Monitoring Social Indicators for Ecosystem Management

Gary E. Machiis, Jo Ellen Force and Shawn E. Dalton

15 November 1994

Technical paper submitted to the Interior Columbia River Basin Project
under Order #43-OEOO-4-9186

Contact: Dr. Gary E. Machlis
College of Forestry, Wildlife and Range Sciences
University of Idaho, Moscow, Idaho 83843
Phone: (208) 885-7129
Fax: (208) 885-6226
E-mail: gmachlis@uidaho.edu

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

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

Odum (whose sons, H.T. and E.P. Odum were to become central figures in the rise of ecology) was a pragmatist as well as 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 expianations 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).

Odum described an interdisciplinary framework for guiding the 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 a large number of social indicators: the core analysis includes data on 685 individual measures (see Figure 1). 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

INDICES OF MEMUREMENT FOR REGIONAL CULTURE UTILIZED IN THE SOUTHERN REGIONAL STUDY

In the attempt w insure measurable reality in research and ● ttainability in emerging programs, more than 700 factors were explored in the Southern Regional Study with varying degrees of completeness with • view to utilizing • larger number of indices than had heretofore been available. The arrangement of such indices on this page follows the general framework of the • tudy; namely, in terms of natural resources and agrarian culture, technological deficiencies and waste, industry and wealth, the southern people, and their institutions and folkways. The present list catalogues only those in which national and regional comparisons are involved and is therefore exclusive of a considerable number in which only the Southeastern States are characterized.

Specal limitations of such comparative indices • re • pparent. In the first place comparisons in terms of census data and other measures • re not always in terms of homogeneous figures, in the sense that data gathered by southern e numerators may not be gathered under ♦:m • ame conditions as in some other regions; in the sense that regional estimates of values are often conditioned *by* ocher cultural factors *mad* are stated in terms of • verages based on unequal quantities and distribution: that various contributing factors to standards, income, wealth, and general culture are often not included: and that many *of* the cultural factors, such as personality, folkways, motivation, handicaps, • re not measureable in terms of our present objective methods. Yet, in spite of these limitations, the picture of the region for the purposes in hand, due to the large number of varying indices susceptible to checking and cross checking, is relatively authentic and complete. More detailed catalogues of these indices appear in the respective chapters • nd in the maps, tables, and graphs themselves.

Numbea of Indices	Classification
1–6.	Acres of land, Grades 1-5
7.	Pasture capacity of land
8–11.	Erosion and impoverished land
12-m.	Use of land
21–23.	Farm • creage and regional per cent of total area
24-27.	Ownership of land by class
28–29.	Tenancy ratio • ndlandharvestedbytenants
30–40.	Distribution of land by use and production
41–58.	Number and size of farms
59-73.	Number of farms by use
74–80.	Value of chief kinds of livestock
81–99.	Kinds of livestock
100–106.	i - u and decrease of livestock
107–109.	Value farm property, implements, dwellings
110–114.	Value of lands and buildings by ownership
115-i 16.	Taxes and decreased value of real estate
117–125.	Horse power, vehicles, trucks, tractors, motors, conveniences, per farm
126–138.	Amouat • md distribution of farm income
139–154.	Production of selected commodities: milk, farm garden vegetables, wheat, corn, livestock, cotton, lumber
155–203.	State and regional production and distribution of chief commodities
204–207.	Farm indebtedness and federal loans and benefits
208–212.	Fertilizer tonnage and distribution
213–216.	Number, value, ● xpenditures, products of nurseries
217–221.	Types of forests and timber
122–223.	Location of waterways
124–227.	Potential water power • vailable
128–239.	Distribution of selected minerals: phosphate, coal, iron, building stone
140–241.	Growing • eason and precipitation
142–246.	Types of days per year
147–249.	Local, state, and regional taxes
150–253.	Value, investment, and indebtedness of schools
154–255.	Home ownership and owner occupancy
156–257.	Per capita tangible and true wealth
158–263.	Selected measures of wealth: bank resources and deposits, postal receipts, corporation income, life insurance, building and loan
164–266.	Taxable property and ratio of property to taxes
167–268.	Bonded and net state debt
169–270.	Retail and wholesale sales
171–276.	Church wealth, expenditures, and debt
177–286.	Net income and taxable incomes
187–294.	Non-farm income—personal, occupational, property
195.	Average teacne's salary.
196–297.	School revenue and expenditures
198.	Receipts of higher institutions of learning
199–311.	Selected measures of manufacturing: distribution, value of product, earners, wages, horse power, value added
312–313.	Increase per earner, per horse power
314–315.	Cotton spindles—counties *and* concentration
316–319.	Distribution of developed water power
320–326.	Distribution of completed and projected waterways
327–341.	Distribution of manufacturing establishments by types
342–345.	Distribution of industrial resources: horse power, water power, value of manufactured product, value added by manufacture
346–356.	Production of coal, petroleum, building stone
X7-360.	Value of all minerals and per cent of U. S. total
361–366.	Limestone, granite, marble—regional differentials in rank and uses
367–370.	Value increased by manufacture, per earner, per horse power
371–374.	Amount and distribution of wages
375–379.	Distribution of income from sources
380–385.	Apportionment of federal relief
386–391.	Roads and highways
392–398.	Ratio of types of highways and gasoline to population and income
399–404.	Highway funds
405–411.	Illiteracy *by* race and age groups
412–414.	Population per square mile, local unit, region
415–419.	Population by age, sex, and marital status
420–423.	Reproductive index and increase variations in population
424–437.	Population *by* residence and race
438–446.	Births and deaths by color and residence
447–452.	Infant mortality and maternal mortality
453–465.	Increase of population—total, by decades, urban rural
466–483.	Distribution of population: urban, race, and nativity
484–487.	Interregional gain or loss by migration
488–492.	Place of binh and residence Of migrants
493–499.	Distribution of wage earners by number • nd density
500–508.	Age, sex, occupation of wage earners
509–518.	Governmental outlay and state expenditures
519.	Number of local governmental local units
520–525.	Parks, monuments, refuges, • *ocma=
526–534.	Per ♋□ᚠ♦ ● rpcnditam for general welfare
535–536.	Physicians, hospitals
537–539.	Insanity, suicide
540–548.	Prisoners and offenses
549–550.	Homicides, lynchings
551–557.	Weekly and daily papers and magazines
558–572.	Students by sex and by types of school
573–574.	Increase in graduates and graduates continuing
575.	Extra-regional students
576–597.	Schools by kinds
598–601.	Educational leaders and Who's Who notables
602–605.	Negro schools: teachers, attendance
606–608.	Rural home and farm agents
609–610.	School tax and income
611–620.	Libraries: revenue, readers, circulation, ratio t people, facilities
621.	Distribution of general cultural items
622–624.	Location of dramatics
625–642.	Church members by sects
643–649.	Churches per population and by type of pastor
650.	Church periodicals
651–652.	Highways and airways
653–657.	Types of vehicles
658.	Taxes for roads
659–663.	Political affiliations
664–668.	Selected cultural measurements: radios, stores automobiles, stills seized
669–685.	Regional classifications of the nation

Figure 1. Indices of measurement for regional culture utilized in the Southern Regional Study. (From Odum. 1936, p. 4)

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 regionai 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 of the United States became a landmark study in the fields of regional science, social indicators and human ecology. It helped guide the South's dramatic post-Civil War resurgence. To read the report in the 1990s with the western U.S. in mind is to realize the contemporary potential of social indicators for aiding decision-making in our region. We,' too, face the challenge of change-in natural resources, economy, people and culture. A new paradigm, ecosystem management, is emerging. There is a significant need for "basic facts," an assessment of socioeconomic conditions that can help resource management agencies "achieve attainable ends."

The purpose of this report is, to: 1) explain how monitoring social indicators can contribute to ecosystem management, 2) provide a theoretical framework for selecting relevant indicators, 3) provide a list of potential social indicators, and 4) make recommendations for their monitoring as one part of the social science contribution to the Interior Columbia River Basin Project (ICRBP).' The report does not address other methods of assessing social conditions, such as ethnographic community-based studies.

The paper is organized as follows. First, we provide a review of social indicators, describing their development and use. Second, we explain their specific application to ecosystem management, and their potential for monitoring socioeconomic conditions within ecosystems, ecoregions, watersheds, and *other* biological units. Third, we present a theoretical framework, derived from human ecology and focusing

on the human ecosystem as an organizing concept. A conceptual model is presented, and key components of the model are described. Fourth, we present a potential list of indicators, as well as their data sources. Fifth, we describe several ways these specific indicators could be monitored to aid ecosystem management. Finally, we make several recommendations for the development and application of social indicators for ecosystem management, and for their use by the ICRBP.

1.1 Defining Social Indicators

Social indicators are statistics collected for policy analysis and decision-making. Numerous formal definitions exist. Rossi and Gilmartin emphasize data collection over time:

> Social indicators are time-series that allow comparison over an extended period and can be desegregated by relevant characteristics. Since they are time-series, social indicators 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 stress the policy relevance and social values associated with indicators. The U.S. Department of Health, Education and Welfare 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 (USHEW, 1969:97).

For the ICRBP, both the time-series character and policy relevance of social indicators are particularly important. In this paper, social indicators are defined as ***an integrated set of social, economic and ecological measures, collected over time and primarily derived from available data sources, grounded in theory and useful to ecosystem management and decision-muting.***

This definition has several implications. Social indicators are not merely a collection of facts or statistics, but result in an integrated ***set*** of measures. (Measures

are the numerical values used to calculate the indicator, such as the percent of population of a certain age or the ratio of part-time to full-time workers.) Social indicators are primarily developed from existing data sources, available over time and 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, i.e. they are multidisciplinary. The indicators provide' "usable knowledge," i.e. they are relevant to monitoring, decision-making, policy analysis, research and other activities related to ecosystem management.

2. SOCIAL INDICATORS: A LITERATURE REVIEW

2.1 An Overview of Social Indicators

Even before Odum's ***Southern Regions;*** social indicators were experimented with by the U.S. government. President Hoover created the President's Research Committee on Social Trends, which prepared a report on trends using social indicators (PRCST, 1933). After Odum's work in the 1930s, other government agencies (such as 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, Bauer published an edited ***volume Social Indicators.*** It represented the state-of-the-art at the time. There was an unsuccessful effort in the late 1960s 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 located in Washington, D.C. to disseminate information and facilitate communication among the many 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 with which to construct a set of social indicators (Andrews, 1989; Bulmer, 1989; Ferriss, 1989; Innes, 1989; Johnston, 1989).

Table 1 presents a list of examples of literature and data generated by the social indicators movement. It suggests that while the theory and methodology for use of social indicators remain immature, social indicators have been used by a variety of organizations and professionals.

In addition to academic and governmental use, social indicators provide data and background information to a growing body of non-academic media and writing. Examples include ***The*** *Rating Guide to Life* ***in America's Small Cities*** (Thomas, 1990), ***Megatrends 2000:*** *Ten* ***New*** *Direction-s 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*** (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 research has also continued. Ray (1989) used social indicators to measure social development. He argued that per capita income is inadequate as a measure because it excludes factors outside the economic sphere, creates rankings of social development that are contrary to common sense, and per capita national income measures economic, not social, development. He suggested that the selection of indicators depends upon the context and availability of data. Similarly, Lind (1992) describes the strengths and limitations of the Human Development Index (HDI), and the indicators of which it is composed. The HDI, a tool proposed by the United Nations Development Programme in 1990, is composed of three indicators: gross domestic product (GDP) per capita, life expectancy at birth, and adult literacy. Again, selection of indicators is demonstrated as critical.

Table 1. Examples of Literature Generated by the Social Indicators Movement (adapted from Ferriss, 1989).

- Social *Indicators 1973* (U.S. Office of Management and Budget, 1974)
- Social Indicators *III* (U.S. Bureau of the Census, 1981)
- *Science Indicators* (National Science Board, 1985)
- *Health USA* 1987 (U.S. Department of Health and Human Services, 1988a)
- *Educational Indicators* (U.S. Department of Education, 1988a)
- *The Condition* of *Education* (U.S. Department of Education, 1988b)
- *Youth Indicators* (U.S. Department of Education, 1988c)
- *Aging America* (U.S. Department of Health and Human Service, 1988b)
- *The Sourcebook of Criminal Justice Statistics* (U.S. Department of Justice, 1988b)
- *Criminal Victimization of the United States* (U.S. Department of Justice, 1988a)
- *Indicators of Housing and Neighborhood Quality* (U.S. Bureau of the Census, 1988)
- *Current Population Reports* (U.S. Bureau of the Census, 1985)
- *North American Social Report* (Michalos, 1981)
- *Kerncr Report: Twenty* Years *Later* (Harris and Wilkins, 1988)
- *A Common Destiny: Blacks in American Society* (Jaynes and Williams, 1989)
- *The Aging Population in the Twenty-First Century* (Gilford, 1988)
- *The* Social *Progress of Nations* (Estes, 1984)
- *Trends in World Social Development* (Estes, 1988)
- *The American Woman 1987-88 (Rix,* 1987)
- *Social Stress in the United States: Clues to Regional Patterns of Crime and Illness* (Strauss and Lansky, 1986)
- *Monitoring the Future: A Continuous Study of the Lifestyles and Values of Youth* (Johnson, Bachman and O'Malley, 1987)
- *Research on the Quality of Life* (Andrews, 1986)
- Other Sources:
  Social Indicators Research
  Demography,
  American Demographics
  SINET: The Social Indicators Network News
  Journal of The American Statistical Association
  INESNEWS (International Indicators and Evaluation of Educational Systems) Newsletter of the *Clearinghouse* on *Health Indexes* of the U.S. National Center for Health Statistics

Jacob and Willits (1994) used secondary sources to construct indices of well-being representing socioeconomic status, family status, health status, and alienation at the county level. Data from a statewide survey of Pennsylvania residents were then collected on how people evaluated their communities of residence. It was expected that the indices of well-being would correlate with one another. This proved to be

statistically significant for socioeconomic, family, and health status, but not significant for alienation, highlighting the need for care in selecting social indicators.

In addition, the 1990s have seen an increase in private firms that collect federal data and produce it for distribution to researchers, managers, and the general public. Proprietary data are collected by various corporations (i.e., fast food corporations, business data; services, marketing research agencies, and so forth). A small but significant information industry has developed around the dissemination of social indicators information.

2.2 Social Indicators in Natural Resource Management

There are relatively few examples of the direct use of social indicators in natural resource management. They have been used in developing social impact assessments as required by the National Environmental Policy Act of 1969. The U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, and 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. It recommends using social indicators to forecast changes likely to occur as the result of a particular project.

The 1984 publication *Measuring the Social Impact of Natural Resource Policies* (Burch & DeLuca) presented a specific theoretical framework to guide selection of indicators and explore relationships. This book was "intended for the environmental planner, impact analyst, or student interested *in* the social dimensions of energy and natural resource issues" (Burch & DeLuca, 1984). It presents a human ecosystem model, and provides examples of the successful integration of social indicators into natural resource management projects, such as National Forest planning teams, water development projects and studies of threats to national parks.

Machlis and Wright (1984) critiqued the sole use of biological indicators to monitor biophysical change in biosphere reserves. They proposed a system of indirect social indicators to compliment the biophysical monitoring and suggested that carefully constructed social indicators, combined with biophysical measurements, could track change within biosphere reserves. Their suggested methodology was tested for Olympic National Park Biosphere Reserve, where three key variables (utilization of natural resources, industrialization, and tourism) were used in a pilot monitoring effort. On the basis of this pilot project, Machlis and Wright argued that social indicators could provide an inexpensive set of baseline data that, with periodic updating, could be used to identify long-term trends. In addition, social indicators could provide "early warning" of impacts upon the biosphere reserve, and be used to compare different reserves.

A government example is *The State of Canada's Environment* (Government of Canada, 1991), a comprehensive inventory of Canada's natural resources. It combines social and biophysical indicators to provide an assessment of the environmental integrity of the country. While the goal seems to be to discover the impacts humans have on "the environment," rather than viewing humans as an integral part of a system, it nevertheless represents an attempt on the part of the Canadian government to understand the interactions between humans and the resources upon which they depend. Further, this document is to be updated every five years, providing for time-series analysis.

2.3 Strengths and Limitations of Social Indicators

Social indicators, like other social science methodologies, have both strengths and weaknesses. Social indicators 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 and/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-what more pithy discourse on the fate of the marginalized underclass? Social indicators are, by definition, easily accessible, and often can be interpreted by non-experts. An example is the widespread understanding of the Consumer Price Index (CPI). Finally, social indicators are policy-relevant; they are useful in policy analysis, decision-making and program evaluation. An example is the reliance of education reformers on Scholastic Aptitude Test (SAT) scores in the development of their reform proposals.

Social indicators have weaknesses as well. As they are dependent upon accessible' secondary information, they are often not available at levels or periods useful to decision-makers. An example is the relative lack of community-level data for state or regional-wide comparisons. 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 (Alanso and Starr, 1987).

Another weakness is the potential instability of measurement criteria-the potential for indicator data to be collected differently or redefined at different times. For example, the number of rapes per 1000 female population is a potential indicator of social disorder. However, if police departments, legal codes, and/or society change the definition of rape (e.g., 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: examples include ethical values, cultural concerns, social tensions within political units, and so forth.

Finally, social indicators are, as Odum noted, the "basic facts." In and of themselves they cannot provide explanations for *why* conditions are changing or what structural constraints limit 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 baseline description and monitor trends in social conditions.

3. RELEVANCE OF SOCIAL INDICATORS TO ECOSYSTEM MANAGEMENT

If social indicators are to be useful to natural resource managers in the 1990s, they must be understood in the broader context of ecosystem management. Yet, "ecosystem management" is not well defined. There are numerous definitions of ecosystem management in the literature, as well as vigorous debate (see for example the August 1994 issue of the *Journal of Forestry).* Some argue that ecosystem management is a significant paradigm shift for natural resource managers; others (such as Forest Service Chief Jack Ward Thomas) suggest it is an evolution. There is wide consensus that definitions of ecosystem management are in flux and implementation of such management "on-the-ground" is fraught with ambiguity and uncertainty.

We chose to use an adaptation of the definition and principles of ecosystem management proposed by Moote et al. (1994), as shown in Table 2. Their definition was the result of a review of the ecosystem management literature, including "writings in the areas of adaptive management, conservation biology, ecosystem management, integrated environmental management, and a miscellany of social science literature" (Moote et al., 1994:i). They state:

> 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).

Table 2. Definition and Principles of Ecosystem Management (adapted from Moote, et al., 1994).

Principles of Ecosystem Management

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.

Socially Defined Goals and Management Objectives

Desired future conditions and the means by which we choose to achieve these conditions are social values. Therefore, ecosystem management, like all forms of management, is a socially defined process. There is nevertheless a recognized need for human society to adapt its activities to protect crucial ecological processes.

Integrated, Holistic Science

Ecosystem management uses a holistic approach, rather than focusing on specific system outputs. It attempts to conserve biodiversity from the genetic to the community level. Ecosystems are recognized as open, changing, complex systems. Ecosystem management focuses on the dynamic interrelations of system components—including social, political, economic, biological, and physical features —and requires better understanding of each of these components and their interrelations. Humans are recognized as a part of ecosystems.

Broad Spatial and Temporal Scales

Specific scales of management will be determined individually for each system, based on societal values and goals. In general, however, ecosystem management requires management on larger spatial and longer temporal time scales than has been the norm in resource management. Ecosystem management means management across ecological, political, generational, and ownership boundaries.

Adaptable Institutions

Institutions for ecosystem management must reflect its experimental nature. Organizations, laws, policies, and management practices need to be flexible, in order that they may adapt to changes in social values, environmental conditions, political pressures, available data, and knowledge. Adaptable institutions treat management as a learning process in which decision-making to go forward in the face of uncertainty. At the same time, it is recognized that institutional decision-making is bounded by the currently defined legal limits of planning and management and by socio-political factors.

Four principles are central to this definition of ecosystem management: 1) socially defined goals and management objectives, 2) integrated, holistic science, 3) broad spatial and temporal scales, and 4) adaptable institutions. In addition, a fifth principle (collaborative decision building) is presented by Moote et al. (1994). It suggests public participation in the decision-making process (which the authors call "joint organizational and community learning") and open governmental structures and processes are important components of ecosystem management.

Collaborative decision building is appropriate (and probably critical) in the Columbia River Basin as an organizational strategy for land management agencies and community institutions. However, there are decision-making systems in many parts of the world that have existed for centuries, as well as contemporary political systems, where collaborative decision-building may not be appropriate, but ecosystem management has been practiced and is appropriate. Thus, we do not include this principle *as* a ***required*** component of all forms of ecosystem management.

3.1 *The Importance of Scale*

Issues of scale are important to social indicators for ecosystem management. One of the principles of ecosystem management calls for larger spatial and longer temporal scales than have been the norm in natural resource management. In research, Allen and Starr (1982) recognized the importance of increasing the scale of analysis, if ecology is to advance. Natural resource managers are often asked to simultaneously consider local concerns and national environmental and economic issues in their decision-malting.

Appropriate spatial scales of human activities range from an individual's personal dwelling to the planet. However, four scales seem critical for social indicators of ecosystem management in the U.S.: communities, counties, states and regions. These scales are hierarchical. In most cases, a specific rural community is nested

within a county which is clear political division of a state. Regions include several entire states or portions of states (for example, the land area included in the ICRBP is considered a region). The discrete spatial concepts of stand, habitat type, forest, watershed, province and region are, as Allen and Starr (1982) generally note, based on both biological characteristics and management convenience. Likewise, the spatial divisions in the socio-political scales are a product of human perception and convenience.

The definition of a human community is complex and varied (see Machlis and Force 1988 for an extensive discussion). In the context of ecosystem management (with its emphasis on landscape), *communities* of place with specific geographic boundaries are appropriate. The short-term impacts of resource management decisions are often 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 the forest ecosystem, 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 boundaries were not always determined by ecological features (e.g., rivers, mountain ridges) or social considerations. However, they are an important administrative and political unit in the United States, and 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 national-level comparisons. As a broad-scale human ecosystem, they give context for understanding local impacts; state law (such as water law) has significant impacts upon resource management. An even broader scale unit of analysis is the region as defined by the ICRBP. Regions have considerable influence (often

indirect) on resource management (Odum, 1936: Field and Burch, 1988), and are increasingly being employed as key planning units.

Temporal scales are also important in human ecosystems. Some are similar to temporal scales in biological ecosystems, such as wildlife seasons. Others are specific to human activities, such as fiscal years and elections. Ecosystem management will involve many different landowners; not all make decisions on the same time scale. An important temporal scale to the non-industrial private forest landowner may be a lifetime; to the federal agency managing adjacent public land, the most important temporal scale may be presidential election cycles. The ability of managers to implement activities may be related to the fiscal calendar of their organizations. Social indicators that capture the various temporal cycles of human activity are necessary.

We recommend that the county be used as the level of analysis for social indicators to monitor the human ecosystem. This is 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 U. S. The county is a major unit of analysis for most national census efforts, and is an exceptionally stable geographic unit for time-series data (little change in county boundaries occur over time).

Second, counties are an important administrative unit for government regulations and policy related to both social and biophysical aspects of ecosystem management. County governments are increasingly 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, McGown (1994) found that a significant proportion of counties were involved in activities associated

with ecosystem management: comprehensive planning (93%), monitoring water quality (40%), and wildfire mitigation (25%) are examples.

Third, county governments are moving to expand their capability to deal with environmental issues. Waugh and Hy (1988) surveyed county executives nationwide and found four of the top five issues facing county governments were environmental: solid waste, land use and zoning, water supply/sewage and toxic waste. In response, counties are increasing the presence of 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* land managers, addressing many ecosystem management issues. They develop comprehensive plans, establish zoning ordinances, grant variances, and in many ways impact human ecosystems.

Finally, county government is-the socio-political unit closest to the landscape 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-

3.2 Monitoring Human Change and Conditions

Monitoring has been, to various degrees, a component of natural resource management and the environmental sciences. It is an essential part of contemporary ecosystem management. Monitoring changes in the environment was significantly expanded with passage of the National Environmental Policy Act of 1969 (NEPA), which established the Council on Environmental Quality to produce annual reports on the quality of the environment. The passage of the Forest and Rangeland Renewable Resource Planning Act of 1974 (RPA), the National Forest Management, Act of 1976 (NFMA) and the Federal Land Policy and Management Act of 1976

(FLPMA) all contributed to the increase in monitoring mandates and requirements. The planning processes adopted by the USDA Forest Service under NFMA and the USDI Bureau of Land Management under FLPMA include monitoring and evaluation. Monitoring changes in *human* conditions as a result of various land management strategies has been sporadic and often atheoretical. Yet, managers are often asked about the effects of management decisions on the lives of those who live in and/or use the forest ecosystem. Managers may also be held accountable for real or imagined changes that impact the lives of citizens. Hence, monitoring of socioeconomic conditions is likely to have an increasing role in ecosystem management. That is, the scope of monitoring must expand. As Staebler (1994:5) suggests:

> ... *ecosystem* management **is not a static program with a beginning and ending date, but rather involves concepts and principles that evolve and adapt** along with changes **in science, economics, and demographics.**

Managers need an integrated set of socioecological measures, collected over time and grounded in theory, to monitor a dynamic program with evolving management practices. Accurate knowledge of conditions is the first prerequisite to understanding ecosystem change, which itself is a prerequisite for action.

4. THEORETICAL FRAMEWORK

The basis of a human ecological approach to social indicators for ecosystem management is a sound theoretical model. The model should be: 1) derived from strong 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. We begin with a brief history of the concept. Next, we present an outline of its critical

elements, followed by a more detailed description of the individual components and their interaction.

4.1 *The Roots of Human Ecology and the Human Ecosystem Concept*

The ecosystem concept was formally defined by Sir Arthur Tansley in 1935, and brought into common application by Eugene Odum's use of the ecosystem as an organizing concept in his 1956 text ***Fundamentals of Ecology.*** Several contemporary histories of the ecosystem idea have been published, notably Frank Golley's A ***History of the*** *Ecosystem Concept* **in *Ecology*** **(1993)** and Joel Hagen's ***An Entangled Bank*** **(1992).** Both limit their discussions to biological ecology.

The roots of a ***human*** ecology lie primarily in general ecology, sociology, and anthropology, as documented by comprehensive literature reviews (Micklin, 1977; Field and Burch, 1988). The application of general ecological principles to human activity was sparked by sociologists at the University of Chicago, where in the 1920s and 30s, the field of sociology experienced rapid growth. Sociologists Park and Burgess drew analogies between natural and human communities, describing society's symbiotic and competitive relationships as an organic web (Faris, 1967). Simultaneously, anthropologists such as Julian Steward and others began to employ the ecosystem as a tool for organizing field work and research. While the Chicago "school" treated the community (and for them that meant the city) as a key unit of analysis, its limited focus on spatial relationships and urban life eventually led to a search for a more holistic framework.

That search (active in the 1950s and 60s) led to what has been termed " the POET model." This model defined the human ecosystem as the interaction between ***population, organization*** and ***technology in*** response to the ***environment*** (Duncan 1964; Catton, 1982). These are human ecology's "master variables"; their interaction is the human ecologist's ***central*** concern. In the 1980s and early 90s, Bill Burch at ***Yale*** and

his students employed the human ecosystem as a theoretical framework for studying energy policy (Burch and DeLuca, 1984), threats to national parks (Machlis and Tichnell, 1985), and anthropogenic impacts upon biodiversity (Machlis, 1992).

4.2 *The Human Ecosystem Defined and Described*

In this paper, the human ecosystem is *a coherent* system *of biophysical* and *social factors capable of adaptation and* sustainability *over time.* For example, a rural community can be considered a human ecosystem, if it exhibits boundaries, resource flows, social structures, and continuity over time. Human ecosystems can be described at several spatial scales, and these scales are hierarchically linked. Hence, a family unit, community, county; region, nation, even the global population can fruitfully be treated as human ecosystems.

While the scale of human ecosystems can vary, there are several essential elements. Figure 2 outlines these elements. A set of *critical resources* are 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 functioning and sustainability. Some of the critical resources may be indigenous to the local area (and used locally or exported), others may be imported from adjacent or far away locales. For example, eastern U.S. sources of investment capital in rural western communities, and national media sources of local information are integral parts of rural human ecosystems—as are other distantly produced but critical supplies.

The flow of these critical resources is regulated and used by the *social system,* the general social structures that guide much of human behavior. The social system is composed of three subsystems. The first is a set of *social institutions,* defined as

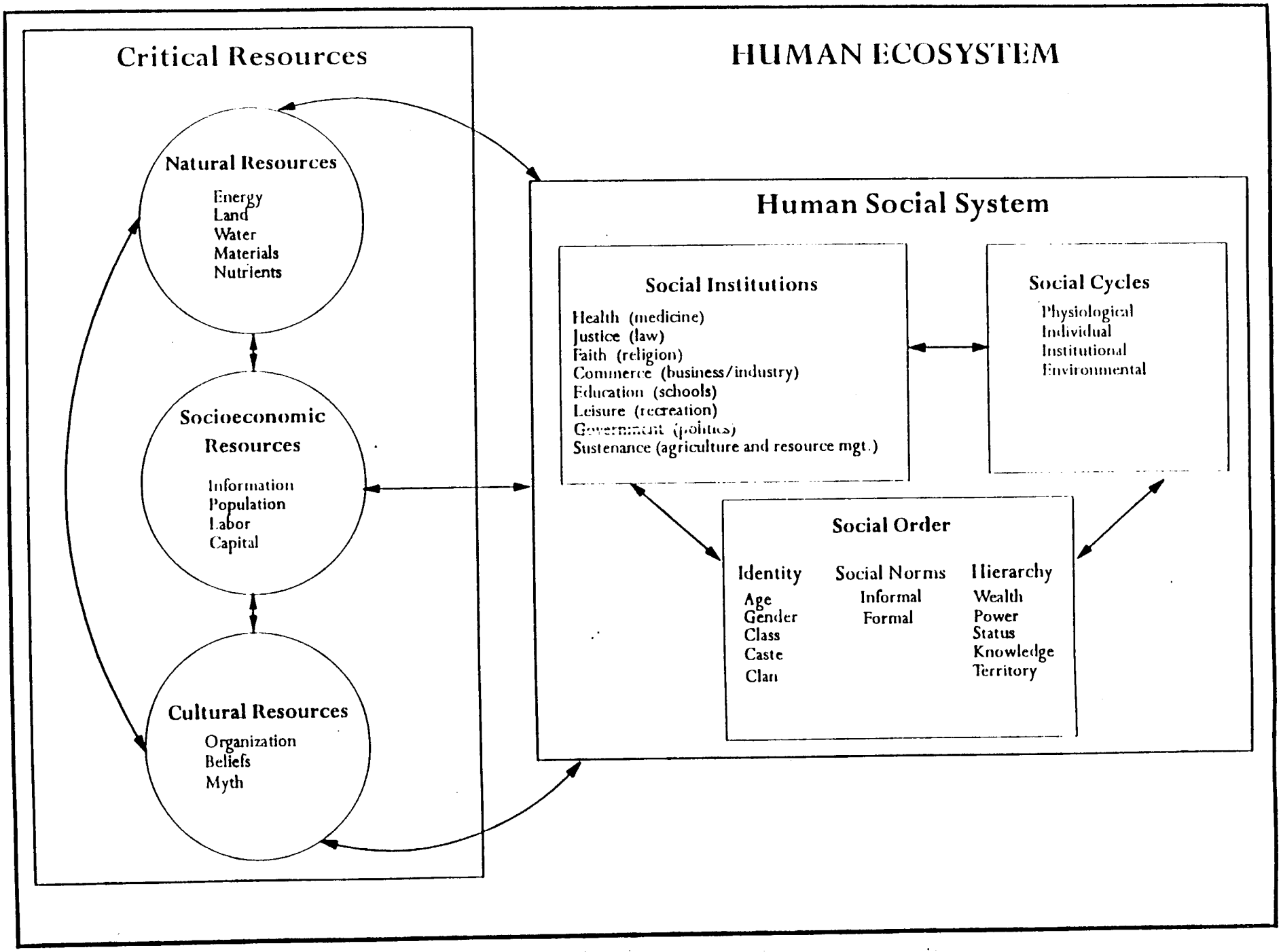

Figure 2. Working Model of Human Ecosystem: Equilibrium Model
(Machlis, Burch and Force, 1994)

collective 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, preventative care and traditional shamans. Other social institutions deal with such universal challenges such as justice (law), faith (religion), and sustenance (agriculture and resource management).

These institutions require critical resources, transform them for various uses, and.. regulate and distribute the resources throughout the human population. Hence, natural resource organizations such as forest districts and processing plants require a supply of labor, transform that labor into products (such as dimension lumber) and regulate the use of that labor (determining the timing and amount of work applied to provide logs to the mill).

The second subsystem is a series of ***social cycles***, which are the temporal patterns for allocating human activity. Tie 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 (permitted hunting seasons). Still others may be specific to the individual (such as grave-yard 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 pups. The social order includes three key mechanisms for ordering behavior: personal ***identities*** (such as age or gender), ***norms*** (rules for behaving) and ***hierarchies*** (of wealth or power, for example). Hence, certain 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.

The social order (individually, collectively and in relationship to social institutions and social cycles) provides high predictability in much of human behavior. 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 at a particular scale. Each of these elements substantially influence the others. For example, changes in the flow of energy (such as an embargo and resultant rationing) may alter hierarchies of power (those with fuel get more) and norms for behavior (such as informal sanctions against wasting fuel).

Adaptation is continuous in human ecosystems (Bennett, 1976); social institutions adapt to changes in resource flows and in turn alter such flows. The result is a dynamic system that changes over time. For example, political institutions may adapt to the increased demands on forest resources by altering decision-making processes (such as increased public participation), and by altering the resource flow (as when the legal system issues injunctions against timber-cutting). Adaptation is used here in a non-valued sense; what is adaptive (or advantageous) for one institution or social group may be maladaptive (or harmful) for another (Bennett, 1976; 1993).

Finally, a particular human ecosystem may be hierarchically nested within human ecosystems at different scales. Hence, the rural community as a human ecosystem may be linked to a *larger* watershed, *region or state,* and to smaller human *ecosystems* such as clans or households. Changes in a human ecosystem at *one* scale may have effects at larger and smaller scales. For example, a rise in rural unemployment may impact family health conditions, increase demands upon community doctors, and deplete state medical funds. Figure 8 illustrates the dynamic model, emphasizing scale linkages and adaptive change over time. It is this

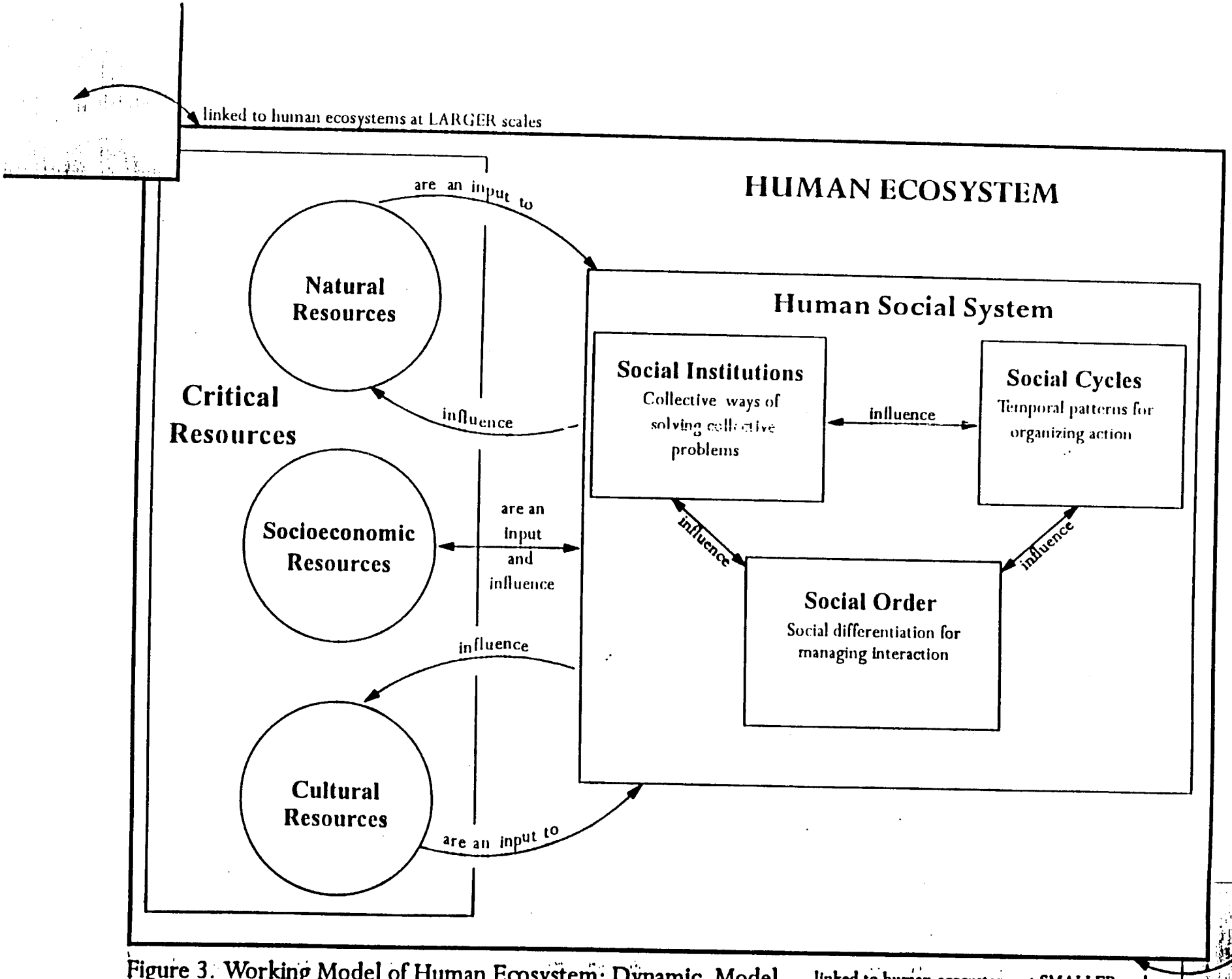

Figure 3. Working Model of Human Ecosystem: Dynamic Model
(Machlis, Burch and Force, 1994)

model (both the equilibrium and dynamic versions) that provides an organizing framework for the key components discussed below. These components (or variables) in turn provide the rationale for selecting a comprehensive set of social indicators for ecosystem management.

4.3 Key Components in the Human Ecosystem

In this section, we identify and describe the key components in human ecosystems (see Figure 2), suggest ways they can be measured, and give selected examples of how they may influence other components and the human ecosystem as a whole.

Natural Resources

4.3.1 Energy

Energy is the ability to do work and/or create heat. As Cottrell (1955) notes, the energy available to humans "limits what we can do, and influences what we will do." Energy is a critical natural resource, and its influence upon social systems is well-documented (see *for* example Rosa et al., 1988). ***Energy flows vary*** by type of source (hydroelectricity, petrol, natural gas, solar, nuclear, wood and so forth) as well as quality (high or low entropy) and flow (continuous, cyclical or interruptable). Energy can be measured by heat output (kcal) or economic value ($/kcal). Changes in energy flows can dramatically alter social cycles and the social order (witness the oil shortages in 1973 and 1979), and can force social institutions (such as the recreation industry or agriculture) to make significant adaptations.

4.3.2 Land

Land includes both surface and underground features. Land is a critical resource, both for its economic and cultural value (Zelinsky, 1973), and can be characterized by ownership patterns (public or private), cover (vegetation or plant community types),

use (such as agricultural, forestry, urban, and so fortb) and economic value. Changes in the resource can often be measured in hectares/land cover-land use type. Such changes often follow restricted trajectories, as forested land is altered to agricultural and then urban uses (Turner et al.,1990). Such changes powerfully influence many social institutions (sustenance and commerce are examples), and alterations in land use often are reflected in altered hierarchies of wealth, power and/or territory through shifts in land tenure and property rights.

4.3.3 Water

Water includes surface and subsurface supplies. Ground water (quickly renewed) and aquifers (a form of capital stock not easily renewable) can both be integrated into human ecosystems. Water resources can be characterized by quality, flow (acre-feet/second), distribution patterns and cyclical trends (such as wet years or drought periods). For much of the western U.S., the aridity of the landscape makes the control and distribution of water a critical function, and a major source of economic, social and political power (Reisner,1986). Changes in water quality can impact social institutions such as health and commerce; water rights are crucial to maintaining social order; access to water influences wealth.

4.3.4 Materials

Materials include basic products derived largely from natural resources. Examples include fertilizers (petrol as a source), dimension lumber (wood), silver and other minerals (ore) plastic (oil), and glass, concrete and denim. The variety of materials used by human ecosystems varies by culture, stage of economic development and consumption patterns. Common measures include economic value/unit and/or the flow of raw product (by ton, pound, ounce or milligram). Much of the sustenance and commerce institutions are based on the-production, distribution and exchange of materials. When flows are altered, norms for use can be

impacted (conservation incentives increase with price), and certain materials may be critical for specific institutions, such as precious gems for industrial use.

4.3.5 Nutrients

Nutrients include the full range of food sources used by a human population. The range of tolerance for nutrient gain or loss is relatively small in *Homo* sapiens, making food a critical resource on a continuous basis. Such resources may vary by culture (religious proscriptions may make certain foodstuffs unedible) as well as climate, and both the caloric value and nutritional supplies (such as amino acids) are critical. Modem human ecosystems include a wide range of imported foods (witness espresso coffee beans from Brazil being brewed in Montana gas stations), and few are self-reliant even for short, seasonal periods. The need for food resources certainly influences sustenance institutions such as agriculture, and food carries mythic connotations (the spiritual value of salmon to several indigenous tribes in the northwest; the turkey as a celebratory poultry). In addition, both wildlife and domesticated stock may have important social values that extend beyond nutrient values. Hence, changes in nutrient flows can alter human health, social norms and cultural beliefs.

Socioeconomic Resources

4.3.6 Information

Information is a necessary supply for any biophysical or social system. Information flow (and its potential for feedback) is central to general systems theory (von Bertalanffy 1968), sociobiology (Wilson, 1975; 1978), and human ecology (Hawley, 1950; Burch and DeLuca, 1984). Information may be coded and transmitted in numerous ways: "body language," oral traditions, electronic (digital data), print (local weeklies, national dailies, newsmagazines), film, radio and television. It can be measured by both transmission rates (such as amount of local radio programming)

and/or consumption patterns (such as paper circulation rates). Information flow can significantly alter numerous components of social systems (such as educational institutions or hierarchies of knowiedge); its impact upon other critical resources (such as land) is also substantial (for example, the importance of maps in resource management).

4.3.7 Population

Human population growth is a dominant factor influencing much of human ecology (Hawley, 1986), both historically (Turner et al., 1990) and within contemporary nation-states, regions and cities. Growth may include natural increases (births over deaths/ year) as well as migration flows. While many conservationists and some demographers treat population as a ecosystem stressor (usually with such value-iaden terms as "threat," "crisis," and so forth), population' is also a supply source for many critical factors within human ecosystems, such as labor, knowledge and social institutions. (Of course. like other resources, oversupply of population can stress the human ecosystem.) However, by treating population as a socioeconomic resource, the model avoids focusing solely on the consumption impacts of people, and includes as well their creative actions (accreting knowledge, providing labor, and so forth).

4.3.8 Labor

Labor has many defmitions; in the human ecosystem model it is defined as the individual's capacity for work (economists sometimes label this as labor power; Thompson, 1983). Applied to raw materials and machinery, labor can create commodities, and is a critical socioeconomic resource. There are many measures: labor time needed to create a unit of economic value (hrs./$100 value), labor value (measured in real wages), labor output (units of production per worker or hour labor), or surplus labor capacity (unemployment rates) are examples. Labor is critical to

human ecosystems both for its energy and information content; that is, both relatively unskilled yet physically demanding labor (such as harvesting crops) and specialized, sedentary skills (such as resource planning or stock brokering) have economic and sociocultural importance. Changes in labor (such as increased unemployment) can impact a variety of social institutions and hierarchies (such as health care and income distribution).

4.3.9 Capital

TO economists, capital can have a range of meanings. A narrow definition treats capital as the "durable physical goods produced in the economic system to be used for the production of other goods and services" (Eckaus, 1972). Other definitions include 'human capital', financial capital and so forth (McConnell, 1975). In the human ecosystem model, capital is defined as the economic instruments of production, i.e. financial resources (money or credit supply), technological tools (machinery) and resource values (such as underground oil). These instruments of production supply the basic materials for producing (with labor inputs) commodities. Capital is a critical socioeconomic resource; its influence over production, consumption, transformation of natural resources and creation of by-products (such as pollution) is significant. Capital is often measured in dollar values, either for commodities produced or the stock of capital on hand. Changes in capital, either in its mix of sources (a new processing plant or mill) or output (a reduction in profits earned by the plant or mill) can alter other institutions as well as hierarchies of wealth, class identities and other features of the human social system.

Cultural Resources

4.3.10 Organization

In the human ecosystem model, organization is treated as a cultural resource, for it provides the structural flexibility needed to create and sustain human social

systems. That is, our species' special ability to create numerous and complex organizational forms is a necessary skill in interacting with nature and society (Wilson, 1978). It is a cultural resource because there is demonstrated wide variation among cultures in how these generic organizing skills are employed. For example, citizens of the United States are willing to create, continually and often, new organizations to deal with collective issues: building a water supply system (irrigation districts), managing education (school boards), caring for the poor (welfare societies) and so forth. Organization can be measured by its diversity (the range of organizational types), intensity (the number of organizations), or saturation (the percent of population that claim membership). Organization is critical to natural resource management-ecosystem management (like river basin accounts in the 1940s and planning districts in the 1970s), is itself an experiment in new ways of organizing.

4.8.11 Beliefs

Beliefs are statements about reality that are accepted by an individual as true (Theodorson and Theodorson, 1969: Boudon and Bourricaud, 1989); citizens may have the beiief that forests are being overcut, that water quality is low, that certain salmon stocks may not be endangered. (Beliefs differ from values, which are opinions about the desirability of a condition—that overcut forests are harmful, that water quality is important, that endangered salmon are irrelevant). Beliefs arise from many sources: personal observation, mass media, tradition, ideologies, testimony of others, faith, logic and science.

Beliefs are crucial to human ecosystem functioning, for they supply a set of "social facts" (Durkheim, 1938) that individuals, social groups and organizations use in interacting with the world. Hence, environmental interest groups rely on a public set of beliefs concerning environmental crises (which may or may not be factual) to energize and increase their membership. Beliefs can be measured by their ideological

content (liberal or conservative), their intensity (the proportion of a population to feel strongly about a belief), and their public acceptance (the proportion of a population that share a similar belief). As beliefs change (due to new information, testimony ,or perception), social institutions are often forced to respond: the changing public beliefs concerning the safety of nuclear power challenged the nuclear industry and regulatory agencies and has led to a decline in nuclear power production in the U.S. (Dunlap et al., 1993).

4.3.12 Myths

TO the human ecologist, myths are narrative accounts of the sacred in a society; they legitimate social arrangements (Malinowski, 1948) and explain collective experiences (Burch, 1971). Hence, myths are an important supply variable because they provide reasons and purposes for human action. For example, the myth of "manifest destiny" provided U.S. citizens at the turn of the century with a rationale for the permanent and private development of the American west; indigenous tribal groups simultaneously called on *their* myths to legitimate their role as temporary stewards of communal land (Worster, 1992). Myths operate at various scales: national myths (such as the manifest destiny), community myths (a timber, town's story of how and why it was founded), and clan myths (such as a family's story of its early matriarchs). Myths are difficult but not impossible to measure. festivals, symbols, legends are all indicators of myth supply. Myths are critical to human ecosystems as guides to appropriate and predictable behavior (witness Smokey Bear's admonitions about fire); they give meaning to and rationale for a wide range of social institutions and social ordering mechanisms. A change in myth (such as reduced perception of community self-reliance) can impact social institutions (such as faith) and a variety of social nom, as well as resource use (such as wilderness).

Social Institutions

4.8.13 Health (medicine)

The health care institution encompasses the full range of organizations and activities that deal with the health needs of a human ecosystem. Health care in modern industrial societies is relatively complex, including primary care (personal and family health maintenance, out-patient activities by general practitioners), secondary care (such as services of specialists) and tertiary care (such as hospital procedures involving surgery [Rodwin, 1984]). Health care institutions are often measured by capacity (the number of doctors or hospitals per 1000 population) or outcomes (such as infant mortality rates). In rural communities, primary care is often available locally; secondary and tertiary care is often provided on a regional basis. Hence, relatively small changes in the health institution (a doctor's retirement,, the closing of a pharmacy) may have direct and indirect effects that ripple through the social system.

4.8.14 Justice (law)

The collective problem of justice faces all human social systems; its role in human ecosystems is critical. Two challenges are central: distributive justice (who should get what, such as property rights [Rawls, 1971]) and corrective justice (how should formal norms be enforced, such as rules for punishment [Runciman, 1966]). The legal system can be measured by both its practitioners (such as the number of lawyers or judges/1000 population) and its performance (number of trials or convictions). The contemporary legal system plays an important role in ecosystem management-the courts influencing distributive justice through timber sale appeals and injunctions, and meting punishment for resource crimes (such as poaching). Changes in legal institutions, such as new procedures for appeal or new laws (such as revision of the Endangered Species Act) can dramatically and directly impact the use of natural

resources, the development of capital, and other components of the human ecosystem.

4.3.15 Faith (religion)

To the human ecologist, religion as an institution has two components: **1)** its social function as a system of organizations and rituals that bind people together into social groups (Durkheim, **1938),** and 2) a coherent system of beliefs and myths **(Weber, 1930).** Both are critical to human ecosystem functioning. Religion, like other social institutions, can be measured by diversity (range of religious practices), capacity (number of churches) or participation (percent population claiming membership). 'Religion impacts the social system in many ways, altering social cycles (religious holidays), providing identity for both caste and clan and influencing beliefs and myths. A change in faith (such as increased demands after a natural disaster) can have significant bearing on how effectively social systems adapt to new ecological and socioeconomic conditions.

14.3.16 Commerce (business/industry)

All societies require a system for exchanging goods and services, and the institution of commerce is central to this exchange (Durkheim, **1933).** Modem industrialized societies (including their rural regions) rely on a mix of exchange styles; the typical western U.S. rural community usually conducts its commerce through a mix of cash, credit and barter **(Machlis** and **Burch, 1983).** Commerce includes not only the exchange medium but the organizations that manage exchange, such as banks, markets, warehouses, retail outlets and so forth. Commerce can be measured as capacity (such as the percent of production capacity utilized, the number of banks) and/or as a flow (the number of transactions or the dollar value of a gross regional or local product). Commerce in rural western areas is largely dependent upon local natural resources (be it water, energy, timber, scenic value or other values [West, **1982]**); a change in commerce can create a cascading set of

impacts upon other social institutions (such as sustenance), the social order (shifts in wealth or power), social cycles (as in a recession) and on critical resources (such as land or labor).

4.3.17 Education (schools)

Individual *Homo sapiens* are born into tbe world sorely lacking in the knowledge needed to survive, adapt and interact with others. Hence, education is a ubiquitous collective challenge: we must educate our young. While significant learning takes place in the home (and on the streets), the educational institution largely functions 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), input (dollars expended/student) and an output (percent 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, the distribution of knowledge, the availability of skilled labor). Dramatic changes in tbe institution (such as school consolidation) can have significant effects on the entire human ecosystem.

4.3.18 Leisure (recreation)

Leisure (the culturally-influenced ways we use our non-work time) is an important institution in all but the most harsh human ecosystems (Cheek and Burch, 1976). Several studies suggest 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, movie-going, 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 both as an amount (hours per day per capita), as a level of participation (percent 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, such as through direct impacts upon commerce (a boom in the tourist industry) and by changing social norms (a decline in festivai attendance or a change in gender participation).

4.3.19 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, legal institutions and so fortb [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, employees are examples) and/or its actions (laws passed, hearings held and so forth). As governments at several scales control critical natural resources in the western U.S. (such as federal government's forestland), changes in government action or process (such as revision to the Endangered Species Act) can have a significant influence upon human ecosystems.

4.3.20 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 requires agricultural and resource management institutions of some complexity (Field and Burch, 1988). Irrigation districts, farmer's cooperatives, agribusiness firms, agricultural extension offices, and environmentally-oriented interest groups are all components of the sustenance institution. So are timber companies, tree farm associates, forestry extension offices and federal management agencies. 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.

Social Cycles

4.3.2 1 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 Burcb 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).

43.22 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 (such as leisure) and the use of natural resources (such as energy or land). They can be measured by such indicators as population 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 and budgets.

4.3.23 Institutional cycles

Each of the social institutions described above have (or create) social cycles that organize the flow of relevant activities (Burch and DeLuca, 1984). The legal institution, for example, creates court seasons and trial days; the recreation and sustenance institutions create hunting and fishing seasons, opening days, and so forth. 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 duration (the length of a hunting season) or intensity (the proportion of a population following a particular cycle, such as school years or banking hours). 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).

4.3.24 Environmental cycles

Not all social cycles are socially constructed: environmental cycles are natural patterns that can significantly influence the human ecosystem (Turner et al., 1990). Environmental cycles include seasons, drought periods, El Niño patterns, and long-term climatalogical change. Drought cycles in the western U.S., for example, impact the growth of 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

4.8.25 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 that 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 to each other, both groups see 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) are likewise 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 upon 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., 1984). 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/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/or 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, women, blue-collar workers, Jews or the McCool family leads to shifts in what is expected as well as what people do; these shifts further alter the human ecosystem.

4.3.26 Social Norms

Norms are rules for behavior, what Abercrombie et al. (1988) call 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 are also informal norms. ***Formal norms*** are more serious and institutionalized; formal norms are usually codified in laws that not only prohibit certain actions but proscribe sanctions (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 result are "folk crimes," i.e. activities that are against the law but not considered harmful by the population. Some kinds of wildlife poaching or illegal wood cutting 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/or deviance (the number of felonies per capita). Changes in social norms can impact the social system

through the full set of social institutions (divorce directly impacts health and justice for women), and by altering resource use.

4.3.27 Hierarchy

An important mechanism for social differentiation, and for managing the social order, is hierarchy. In human social systems (all but small communes or utopias), 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 other's behavior, either by coercion or deference (Wrong, 1988; Mann, 1984). The powerful (often elites with political or economic power) can have access to resources denied the powerless; an example are small-town (or big-city) politicians that make land-use decisions and personally profit from these decisions at the expense of other citizens. *Status* is access to honor and prestige (Lenski, 1984; Goode, 1978); 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 (e.g. teachers are given high status in China, modest status in the U.S.). 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, and 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; in the

U.S. arid West, water rights (granted by historical priority) may be especially critical, 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. Power is difficult to directly measure; rates of participation in certain decision-making (such as public hearings or elections) can provide indirect measures of how power is distributed throughout a population: 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 (i.e. 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.

5. THE SOCIAL INDICATORS

There are 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, and 5) availability, accessibility and quality of data. Table 3 presents recommended social indicators for ecosystem management. The first column lists the variables, derived from the model. The second column lists indicators chosen to represent the variables. In several instances, more than one indicator has been selected for a given variable. Where applicable and possible; an indicator of structure and an indicator of flow have been provided. 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 fourth column describes how to make recommended calculations. The fifth column identifies potential data sources.

Table 3. Recommended Indicators for EEMP Monitoring of Human Ecosystems.

Variable	Indicator	Measure	Calculation	Potential Data Source
Natural Resources				
1. Energy	Occupied housing units heated with wood	% Occupied housing units heated with wood	# occupied housing units heated with wood *divided by* total # occupied units	USA Counties CD-ROM
2. Land	Non-federal land use: cropland, irrigated cropland, forest land, pasture, rangeland, developed land, urban, transportation	% Non-federal land in cropland, irrigated cropland, forest land, pasture, rangeland, developed land, urban, transportation		Soil Conservation Service, "National Resources Inventory"; Bureau of Land Management, "Public Land Statistics"
3. Water	Available water Exposure to pollutants	Total acre-feet of water available Number of exposures to unhealthful levels of primary pollutants		U.S. Geological Survey, "Estimated Use of Water in the U.S." EPA Public Water Supply, Federal Reporting Data Systems
4. Materials	Material production	Amount of material produced by the dominant manufacturing or extractive industry in county		Census of Agriculture; Census of Manufacturers, "Annual Survey of Manufacturers"
5. Nutrients	Agricultural product	Amount of agricultural product (including livestock) produced		Census of Agriculture

Variable	Indicator	Measure	Calculation	Potential Data Source
Socioeconomic Resources				
6. Information	Newspaper subscription rate	% households subscribing to a daily or weekly newspaper		Editor and Publishing Company, "International Yearbook"
	Library loans	Number of books loaned by public libraries per capita per year		State Library Associations
	Literacy	Literacy rate		States Depts. of Education (available at national level from U.S. Dept. of Education)
7. Population	Total resident population	Total resident population		USA Counties CD-ROM
	Rural/urban population	Ratio of rural to urban residents	Rural population *divided by* urban population	USA Counties CD-ROM
8. Labor	Unemployment	Civilian labor force unemployment rate		USA Counties CD-ROM
9. Capital	Bank deposits	Bank deposits (June)		USA Counties CD-ROM
	Income	Median household income (adjusted for inflation)		USA Counties CD-ROM
Cultural Resources				
10. Organization	Service organizations and NGOs	Number of service organizations and non-government organizations (each local chapter)		Primary data
11. Beliefs	Votes by political party	% votes cast for Republican presidential candidate	Votes cast Republican *divided by* total votes cast	USA Counties CD-ROM
12. Myth	Attitudes about private property rights	% population supporting property rights movements		Primary data from public opinion polls (e.g. Gallup)
	Environmental voting records of representatives to state legislature			The Sierra Club; League of Convervation Voters; League of Women Voters
Social Institutions				
18. Health	Infant mortality	Number infant deaths per 1000 live births		USA Counties CD-ROM
	Physicians	Number physicians per 100,000 population		USA Counties CD-ROM

Variable	Indicator	Measure	Calculation	Potential Data Source
14. Justice	Law enforcement	Number police officers with arrest powers per 1000 population	# police officers with arrest powers *divided by* # total residents (convert to per 1000 residents)	USA Counties CD-ROM
	Legal services	Number lawyers per 1000 population		State Bar Associations; Bureau of the Census, "County Business Patterns" and "Census of Service Industries"
15. Faith	Religious service attendance	% population who regularly attend religious services		Princeton Religious Research Center
	Religious affiliation	% population who claim affiliation with an established religion		Glen Mary Research Center, "Churches and Church Membership"
16. Commerce	Earnings	Earnings in all industries		USA Counties CD-ROM
17. Education	Public school enrollment	Number of students per 1000 population	# students *divided by* # total residents	USA Counties CD-ROM
	High school graduates	% high school graduates (persons 25 or older)		USA Counties CD-ROM
18. Leisure	Government expenditures on recreation programs & facilities	Amount of government (county, state, national) expenditures on recreation programs & facilities		Bureau of the Census, "City Government Finances," "Census of Governments," "Historical Statistics on Government Finances and Employment"; National Park Service, "National Park Statistics Abstract"
	Visitor days	Number of recreation visitor days spent on federal, state, and local land		Bureau of Census "Statistical Abstract of the U.S."; National Association of State Park Directors,"Annual Information Exchange";
	Recreational land use	% total land area in county devoted to dominantly recreational use		USDA Economic Research Service, "Major Uses of Land in U.S."

Variable	Indicator	Measure	Calculation	Potential Data Source
19. Government	Voting rate	% population (>18 years of age) participating in presidential elections	Vote cast for president *divided by* total population >18 years of age	USA Counties CD-ROM
	Local government finances	Direct general expenditures per capita		USA Counties CD-ROM
20. Sustenance	Resource-related employment	% employed persons in agriculture, forestry, fisheries, mining	Employed persons in agriculture, forestry, fisheries, mining *divided by* total labor force	USA Counties CD-ROM
	Land use	Acres of irrigated land		USA Counties CD-ROM
Identity (social order)				
21. Age	Median age	Median age		USA Counties CD-ROM
	Dependency	% persons <18 and >64 years of age	(Total population minus persons 18-64) *divided by* total population	USA Counties CD-ROM
22. Gender	Women in labor force	% women in labor force	Total labor force (females) *divided by* total labor force (x100)	USA Counties CD-ROM
	Sex ratio	Ratio of females to males	Female population *divided by* male population	USA Counties CD-ROM
23. Class	Professional and skilled employment	% workers that are professional and skilled workers		USA Counties CD-ROM
24. Caste	Ethnic/racial composition	Ratio Black + American Indian + Asian + Hispanic + Other races to White Population	(Black pop. + American Indian pop. + Asian pop + Hispanic pop. + Other races pop.) *divided by* White population	USA Counties CD-ROM
25. Clan	Household composition	% households of single parents with children under 18	(Male householder, no spouse present, with own children) + (Female householder, no spouse present, with own children) *divided by* (Family households with persons under 18 years old)	USA Counties CD-ROM

Variable	Indicator	Measure	Calculation	Potential Data Source
Social Norms (social order)				
26. Formal	Crime	Number serious crimes known to police per 100,000 population		USA Counties CD-ROM
27. Informal	Divorce rate	Divorces per 1000 population		USA Counties CD-ROM
Hierarchy (social order)				
28. Wealth	Poverty rate	% persons living below poverty level	Persons below poverty level *divided by* Persons for whom poverty status has been determined (x100)	USA Counties CD-ROM
29. Power	Elected positions	Number of elected positions per 1000 population		State Association of Counties
30. Status	*Will not be measured separately from class*			
31. Knowledge	College graduates	% college graduates		USA Counties CD-ROM
32. Territory	Home ownership	% housing units occupied by owner		USA Counties CD-ROM
Social Cycles				
33. Physiology	*a constant*			
34. Individual	Employment terms Work days	Ratio of part-time workers to full-time workers Average number of days worked per year	Part-time workers *divided by* full-time workers	State Depts. of Employment U.S. Dept. of Commerce, State Depts. of Employment
35. Institutional	Term time of elected officials	% elected officials with less than one term in office		state legislatures
36. Environmental	Precipitation Drought	Number of years in last decade with below average precipitation Number of years in last decade declared official drought years		National Climate Data Center Soil Conservation Service

6. METHODS AND APPLICATIONS FOR USING SOCIAL INDICATORS IN ECOSYSTEM MANAGEMENT

In earlier sections, we discussed the general relevance of social indicators to ecosystem management and presented a set of indicators, measures and data sources for the human ecosystem model. The purpose of this section is explain how to collect, display, monitor and apply social indicators to ecosystem management and decision-making. The social indicators we have proposed (see Table 3) are available from relatively few sources; all are easily accessible. Over half of the indicators are in one source: ***USA Counties,*** published by the U.S. Bureau of Census, and available on CD-ROM.

6.1 Collecting the Data

The first step in data collection is to determine the boundaries of interest. Based on the ecological and administrative boundaries of concern, one must identify all counties wholly or partially within these boundaries. Counties adjacent to the boundary may possibly be included, depending on the scale of the project and the need to understand wider regional contexts. The boundaries of interest for the social indicators of the human ecosystem (counties) may vary from those for other components of the ecosystem. This is common to ecosystem-level analyses. For example, the boundaries for vegetation-based ecosystems are often different than that for certain wildlife resources with their seasonal habitats and migratory routes. Thus, in any ecosystem management project one would expect a variety of "boundaries" around the core area of interest, depending on the ecosystem components of concern.

The next step is to establish a detailed data dictionary that: 1) defines each indicator, '2) includes all calculations for indices, 3) describes all data sources and, 4) provides specific instructions on obtaining the data. This step is critical to

establishing long-term monitoring of social indicators and developing an "institutional memory," as personnel change frequently within agencies and among decision-makers. The data dictionary must be updated as appropriate.

A third step is to store data in a database that is user-friendly both in storage and retrieval operations. The data must be accessible to managers, amenable to relatively basic manipulations and transferable to a geographic information system file. Finally, the database should be carefully archived (along with the data dictionary) in at least two separate locations.

6.2 Displaying the Data

The purpose of data display is to allow ecosystem managers to analyze data, summarize the information and make comparisons across time and space. Data displays can be in tables, graphs/charts or maps. The displays can be organized in two general ways. Each county can be displayed individually with a complete data set for all variables for that county. Conversely, each variable and its indicator(s) (e.g., labor and its indicator unemployment rates) can be displayed across all counties. The organization of the display depends upon the manager's need. In most ecosystem management situations it is advisable to do both. Communication of data displays can be via report, atlas and/or statistical abstract using print or electronic mediums. There is a large literature on creating accurate and useful, visual displays of quantitative data (see, for example, Tufte, **1990**; Fortner, **1992).**

Maps are a powerful medium for the display of social indicators. They can best display data by variable and indicator. For example, a map displaying a social indicator for ***wealth*** (such as percent of persons below poverty level) can provide information about the range of variability in poverty levels across all counties in the ecoregion, and allow managers to determine geographic areas where poverty levels are similar and/or at the extremes. Maps should follow sound cartographic design.

Issues of map scale, size, orientation, etc., need to be carefully considered. Again, there is a sizable literature to guide the map production process (see for example Lobeck, 1993; Monmonier 1991). Appropriate GIS software systems, desktop mapping tools and cartographic production services are all available.

6.3 *Monitoring*

Monitoring (the continued or repeated collection of data at systematic intervals) is a critical part of natural resource planning and management activities. For some agencies it is required by law; for ail entities it is a valuable planning and management tool. Similar to monitoring of other components of the ecosystem, social indicator monitoring is a long-term effort. By definition, social indicators are usually secondary data, thus, they are not always available on an annual basis. The largest source of social indicator data is the series of censuses conducted by the 'U.S. Bureau of Census. The decennial population census is complemented by 5-year censuses of agriculture and manufacturing. With projections, periodic updates and revisions, new data are usually available every three to five years. Hence, monitoring of most human ecosystem variables can usually be done on this three- to five-year cycle.

Monitoring consists of two steps: collecting data as described above, and calculating rates of change from one period to another. Monitoring displays (tables, charts, maps) which present rates of change require more complex presentations than baseline data displays. It is also important to display variation in the rates of change for an indicator, such as unemployment levels. Targets, tolerance ranges or warning thresholds can be set to make decision-makers aware of critical changes in the human ecosystem. Because of the long-term nature of monitoring, protocols must be given careful attention.

6.4 *Applications*

There are six main applications of social indicators for ecosystem management. Three of these involve making comparisons: comparisons ***within*** an area of interest (such as ecoregions); ***between*** ecoregions; and over time. Three other applications provide valuable management information and will also be discussed.

6.4.1 Comparisons within ecoregions

It is often useful to compare across counties within an ecoregion to describe variation between counties. 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.

An important caution: social indicators collected at one scale cannot be automatically 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; town populations may vary dramatically from county-wide average income. Such misapplication is described in sociology as "the ecological fallacy" (Abercrombie et al., 1988). County-level indicators can provide a *context* for community-level analysis, but should be used carefully. For example, only two counties in the ICRBP include the site of a state capital, with the associated unique roles of government and impacts on hierarchy within the county.

6.4.2 Comparisons between ecoregions

These comparisons help decision-makers determine whether there are unique or generalized conditions in an ecoregion. All ponderosa pine communities share certain characteristics (e.g. drier, lower elevation sites), whether in Idaho or Colorado. Likewise, 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 percent of college graduates (knowledge), compared to urban areas or other agricultural ecoregions. If social indicator monitoring is implemented in several ecoregions, then the influence of changes in one region may be observed and measured in a different region. For example, a decrease in materials such as timber in the western Cascade Mountains of Oregon and Washington may not only impact the human ecosystem within that region, but may change the demand (and price) for materials in the ICRBP or the southern U.S.

6.4.3 Comparisons over time

Comparisons over time are central to ecosystem monitoring. Silviculturists use measures at various time intervals of tree growth following fertilization activities. Similarly, social indicator monitoring can provide valuable insights into the relationships between the variables in the human ecosystem and managers' actions. For example, management decisions about water availability will' influence the number of people employed in agriculture. Also, just as fire ecologists reconstruct the fire history of a stand, it may be useful to reconstruct the historical human record to better understand current trends. Temporal comparisons of social indicators can be made within and/or between ecoregions. Historical data for most (but not all) of the social indicators are available.

6.4.4 An early warning system

Social indicators can be used in ecosystem management just as wildlife indicators, water quality indicators and others are used: to identify potential problems early. 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 (the definition of "at risk" is itself a subject of considerable debate). They also serve as an early warning system for managers, indicating a particular component

(e.g., the health care system) that needs careful treatment and attention. As Secretary of Interior Babbitt has stated, resource management agencies need to avoid "train wrecks." Managers, decision-makers and citizens should be prepared to take action if significant change in the human ecosystem begins to occur.

6.4.5 Evaluate responses to ecosystem management

Ecosystem managers must be able to evaluate human ecosystem responses to resource management decisions/actions. Once baseline data are collected and monitoring is underway, social indicators can be used to evaluate the rate, intensity and spatial distribution of response to various natural resource management actions. There are significant data and research on certain relationships in the human ecosystem model. For example, economists have developed causal models for the relationships among labor, capital and commerce; anthropologists provide insights into the relationships among myths, beliefs and social norms; and sociologists have examined relationships between material flows and social institutions. For others, 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 causal. Nevertheless, it is important to evaluate the responses and build an empirical database that will contribute to model deveiopment for future predictions and management decisions.

6.4.6 Prioritize actions

Resource managers, local officials, and individual citizens must all prioritize their actions. Descriptions and comparisons of components of the human ecosystem across counties 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 re-training 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, providing information to Congress, and so forth.

7. RECOMMENDATIONS

We recommend that the ICRBP undertake several actions; these are discussed below.

7.1 A comprehensive, long-term program of using social indicators to monitor the human ecosystem in the ICRBP area should be initiated.

Because the human ecosystem is a coherent *system* of social as well as biophysical factors, it is important that a comprehensive program be undertaken. Human ecosystems are capable of adaptation and sustainability over time. Thus, the program should be long-term. Such a program would also be transferable to ecosystem management efforts which may be developed in other regions of the country.

7.2 The monitoring program should be integrated into existing and planned monitoring and evaluation programs.

One existing monitoring program in the USDA Forest Service is that mandated by the National Forest Management Act and requiring annual monitoring and evaluation of forest plan activities, including a report to the public. To date, monitoring and evaluation have primarily focused on indicators of the biophysical environment (e.g., water quality measures), product outputs (e.g., timber cut, animals grazed, roads constructed) and recreation use of the national forests. The extension of these and similar efforts to include social indicators of the human ecosystem would greatly strengthen monitoring and evaluation activities useful to ecosystem management.

7.3 The program should use the human ecosystem model described in this paper, and focus on social indicators at the county level.

The rationale for use of the human ecosystem model and the appropriateness of county level data are presented in detail in earlier portions of this report. By following such an explicit theory, the criteria and rationale for selecting indicators will be clear. By using county-level data, a practical and insightful database can be developed.

7.4 A pilot effort should be undertaken on social indicators at the county level for the ICRBP area or a portion thereof. This effort should include an assessment based on the county level data and an atlas displaying the data.

The ICRBP includes counties in portions of 7 states. A pilot effort is recommended to identify barriers to implementation and to recommend efficient ways to implement the use of social indicators throughout the project area. A map series or atlas displaying each social indicator and its variation across the project area could be a powerful visual analysis tool. Data could be easily communicated to decision-makers within public agencies, county-level government and the general public. This pilot effort should be carefully evaluated by potential users and revisions made prior to widespread adoption.

7.5 Responsibility for social indicator monitoring should be centralized with a small, but expert staff.

The acquisition, storage, and retrieval of social indicators does not require the full-time attention of a social scientist or database manager at small scales such as a state BLM or Regional Forest office. Consolidation of such activity in 2-3 centers around the U. S. will better utilize human and monetary resources and be more efficient. Such a centralized data management system should be readily accessible to decision-makers in USDA and USDI agencies, as well as state and local agencies.

The USDA Forest Service Rocky Mountain Regional Office is currently developing the "Common Social Unit Geographical Information System" (CSUGIS) for most of the western Forest Service regions (Case, personal communication, 1994). This system is built on demographic data from the 1990 U. S. Census at the block group level. (The "block group" is a delineation of rural land comparable to a "census tract" in urban areas. Each block group has approximately 8000 people; block groups are nested within counties [Case, n.d.].) Although all the recommended social indicators for the human ecosystem model are not available in the U. S. Census data set, the CSUGIS is an excellent start and could be expanded to include social indicators for ecosystem monitoring.

7.6 Use of social indicator monitoring information should be decentralized, and data should be available to local government decision-makers and citizens.

Whereas the responsibility for managing the information system can be centralized across several ecosystems, the *availability* of information to decision-makers and citizens must be at the local level. It must be provided in easily understandable formats (such as statistical abstracts, interactive databases or map series) and at regular intervals. Trend information should be provided.

7.7 A strategy for adoption of the program must be developed, including training and evaluation activities.

The use of social indicators for monitoring ecosystem management activities is an innovation for most natural resource managers. A careful adoption strategy is necessary. Adoption-diffusion theory (Rogers; 1983) has been widely used to introduce new innovations in a wide variety of situations. It is applicable to the adoption of social indicators for ecosystem management. Training activities within agencies, in professional societies, and at universities need to be designed. Their purpose should be to assist decision-makers and citizens in developing and using

social indicators. Evaluation focusing on improving the utility of the program to users should be conducted.

7.8 A modest research agenda dealing with social indicators and the human ecosystem model should be undertaken.

There is much to learn about social indicators, particularly as applied to their use in ecosystem management decisions. Research should cover such topics as: 1) improving the reliability and accessibility of social indicator data; 2) testing the overall human ecosystem model and relationships between specific variables; 3) conducting an assessment for the past 40-50 years to reconstruct the recent historic range of variability within an ecoregion, 4) examining relationships between the human ecosystem and resource management practices, and 5) evaluating the effectiveness of adoption-diffusion strategies for implementing social indicator monitoring.

8. CONCLUSION

Social indicators represent one valuable tool for ecosystem management. Adopting and implementing a system of social indicators for ecosystem management requires new skills and expertise. It is likely to require a cultural change within natural resource organizations and professions. The adoption and diffusion of social indicators among natural resource managers will depend upon patience and planned strategies. The benefits are likely to be significant.

As Burch and Deluca remind us, there is a close relationship between social goals and ecological conditions. They state:

> All resource management professions and agencies have certain goals they hope to attain—the continuous yield of saw timber, increased production of elk, protection of endangered habitats, energy independence, economic growth or improved environmental conditions... We use hunter success days, recreation visit days, growth volumes of forests, storage rates of water impoundments, and a variety of other indicators to monitor our success and failure in accomplishing certain resource management goals (Burch and Deluca, 1984:182).

Hence, the experience of resource managers in dealing with environmental monitoring may provide guidance for useful approaches to human ecosystem monitoring. An example is global climate change. There is a paucity of data, and theoretical models are in flux. Causal relationships are not fully understood, nor 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 watched 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 theory always available. Yet, the wise ecosystem manager, decision-maker and citizen needs to come to grips with what Odum, 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.

9. REFERENCES CITED

Abercrombie, N., S. Hill, and B. S. Turner. **1988.** ***The penguin dictionary of sociology.*** **2d** ed. New York: Penguin Books.

Allen, T. F. H., and T. **B.** Starr. **1982.** *Hierarchy: perspectives* **for** ***ecological complexity.*** Chicago: University of Chicago Press.

Alonso, W., and P. Starr. **1987.** *The politics* ***of numbers. New*** York: Russeil Sage Foundation.

Andrews, F. M. **1989.** The Evolution of a Movement. ***Journal of Public Policy*** **9(4):401-405.**

____, ed. *1986.* ***Research on the quality of life.*** Ann Arbor: University of Michigan.

Bauer, R. A., ed. **1966.** ***Social Indicators.*** Cambridge: MIT Press.

Bennett, J. W. *1993.* ***Human ecology as human behavior. New*** Brunswick: Transaction Publishers.

____. 1976. ***The ecological transition: Cultural anthropology and human adaptation.*** New York: Pergamon Press.

Bidwell, C. E., and N. E. Friedkin. **1988.** The sociology of education. Pp. **449-471** in ***N.*** J. **Smelser,** ***Handbook of*** sociology. **Newbury** Park: Sage Publications

Boudon, R., and F. Bourricaud. *1989. A critical dictionary* ***of sociology.*** Chicago: University of Chicago Press.

Bulmer, M. **1989.** Problems of theory and measurement. ***Journal of Public Policy*** **9(4):407-412.**

Burch, W. R, Jr. *1971.* Daydreams ***and nightmares: A sociological essay on the American environment. New*** York: **Harper** and Row.

Burch, W. R., Jr., and D. R. **DeLuca. 1984.** ***Measuring the social impact of natural resource policies.*** Albuquerque: University of New Mexico Press.

Case, P. **n.d.** The "common social unit" geographical information system. Unpublished paper. USDA Forest Service Rocky Mountain Region, Golden, CO.

____, *1994.* Personal communication, October. Regional social scientist, Rocky **Mountain** Region, USDA Forest Service, Golden, CO.

Catton, W. R, Jr. **1982.** ***Overshoot:*** *The ecological* ***basis of revolutionary change.*** Urbana: University of Illinois Press.

Cheek, *N.* H., Jr., and W. R. Burch, Jr. **1976.** *The social organization of leisure in human society. New* York: Harper and Row.

Cottrell, F. *1955. Energy and society: The relation between energy, social* change, *and economic development.* Westport, CT: Greenwood Press.

Duncan, 0. D. **1964.** Social organization and the ecosystem. In *Handbook of modern sociology,* ed. F. Robert. New York: Rand McNally.

Dunlap, R. E., M. E. Kraft, and E. A. Rosa, eds. **1993.** *Public reactions to nuclear waste.* Durham, NC: Duke University Press.

Durkheim, E. *1938. The rules of sociological method.* 8th ed. New York: The Free Press.

____. *1933. The division of labor in society.* Glencoe, IL: The Free Press.

Eckaus, R. S. **1972.** *Basic economics.* Boston: Little, Brown and Company.

Eisenstadt, *S. N.* **1956.** *From generation to generation.* Glencoe, IL: The Free Press.

Estes, R. J. *1988. Trends in world social development.* Westport, CT: Praeger.

____. **1984.** *The social progress of nations.* Westport, CT: Praeger.

Faris, R. E. L. *1967. Chicago sociology 1920-1932.* Chicago: University of Chicago Press.

Ferriss, A. L. **1989.** Whatever happened, indeed! *Journal of Public Policy* 9(4):413-417.

Field, D. R., and W. R. Burch, Jr. **1988.** *Rural sociology and the environment.* Middleton, WI: Social Ecology Press.

Fortner, B. *1992. The data handbook: A guide to understanding the organization and visualization of technical data.* Champaign, IL: Spyglass, Inc.

Gilford, D. M. 1988. The *aging population in the twenty-first century.* Washington, D.C.: The National Academy Press.

Goldman, **B.A.** *1991. The truth about where you live: An atlas for action on* **toxins** and *mortality. New* York: Random House.

Golley, F.B. *1993. A history of the ecosystem concept in ecology.* New Haven: Yale University Press.

Goode, W. J. **1978.** *The celebration of heroes: Prestige as a social control system.* Berkeley: University of California Press.

Government of Canada. 1991. ***The state of Canada's environment.*** Ottawa: Environment Canada.

Hagen, J. 1992. ***An entangled bank: The origins of ecosystem ecology. New*** Brunswick: Rutgers University Press.

Harris, F. R., and R W. Wilkins, eds. 1988. ***The Kerner report: Twenty years later.*** Washington: Bahnsen Communications.

Hawley, A. H. 1986. ***Human ecology: A theoretical*** essay. Chicago: University of Chicago Press.

____. 1950. ***Human ecology: A theory of community.*** New York: The Ronald Press.

Henwood, D. 1994. ***The state of the USA atlas: The changing face of American life in maps and graphics.*** New York: Simon & Schuster, Inc.

Innes, J. E. 1989. Disappointments and legacies of social indicators. ***Journal of Public Policy*** 9(4):429-432.

INESNEWS, CERI and the Education Training Division of OCDE, Paris.

Jacob, S. G. and Willits, F. K. 1994. Objective and Subjective Indicators of Community Evaluation: A Pennsylvania Assessment. ***Social Indicators Research*** 32:161-177.

Jaynes, G. D., and R. M. Williams, eds. 1989. ***A common density: Blacks in American*** society. Washington, D.C.: National Academy Press.

Johnson, L. D., J. G. Buchman, and P. M. O'Malley. 1987. ***Monitoring the future: A continuing study of the lifestyles and values of*** youth.. Ann Arbor: Interuniversity , Consortium for Political and Social Research.

Johnston, D. F. 1989. Some Reflections on the United States. ***Journal of Public Policy*** 9(4):433-436.

Journal of Forestry. 1994, vol. 92(8). Ecosystem management: Will it work? Bethesda, MD: Society of American Foresters.

Lenski, G. E. 1984. ***Power and privilege: A theory of social stratification.*** Chapel Hill: The University of North Carolina Press.

Lind, N. 1992. Some thoughts on the human development index. ***Social Indicators Research*** 27:89-101.

Lobeck, A. K. 1993. ***Things maps don't tell us: An adventure into map interpretation.*** Chicago: University of Chicago Press.

McConnell, Campbell R. 1975. ***Economics,*** 6th ed. New York: McGraw-Hill Book Co.

McGown, M. G. 1994. The influence of organizational variables on environmental management by county governments. Ph.D. thesis. University of Idaho, Moscow.

Machlis, G.E. 1992. The contribution of sociology to biodiversity research and management. *Biological Conservation* 61:161-170.

Machlis, G. E., and W. R. Burch, Jr. 1983. Relations between strangers: Cycles of structure and meaning in tourist systems. *Sociological Review* 31(4):666-692.

Machlis, G. E., and J. E. Force. 1988. Community stability and timber-dependent communities. *Rural Sociology* 53(2):220-234.

Machlis, G. E., and D. L. Tichnell. *1985. The state of the world's parks: An international assessment of resource management, policy, and research.* Boulder, CO: Westview Press.

Machlis, G.E., & Wright, R.G. 1984. Potential indicators for monitoring biosphere reserves. Pp. SO-62 in T.N. Vezirohlu (ed.), *The biosphere: Problems and solutions.* Amsterdam: Elsevier Science.

Malinowski, B. 1948. *Magic, science and religion and other essays.* Glencoe, IL: The Free Press.

Mann,M. 1984. *The sources of social power: Volume 1, a history of power from the beginning to A.D. 1760.* New York: Cambridge University Press.

Michalos, A. C. 1981. *North American social report.* (4 volumes). Dordrecht, Holland: D. Reidel Publishing Company.

Micklin, M. 1977. The ecological perspective in the social sciences: A comparative overview. Paper presented at Conference on Human Ecology, October 1977, Seattle, Washington.

Monmonier, M. 1991. *How to lie with maps.* Chicago: University of Chicago Press.

Moote, M. A., S. Burke, H. J. Cortner, and M. G. Wallace. *1994.* Principles of ecosystem management. Tucson: Water Resoures Research Center, College of Agriculture, The University of Arizona.

Myers, D. 1992. *Analysis with local census data: Portraits of change. San* Diego: Academic Press.

Naisbitt, J. & Aburdene, P. 1990. *Megatrends* 2000: *Ten New Directions for the 1990s.* New York: William Morrow & Company, Inc.

National Science Board. 1985. Science *indicators.* Washington, D.C.: U.S. Government Printing Office.

Odum, E. P. 1956. *Fundamentals of* ecology. Philadelphia: Saunders.

Odum, H. T. 1936. *Southern regions of the United States.* Chapel Hill: The University of North Carolina Press.

President's Research Committee on Social Trends. 1933. *Recent Social Trends.* New York: McGraw-Hill.

Rawls, J. 1971. *A theory of justice.* Cambridge: The Belknap Press of Harvard University Press.

Ray, A. 1989. On the Measurement of Certain Aspects of Social Development. *Social Indicators Research* 21:35-92.

Reisner, M. 1986. *Cadillac desert: The American West and* its *disappearing water.* New York: Penguin Books.

Rix, S. E. 1987. *The American woman 1987-88: A report in depth. New* York: Norton.

Rodwin, V.G. *1984. The health planning predicament: France, Quebec, England and the United States.* Berkeley: University of California Press.

Rogers, E.M. 1983. *Diffusion of innovations,* 3rd ed. New York: The Free Press.

Rosa, E. A., G. E. Machlis, and K. M. Keating. 1988. Energy and society. *Annual Review of Sociology* 14:149-172.

Rossi, R J. and Gilmartin, K. J. 1980. *The Handbook of Social Indicators: Sources, Characteristics, and Analysis. New* York: Garland STMP Press.

Runciman, W.G. 1966. *Relative deprivation and social justice.* London: Routledge & Kegan Paul.

Schor, J. B. 1992. *The overworked American: The unexpected decline of leisure. New* York: Basic Books.

Scialfa, M. 1992. An ethnographic analysis of poachers and poaching in northern Idaho and eastern Washington. Master's thesis, University of Idaho, Moscow.

Shell, K.L. 1969. *The Democratic political process.* Waltham, MA: Blaisdell.

Staebler, R. N., ed. 1994. Ecosystem management: An evolving process. *Journal of Forestry* 92(8):5.

Strauss, M. A., and A. S. Lansky. 1986. *Social stress in the United States: Clues to regional patterns of crime and illness.* Dover, MA: Auburn House.

Theodorson, G. A., and A. G. Theodorson. 1969. *Modem dictionary of sociology.* New York: Thomas Y. Crowell Company.

Thomas, G. S. 1990. *The Rating Guide to Life in America's Small Cities.* Buffalo, NY: Prometheus Books.

Thompson, P. 1983. *The nature of work: An introduction to debates on the labour process.* London: Macmillan.

Tufte, E. R. 1990. *Envisioning information.* Cheshire, CT: Graphics Press.

Turner, B. L., II, ed., W. C. Clark, R. W. Kates, J. F. Richards, J. T. Mathews, and W. B. Meyer. 1990. *The earth as transformed by human action: Global and regional changes in the biosphere over the past 300 years.* Cambridge: Cambridge University Press with Clark University.

U.S. Bureau of the Census. 1988. *Indicators of housing and neighborhood quality.* Washington, D.C.: U.S. Government Printing Office.

1985. *Current population reports.* Special Studies, (Series P-23, NO. 144) 'Subject Index to Current Population Reports.' Washington, D.C.: U.S. Government Printing Office.

1981. *Social indicators III.* Washington, D.C.: U.S. Government Printing Office.

U.S. Department of Commerce, Bureau of the Census. 1992. USA Counties. Computer laser optical disk.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 1994. 'Guidelines and Principles for Social Impact Assessment', Report NMFS-F/SPO-16. Washington, D.C.: The Interorganizational Committee on Guidelines and Principles for Social Impact Assessment.

U.S. Department of Education. 1988a. *Educational indicators. CS 88-624.* Stern, J. D., ed. Washington, D.C.: U.S. Government Printing Office.

- - 1988b. *The condition of education.* 2 vols. Washington, D.C.: U.S. Government Printing Office.

- - 1988c. *Youth indicators 1988: Trends in the well-being of American* youth. Washington, D.C.: U.S. Government Printing Office.

U.S. Department of Health, Education and Welfare. 1969. *Towards a social report.* Washington, D.C.: U.S. Government Printing Office.

U.S. Department of Health and Human Services. 1988a. *Health U.S.A. 1987.* U.S. Washington, D. C.: Government Printing Office.

1988 b. *Aging A merica: Trends and projections 1987-88.* LR3377(188-D 12198). Washington, D. C.: U.S. Government Printing Office.

U.S. Department of Justice. 1988a. "Criminal Victimization 1987." *Bulletin.* Washington, D.C.: U.S. Department of Justice.

____. 1988b. *Sourcebook of criminal justice statistics, 1987.* NCJ-111612, Timothy J. Flanagan and Katherine M. Jamieson, eds. Washington, D.C.: U.S. Department of Justice.

U.S. Office of Management and Budget. 1974. *Social* indicators, *1973.* Washington, D.C.: U.S. Government Printing Office.

von Bertalanffy, Ludwig. 1968. *General system theory.* New York: Braziiler.

Waugh, W. L., Jr., and R. J. Hy. 1988. The administrative, fiscal, and policymaking capacities of county governments. *State and Local Law Review* 20(1):28-31.

Weber, M. 1930. *The Protestant* ethic *and the spirit of capitalism.* London: Allen & Unwin.

Weitz, S. *1977. Sex roles: Biological, psychological and social foundations. New* York: Oxford University Press.

West, P. C. 1982. *Natural resource bureaucracy and rural poverty: A study* in *the political sociology of natural resources.* Ann Arbor: University of Michigan.

Wilson, E. *0.* 1978. *On human nature.* Cambridge: Harvard University Press.

____. 1975. *Sociobiology: The new synthesis.* Cambridge: The Belknap Press of Harvard University Press.

Wolff, M., P. Rutten and A. F. Bayers, III. 1992. *Where we stand: Can America make it* in *the global race for wealth, health, and happiness?. New* York: Bantam Books.

Worster, D. 1992. *Under western skies: Nature and history in the American West.* New York: Oxford University Press.

Wrong, D. H. 1994. *The problem of order: What unites and* divides *society.* New York: The Free Press.

____. 1988. *Power: Its forms, bases, and uses.* Chicago: University of Chicago Press.

Zelinsky, W. 1973. *The cultural geography of the United States.* Englewood Cliffs, NJ: Prentice-Hall.