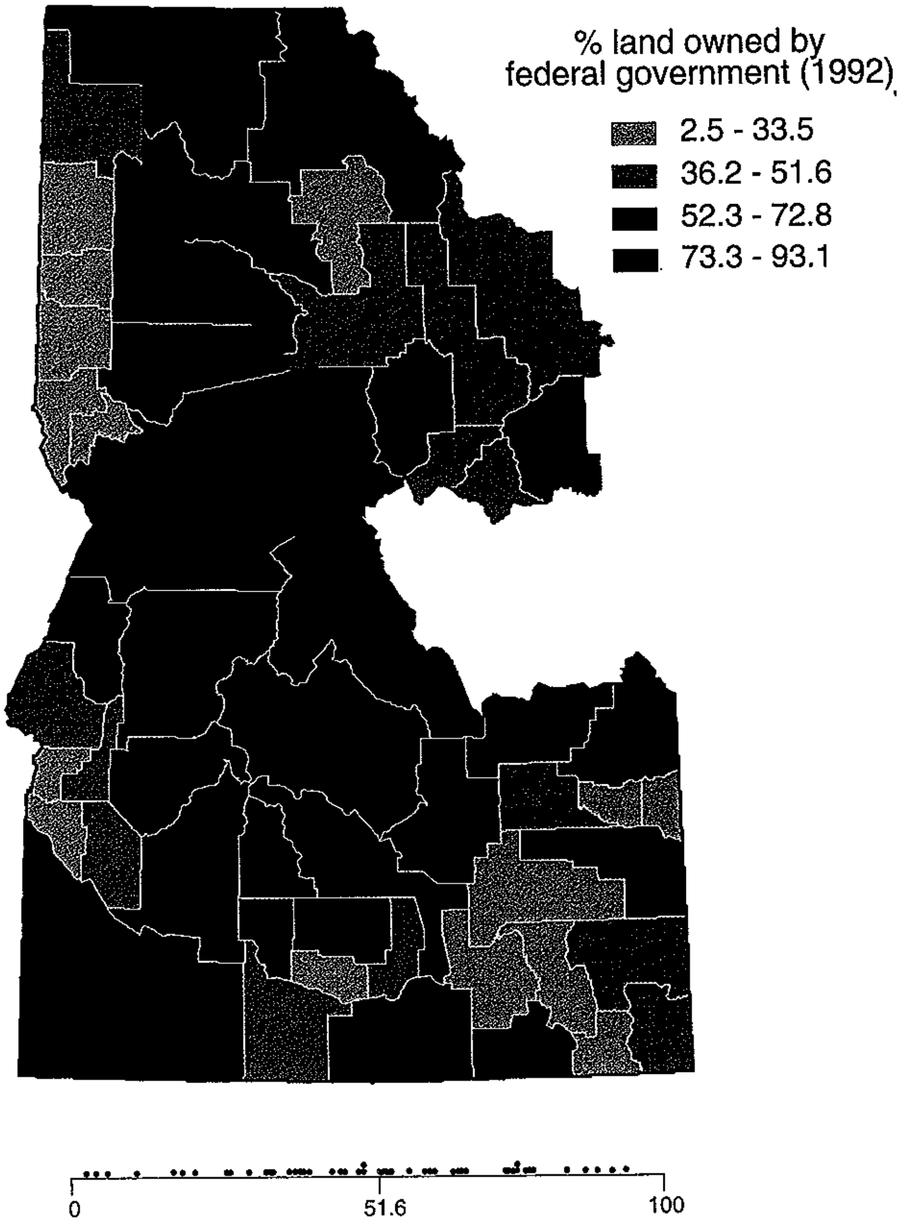

Figure 2a. The percentage of land in federal ownership (1992) for each county in the Upper Columbia River Basin of Idaho and western Montana displayed in quartiles. A number line shows the distribution of data; the median value is indicated with a red dot.

ing. The adoption and diffusion of the use of social indicators among natural resource managers will require patience and planned strategies. The benefits are likely to be substantial.

The experience of resource managers in dealing with environmental monitoring related to some of the serious environmental problems of the past decade provides guidance for useful approaches to human ecosystem monitoring. An example is global climate change where there is a paucity of data, theoretical models are in flux, and causal relationships are not fully understood or unambiguously supported by long-term empirical data. However, natural resource managers are monitoring forest and climate conditions that their professional expertise and judgment suggest need to be observed and understood. Management actions (such as inventorying genetic diversity, attempting to recreate fire conditions within historic ranges of variability, and keeping management options available) are being taken to reduce the vulnerability of ecosystems.

Like climate change, the continual and pervasive changes in human ecosystems are not always fully understood, nor are perfect data and thoroughly tested theories always available. Yet, the wise ecosystem manager, decision maker, and citizen need to come to grips with what Odum (1936), in his grand plan for the southern region of the United States, called the "basic facts." Social indicators can be a useful tool in this effort.

Notes

1. There are many ways to classify data for displays on maps, and the results can vary significantly (for example, equal intervals, quantiles, and natural groups). Each approach has advantages and disadvantages. We used quantiles and divided the counties into four classes or quartiles. Quartiles allow for easy comparison between maps, are familiar to many readers, provide for monitoring trends over time, and emphasize variation with the study area.

2. An important caution when making comparisons is that social indicators collected at one scale cannot automatically be aggregated or disaggregated for use at other scales. For example, county-level measures of per capita income cannot be applied to individual communities within that county; the average income within a particular town may vary dramatically from the county-wide average income. Such misapplication ("the ecological fallacy"; Abercrombie et al. 1988) can significantly distort on-the-ground conditions. County-level indicators can provide a context for community-level analysis, but should be used carefully.

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Poverty

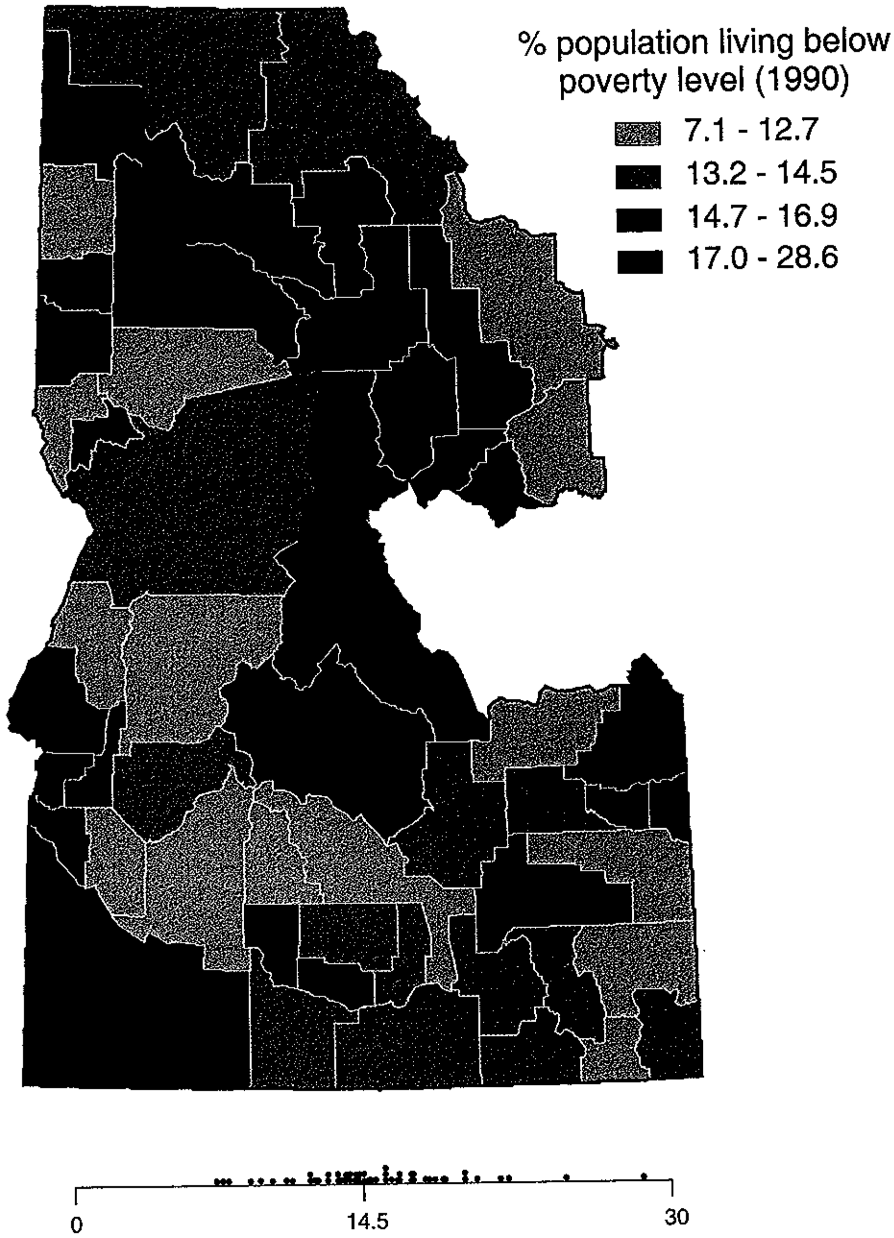

Figure 2b. The percentage of the population living below the poverty level (1990) for each county in the Upper Columbia River Basin of Idaho and western Montana displayed in quartiles.

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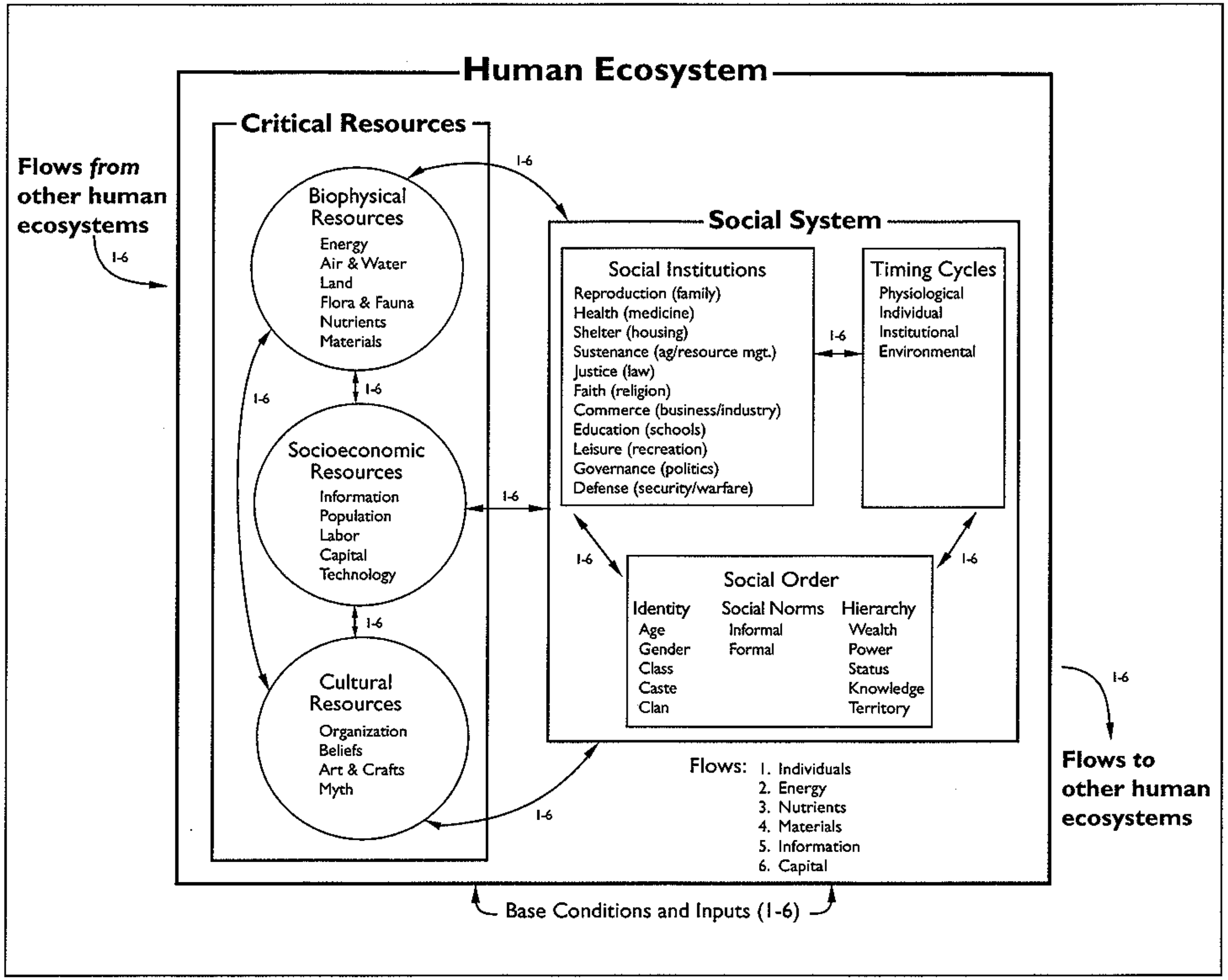

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