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# A social ecology approach and applications of urban ecosystem and landscape analyses: a case study of Baltimore, Maryland

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The early interactions between plant, animal, and human ecology in the 1920s in the United States provide an initial basis for understanding and directing an integrated ecosystem approach to the study of sociocultural and biophysical patterns and processes of present day cities. However, whereas the human ecology approach of the 1920s and 30s was interested in metaphorical similarities with plant and animal ecologists, we propose a more integrated approach to human ecosystem observation and analysis. A critical feature to an integrated, urban ecosystem approach is the ability of researchers to address the spatial heterogeneity of urban ecosystems; i.e. the development and dynamics of spatial heterogeneity and the influences of spatial patterns on cycles and fluxes of critical resources (e.g. energy, materials, nutrients, genetic and nongenetic information, population, labor, and capital). An important question in this context is how differential access to and control over critical resources affect the structure and function of urban ecosystems.

To address this heterogeneity, we illustrate a human ecosystem and landscape approach and how the concept of social differentiation can be applied spatially at different scales with a case study from our research in Baltimore, Maryland. Further, we identify different methods, tools, and techniques that can be used for an integrated, urban ecosystem approach.

*Keywords:* human; urban; ecosystem; landscape

## Introduction

Urbanization is beginning to be fully recognized as a significant global, ecological trend. As Vitousek (1994) notes, ‘‘Three of the well-documented global changes are increasing concentrations of carbon dioxide in the atmosphere; alterations in the biochemistry of the global nitrogen cycle; and on-going land use/land cover change.’’ Although urbanization is an important, underlying process of land use/land cover change, it is not a process with which we have had long-term experience. Indeed, cities may be the glory of humanity, but over the course of human evolution *Homo sapiens* have lived mostly as relatively isolated bands of hunter-gatherers, migratory herders, or agriculturists in scattered farming villages, farmsteads, or small trading centers. Cities have been rare and special places during the course of human history, providing habitation for only a small portion of any given contemporary global village.

The emergence of human ecology in America in the 1920s paralleled an emerging awareness of the social, political, and economic significance of cities to the development of the United States. Those same cities are subjects of renewed interest in human ecology today, although not for their youthful vigor but

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because they are losing population, power, and economic strength and are now the prime locales for ‘‘brown fields,’’ ‘‘asthma alleys,’’ and toxic waters.

Interestingly, the human ecology of the 1920s emerged at the same time as, interacted directly with and developed parallel to the fields of plant and nonhuman animal ecology. This paper argues first that these early interactions between plant, animal, and human ecology provide an initial basis for understanding and directing an integrated ecosystem approach to the study of sociocultural and biophysical patterns and processes of present day cities. However, whereas the human ecology approach of the 1920s and 30s was interested in metaphorical similarities with plant and animal ecologies, ours is one of full integration in our human ecosystem observations and explanations. A critical feature to an integrated, urban ecosystem approach is the ability of researchers to address the spatial heterogeneity of urban ecosystems, i.e. the development and dynamics of spatial heterogeneity and the influences of spatial patterns on cycles and fluxes of critical resources (e.g. energy, materials, nutrients, genetic and nongenetic information, population, labor, and capital). An important question in this context is how differential access to and control over critical resources affect the structure and function of urban ecosystems.

The following pages examine the basis and development of our social ecology approach to urban ecosystems and landscape analyses and its applications to a case study from our research in Baltimore, Maryland. Further, we identify different methods, tools, and techniques that can be used in urban ecosystem and landscape analyses.

## Linkages between plant, animal, and human ecology in America

Park *et al.*’s (1925) landmark publication, *The City*, formally introduced human ecology as a new research agenda for sociology and the study of cities in America. Their research focused on many of the social changes that had resulted at that time from the rapid expansion of America’s urban areas because of the mass immigration of people from Europe and rural America. The explosive growth of the city, the confluence of people from diverse backgrounds, the breakdown of old ways and the changes that were necessary for a viable new urban life caught their imagination (Bell, 1967; Michelson, 1970; Frisbie and Kasarda, 1988; Ross, 1991).

Although Park *et al.* (1925) drew upon the work of European social and biological scientists such as Malthus (1798), Darwin (1859), and Spencer (1876), the initial development of human ecology in America was influenced significantly by and contemporaneous with the emerging fields of plant and animal ecology in America, especially the work of Bessey and Clements at the University of Nebraska and Coulter and Cowles at the University of Chicago (Young, 1974; McIntosh, 1985; Hagen, 1992). According to McKenzie (1925a), the Chicago School – as it came to be known – conceived of human ecology as an extension of the developing fields of plant and animal ecology.

> The young sciences of plant and animal ecology have become fairly well established. Their respective fields are apparently quite well defined, and a set of concepts for analysis is becoming rather generally accepted. The subject of human ecology, however, is still practically an unsurveyed field, that is, so far as a systematic and scientific approach is concerned. To be sure, hosts of studies have been made which touch the field of human ecology in one or another of its varied aspects, but there has developed no science of human ecology which is comparable in precision of observation or in method of analysis with the recent sciences of plant and animal ecology.

The Chicago School articulated and developed an approach to human ecology that drew upon and paralleled the early works of Clements’ *Research Methods in Ecology* (1905) and *Plant Succession* (1916), and Shelford’s (1913) *Animal Communities in Temperate America as Illustrated in the Chicago Region* in three ways (McKenzie, 1925b; Duncan, 1959). First, Park (1936) applied a community ecology approach to the complexities of urban society in order to uncover a set of regular social patterns and processes in the apparent confusion of the urban melting pot. For instance, Park *et al.* (1925) employed ecological concepts such as succession, competition and metabolism to describe stages of human community structure (organization) and function (processes): specifically, indicators of social disorganization such as disease, crime, vice, insanity, and suicide (Burgess, 1925). Second, the Chicago School conceived of the city as a closed and functional system (community) that could be treated as an organism or ‘‘superorganism’’ (Park, 1936). Third, Park and his colleagues focused on the spatial and temporal dimensions of the city (McKenzie, 1925a). According to McKenzie (1925a),

> The general effect of the continuous processes of invasions and accommodations is to give to the developed community well-defined areas, each having its own peculiar selective and cultural characteristics. Such units of communal life may be termed ‘‘natural areas,’’ or formations, to use the term of the plant ecologist. In any case, these areas of selection and function may comprise many subformations or associations which become part of the organic structure of the district or of the community as a whole.

A significant product of this work was Burgess’ (1925) ideal model of the city (Fig. 1), which the Chicago School used to describe and measure the city’s spatial differentiation and development into zones and areas-within-zones through processes of concentration, centralization, segregation, invasion, and succession (McKenzie, 1925b).

The Chicago School’s conception of human ecology was criticized strongly by social scientists for several reasons. First, Alihan (1938), Gettys (1940), and Hollingshead (1947) rejected the notion that either human social structure or individual behavior could be explained with biological facts. They asserted that humans possess culture and that this characteristic makes them different from other species. Further, all human behavior could be explained in reference to its social environment and without consideration of its biological context. Second, Hollingshead (1947) and Alihan (1938) objected to the Chicago School’s reductionist approach and singular use of competition as the ‘‘primary, the universal, and the fundamental’’ mechanism for explaining the organization of economic functions and the spatial distribution of human populations and services. Indeed, many social scientists rejected human ecology because of its apparent similarity to Social Darwinism, which had been used to justify and legitimize inequalities among individuals, groups, races, and societies in the late 1800s and early 1900s (Burch, 1971; Masters, 1989). Finally, many social scientists objected to the Chicago School’s use of macro-scale

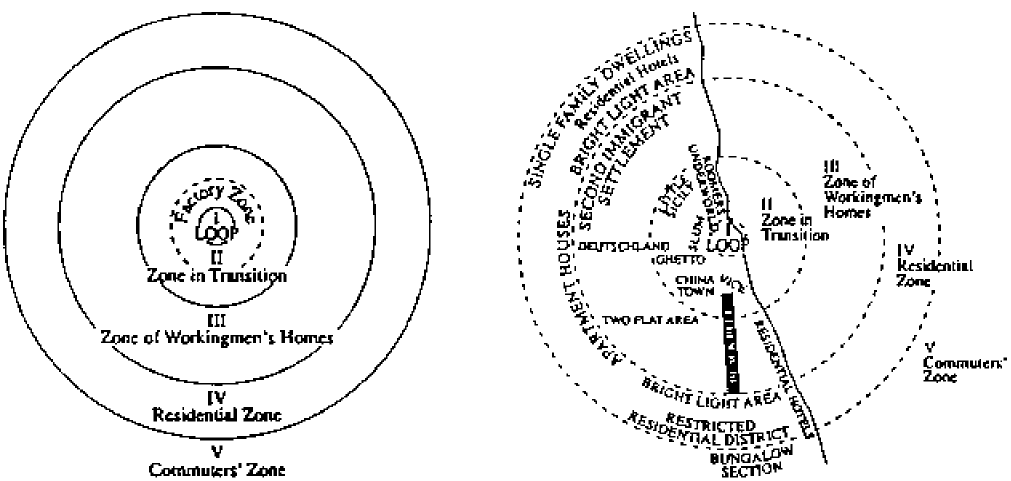


Figure 1. E. W. Burgess (1925) zonal model. (A) The idealized pattern and (B) its application to Chicago. (Used with permission)

processes and functional approaches to explain individual behavior from both a conceptual (Firey, 1945; Firey, 1947; Burch, 1971; Masters, 1989) and a statistical (Robinson, 1950) point of view.

During this time the ‘‘recent’’ but ‘‘well defined’’ sciences of plant and animal ecology that Park *et al.* (1925) had cited as the basis for human ecology were under comparable attack. Although the debates in human ecology did not produce a crystallization of ideas, an important response to the debates in plant and animal ecology was Tansley’s (1935) ecosystem concept as an organizing approach for ecological research (Allen and Hoekstra, 1992; Hagen, 1992; Golley, 1993). In contrast to most plant and nonhuman animal ecologists, however, human ecologists have treated the ecosystem concept until recently as more of a metaphor than a conceptual framework for their research.

## The development of a social ecology approach to urban ecosystem analyses

Today, it is increasingly difficult to determine where biological ecology ends and human ecology begins (Golley, 1993). Indeed, the distinction has diminished through the convergence of interrelated theories, concepts, and methods in both the social and biological sciences. The following are some broad examples of this convergence. First, there is a growing awareness of the need for hierarchical approaches (use of scales) as an alternative to reductionist approaches in the study of sociocultural and biophysical systems (Bailey and Mulcahy, 1972; Allen and Starr, 1982; O’Neill *et al.*, 1986; Allen and Hoekstra, 1992; Young, 1992). For example, living systems cannot be reduced completely to the laws of physics nor are they deterministic (Simpson, 1964; Mayr, 1982); they have an historical and contingent dimension that cannot be predicted from physical laws alone (Botkin, 1990; Gould, 1994; Bell, 1997). A second point of convergence is the rejection of organismal and teleological explanations for both sociocultural and biophysical systems (Degler, 1991; Golley, 1993). This point is crucial in human ecology wherein evolutionary determinism and teleological explanations in the form of Social Darwinist and Eugenicist theories have been used as the basis for racist, fascist, and supremacist social policies (Kevles, 1985; Degler, 1991; Gould, 1995). Finally, spatial heterogeneity is an increasingly significant component to the study of both sociocultural and biophysical systems (Agnes, 1987; Burch, 1988; Zonneveld, 1990; Pickett and Cadenasso, 1995).

Although these examples illustrate broad areas of convergence, they do not provide the rationale for the study of people and their environment in ways that go beyond metaphors and parallels between social and biological disciplines. The rationale for such an integrated study of human ecological systems depends on the following three points:

1. *Homo sapiens*, like all other species, are not exempt from physical, chemical, or biological processes. Human characteristics (biological and social) are shaped by evolution and, at the same time, shape the environment in which *Homo sapiens* lives;
2. *Homo sapiens*, like some other species, exhibit social behavior *and* culture;
3. Cultural traits are involved fundamentally in the adaptation of social species to environmental conditions (Grove, 1996).

This integrated approach to human ecological systems is in essence a biosocial approach (Burch, 1988; Field and Burch, 1988; Machlis *et al.*, 1997) and stands in contrast to others who may adopt either a more traditional geographic or social approach (see for example Hawley, 1950, 1986 and Catton, 1994) or bioecological approach (McHarg, 1969; Hough, 1984; Spirn, 1984). Such a biosocial approach focus on the analyses of human ecological systems as a life science within the larger context of social ecological analyses, whereas social ecology is the ecological study of various social species such as ants, bees, wolves, macaques, and elephants. Thus, we may study *Homo sapiens* as an individual social species or comparatively with the ecology of other social species.

The articulation of a biosocial approach to ecosystems – a human ecosystem approach – has occurred only recently and is based upon the continuing development of and discourse between plant, animal, and human ecologies and social sciences. In particular, as we noted earlier, Tansley's (1935) ecosystem concept was not applied to human ecological systems when it emerged in the 1930s. In the 1950s and 60s, however, Hawley's (1950) book *Human ecology: a theory of community structure* and Duncan's journal articles ''From social system to ecosystem'' (1961) and ''Social organization and the ecosystem'' (1964) attempted to link social systems and biological systems. In particular, Duncan's POET model defined the human ecosystem, or ''ecological complex,'' as the interaction between four master variables: *population, organization,* and *technology* in response to the *environment* (Hawley, 1950; Duncan, 1964; Catton, 1992; Machlis *et al.*, 1997). It was not until the 1970s, however, that Burch, his students and colleagues [Burch (Burch *et al.*, 1972; Burch, 1978; Burch and DeLuca, 1984; Burch, 1988), Field (Field and Burch, 1988), Machlis (Burch, 1978; Machlis *et al.*, 1994; Machlis *et al.*, 1997), Parker (Parker and Burch, 1992; Parker, 1994), Grove (1996, 1997), and Dalton (Machlis *et al.*, 1994)] began to articulate a biosocial approach to human ecosystems that enabled researchers to examine the *flows and cycles of critical biological and social resources* (energy, materials, nutrients, population, genetic and nongenetic information, population, labor, capital, organizations, beliefs, and myths) and to examine *dynamic biological and social allocation mechanisms* [ecological, exchange, authority, tradition, and knowledge (Parker and Burch, 1992)] that affect the distribution of critical resources within a human ecosystem.

This human ecosystem framework (see Pickett *et al.*, 1997, this volume) is not a theory in and of itself. As Machlis *et al.* (1997) note,

> This human ecosystem model is neither an oversimplification or caricature of the complexity underlying all types of human [ecological systems] in the world. Parts of the model are orthodox to specific disciplines and not new. Other portions of the model are less commonplace – myths as a cultural resource, justice as a critical institution. Yet we believe that this model is a reasonably coherent whole and a useful organizing concept for the study of human [ecological systems] as a life science.

This conceptual framework is useful for human ecosystem research in several ways. First, it provides the basis for using a systems approach to integrate sociocultural and biophysical systems by describing the internal behavior of these systems and their interactions with each other in terms of human ecosystem flows and cycles of critical resources (e.g. energy, material, nutrients, information, population, capital, or labor) and allocation mechanisms (e.g. ecology, exchange, authority, tradition, and knowledge). This gives a framework for moving beyond purely biophysical models, which limit researchers to investigating intermediate variables and proximate causes of human ecosystem patterns and processes, and to address underlying, causal sociocultural variables (McKendry and Machlis, 1993). Second, it relates sociocultural and biophysical patterns and processes at different scales (O'Neill *et al.*, 1986; Lee *et al.*, 1990; Allen and Hoekstra, 1992; Fox, 1992; Burch and Grove, 1993; Levin, 1993). Third, by articulating the relationships between and among sociocultural and biophysical patterns and processes, different types of system change such as resilience, resistance, persistence, and variability can be examined (Pimm, 1991) over time and space (Burch, 1988). Fourth, this framework facilitates the explicit spatial measurement, classification, and analysis of sociocultural and biophysical patterns and processes (Zonneveld, 1989; Grove and Hohmann, 1992; Machlis *et al.*, 1997). Finally, this framework fits within a broader understanding of ecological systems for social and biological scientists. Specifically,

1. Human ecological systems are never closed or self-contained;
2. Human ecological systems are not self-regulating;
3. Stable point equilibria are rare, although some systems of sufficient size and duration may exhibit stable frequency distributions of states;

4. Change is rarely deterministic, human ecological systems are stochastic, and future conditions have varying levels of probability;

5. Disturbances are a common component of human ecological systems, although some disturbances are not frequent on the scale of human lifetimes;

6. Human ecological systems are self-aware, and nongenetic information plays an important role in system dynamics. Humans have the ability to develop and communicate descriptions of present realities and knowledge of causes and effects with each other (adapted from Pickett and Ostfeld, 1995).

Parker (1994) describes how researchers can use this human ecosystem framework and understanding of ecological systems. For instance, researchers can use such an approach to: (1) provide the basis for outlining and justifying any assumptions they make and questions they ask during the research process; (2) help identify the most significant variables for them to consider and suggest linkages that may exist between variables; (3) help guide the collection of data for a single study or provide a minimum set of variables that can be tested systematically in comparative studies (if the value of information proposed to be collected can not be established, the collection of the information may not be justified); (4) continually clarify the role the researchers play during the course of the research; and (5) provide a sound basis for their recommendations based upon their results.

## Applications of a social ecology approach to urban ecosystem and landscape analyses: a case study of Baltimore, Maryland

Since 1989, we have applied an urban ecosystem framework and landscape approach in Baltimore, Maryland. Specifically, we have worked through the Yale School of Forestry & Environmental Studies (F&ES) and in partnership with the City of Baltimore and The Parks & People Foundation to develop research, education, and extension programs that link urban revitalization with environmental restoration: The Urban Resources Initiative [URI: we have been joined since then by researchers from the Institute of Ecosystem Studies (Steward Pickett), University of Maryland/Baltimore County (Tim Foresman), US Forest Service (Bob Neville, Rich Pouyat, and Wayne Zipperer), and US Geological Survey (Gary Fisher)]. Much of the conceptual framework for the URI program has been derived from the involvement of F&ES faculty and students in both the Hubbard Brook research program (see for example Bormann and Likens, 1979) and the School's Tropical Resources Institute (TRI). Based upon these programs, URI has worked to combine and apply an ecosystem/watershed approach from Hubbard Brook with social ecology theory and a community forestry perspective from international, rural areas to the City's three primary watersheds: the Gwynns Falls, the Jones Falls, and the Herring Run (for instance, see Cernea, 1991 and Burch and Parker, 1992, particularly Chapter 2, ''Toward a Social Ecology for Agroforestry in Asia'').

URI's approach differs from the original Hubbard Book approach in two significant ways. First, URI's ecosystem/watershed approach has included humans as an integral part of its research efforts. In doing so, URI has worked to extend a forest ecosystem/watershed approach to a human ecosystem/watershed context (Burch and Grove, 1993; Grove *et al.*, 1994). Second, URI has emphasized the spatial heterogeneity of these watersheds in order to study the development and dynamics of spatial heterogeneity and the influences of spatial patterns on cycles and fluxes of critical resources (e.g. energy, materials, nutrients, genetic and nongenetic information, population, labor, and capital). In particular, URI has been interested in understanding how differential access to and control over critical resources affect the structure and function of urban ecosystems. This area of focus has been possible through new and relatively inexpensive computer technologies that have facilitated the use of Geographic Information Systems (GIS) and the development of GIS databases for the Baltimore region. Furthermore, URI has worked to integrate these systems with ecosystem models to measure the linkages between sociocultural and biophysical patterns and processes using an ecosystem and landscape approach (Grove and Hohmann, 1992; Grove, 1996; Grove, 1997).

This approach has enabled URI to develop questions that are comparable to research in the 1960s and 70s at Hubbard Brook. For instance, one of the basic questions Bormann and Likens (1979) asked in their research at Hubbard Brook related to bioregulation: ‘‘does the vegetation structure of the watershed affect its hydrologic cycles?’’ In a similar vein, one of the basic questions of URI’s programs has related to biosocial regulation, e.g., ‘‘do sociocultural patterns and processes affect a watershed’s hydrologic cycles?’’

These questions can be rephrased more broadly. For instance, ‘‘is soil erosion linked to human erosion (e.g. declines in nutrition, employment, housing, family structure, norms)?’’ Or, ‘‘is environmental restoration connected to urban revitalization?’’ Ultimately, these questions are tied to environmental equity because patterns and processes of soil erosion, human erosion, environmental restoration, and urban revitalization are rarely distributed equally across society and space. For instance, ‘‘what are the linkages between urban revitalization (e.g. changes in income or levels of employment) and environmental restoration (e.g. changes in vegetation structure, hydrologic discharge, soil erosion, or air quality)?’’ Or, ‘‘why do some areas decline socially, economically, and environmentally, whereas other areas remain the same or improve?’’ For example, Figure 2 summarizes some of the results from our research, which indicates that even after accounting for variations in population density, communities with higher levels of income and education were more likely to contain areas with trees and grass than communities with lower levels of income and education (Grove, 1996). According to Logan and Molotch (1987) this relationship is the predictable result of inequitable allocations of ‘‘green’’ investments (in this case, trees,

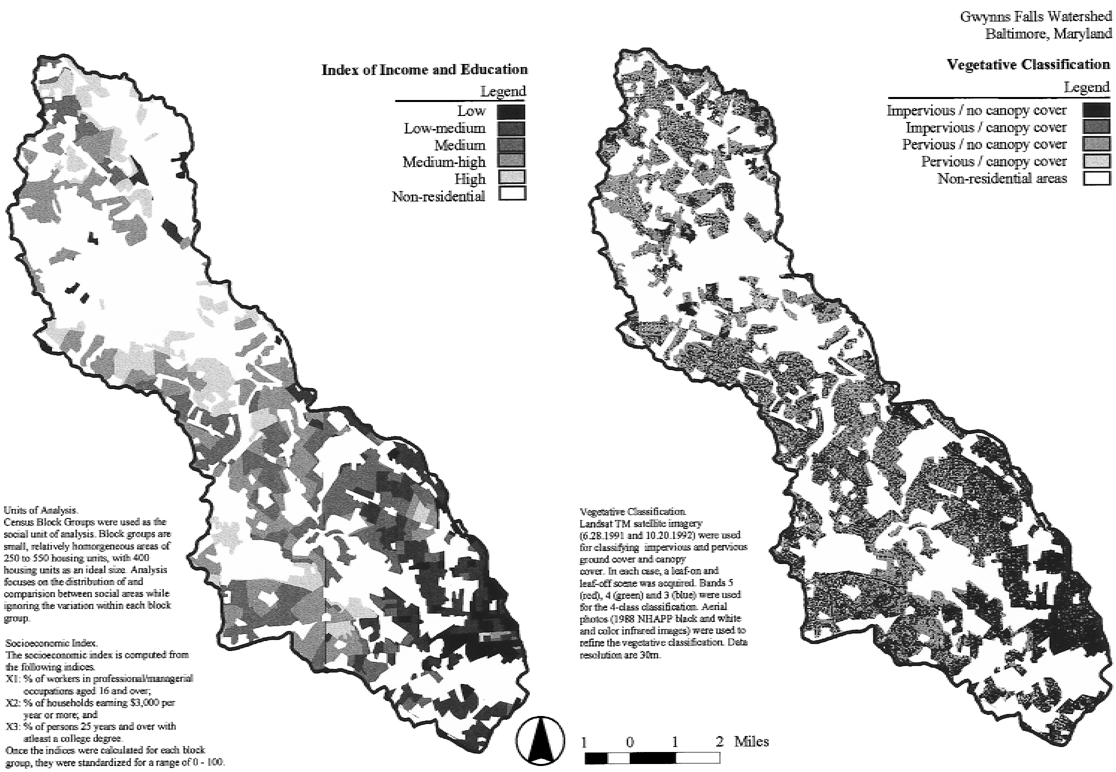


Figure 2. Social and vegetative differentiation of an urbanizing watershed.

parks, lawns, and gardens) by private markets and government agencies based upon the social characteristics of an area. Such questions are subsidiary to a larger one asked by Logan and Molotch (1987): ‘‘How are the fortunes of people tied to the fortunes of place?’’

**Spatial heterogeneity and human ecosystem and landscape analyses**

To effectively address these questions, we worked with our colleagues from research, policy, planning, and management (decision makers) to develop an approach that enables us to integrate human ecosystem and landscape analyses (Grove, 1996; Grove, 1997). This approach is based first upon the idea that a human landscape approach may be understood as the study of the reciprocal relationships between spatial heterogeneity (pattern) and sociocultural and biophysical processes. Second, when a human ecosystem and landscape approach is combined, human ecosystems are defined as homogeneous areas for a specified set of sociocultural and biophysical variables within a landscape and analyses focus on two primary issues: the development and dynamics of spatial heterogeneity and the influences of spatial patterns on cycles and fluxes of critical ecosystem resources (e.g. energy, materials, nutrients, genetic and nongenetic information, population, labor, capital, organizations, beliefs, or myths). For instance, the development and dynamics of an urban-rural watershed’s spatial heterogeneity may influence and be influenced by its sociocultural and biophysical processes. Areas, or patches, within the watershed may function as either sources or sinks as well as regulating flows and cycles (inputs and outputs) of critical resources between patches at different rates. The delineation and classification of these relatively homogeneous patches is based on a limited number of representative sociocultural and biophysical indicators (Burch and DeLuca, 1984; Parker and Burch, 1992; Machlis and Forester, 1994) and studied as ‘‘black boxes’’ with fluxes and cycles of critical resources between areas (Zonneveld, 1989; Turner and Gardner, 1990). In this case, the spatial linkages between the social and ecological differentiation of the watershed and its relationship to different types of allocation mechanisms at different scales are important for understanding the differential flows and cycles of critical resources within the watershed.

Hydrologists have already developed such an approach – a Variable Source Area (VSA) approach – to examine how the abiotic attributes of different areas, or patches, within a watershed – such as seasonal fluctuations in precipitation and temperature and physical characteristics including topography (slope and aspect), soil properties, water table elevation, and antecedent soil moisture – contribute variable amounts of water and nutrients to streamflow, depending on their spatial location in the watershed (Hewlett and Nutter, 1969; Dunne and Leopold, 1978; Black, 1991). This VSA approach can be integrated with a delineation of patches based upon the biotic attributes of the watershed – such as vegetation structure and species composition (Bormann and Likens, 1979) – and the social attributes of the watershed – such as indirect effects from landuse change, forest/vegetation management and direct effects from inputs of fertilizers, pesticides, and toxins – to examine how the abiotic, biotic, and social attributes of different patches within a watershed contribute variable amounts of water and nutrients to streamflow, depending on their spatial location in the watershed (Grove, 1996). This integrated, VSA approach (Fig. 3) represents an example of a human ecosystem and landscape approach to watershed analyses.

A human ecosystem and landscape approach can be applied to other areas of research as well. For instance, ‘‘what are the relationships between changing land uses (Fig. 4), forest/vegetation management strategies within different types of land uses (e.g. agricultural, forested, and residential areas), and the extent, distribution, structure, species diversity, and rates of regeneration, growth, and mortality of forests/vegetation over time?’’ Similarly, ‘‘what are the relationships between these variations in forests and the goods, benefits, and services people derive from forests (e.g. timber, firewood, mushrooms, fruits, community identity, psychological well-being, increased property values, cleaner air, and water)?’’ And, ‘‘how are they distributed among different groups of people?’’ ‘‘What are the relationships between different land uses and land management strategies and the ability of water to infiltrate soils or the

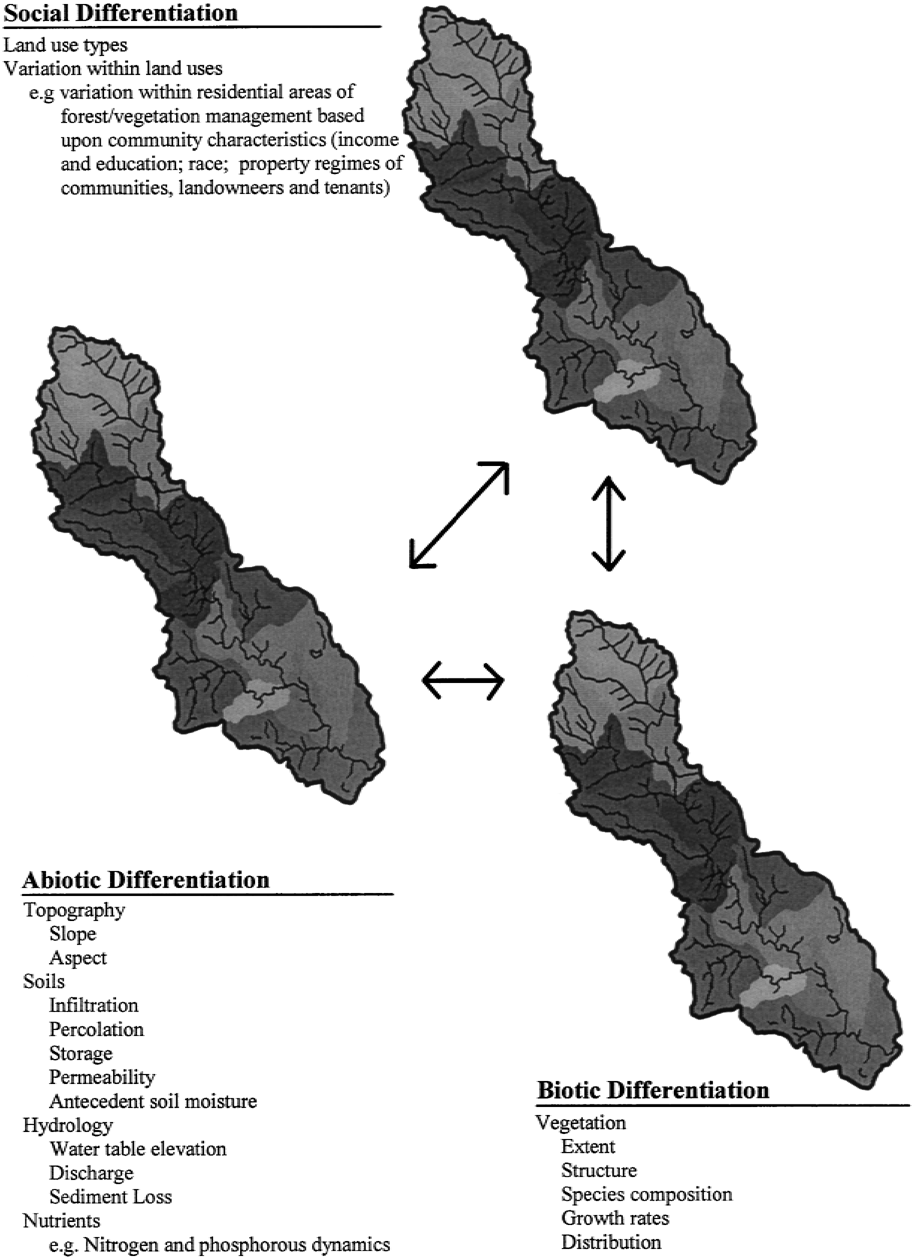


Figure 3. An example of an integrated variable source (VSA) approach to human ecosystem and landscape analysis.

introduction of contaminants into ground water and aquifers?'' ''What are the relationships between these changes and hydrologic flows and water quality downstream?'' And, ''what are the relationships between these changes and people's opportunities to fish in, swim in, and drink clean water?'' To address these types of questions using an human ecosystem and landscape approach, we must understand the conceptual relationships between ecological and social differentiation and spatial analyses.

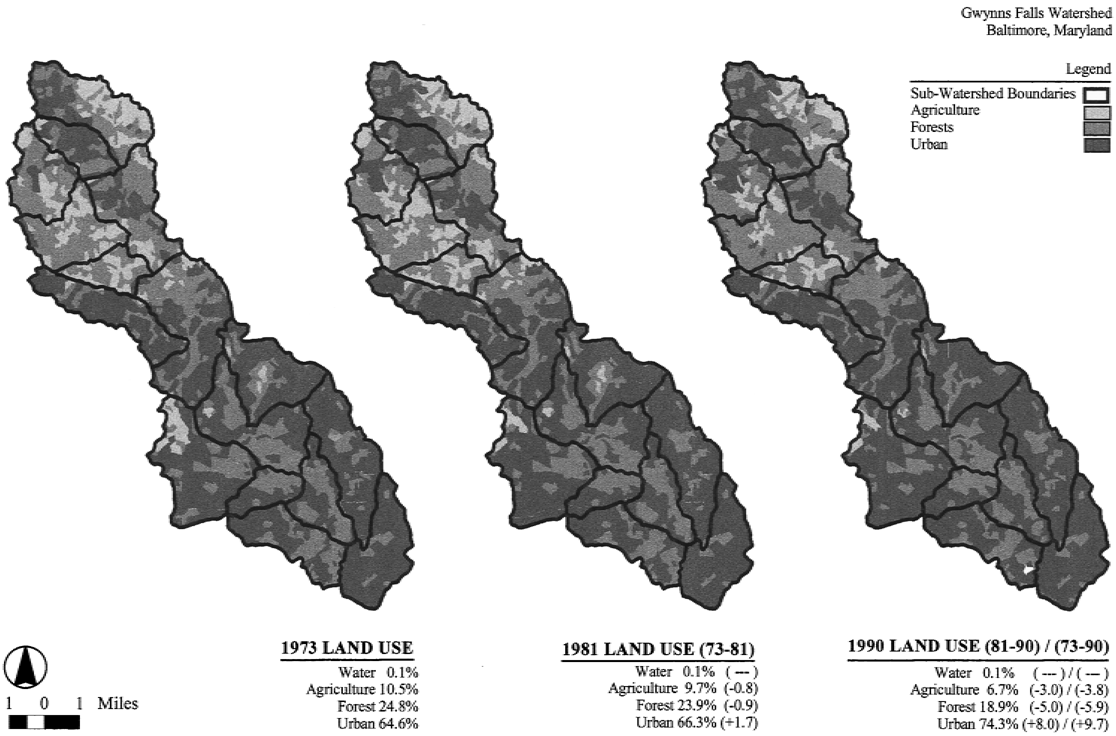


Figure 4. Land use change in the Gwynns Falls Watershed (1973–1990).

## Social differentiation, spatial analyses, and scale

All social species are characterized to varying degrees by patterns and processes of social differentiation (van den Berghe, 1975; Wilson, 1975). In the case of *Homo sapiens,* social differentiation or social morphology has been a central focus of sociology since its inception (Schnore, 1958; Grusky, 1994). In particular, social scientists have used concepts of social identity (age, gender, class, caste, and clan) and social hierarchies (wealth, power, status, knowledge, and territory) to study how and why human societies become differentiated (Garfinkel, 1981; Burch and DeLuca, 1984; Machlis *et al.,* 1997).

Social differentiation is an important concept for a human ecosystem approach to human ecological systems because it affects the *allocation of critical resources* (natural, socioeconomic, and cultural). In essence, it determines ‘‘who gets what, when, how and why’’ (for instance, see Lenski, 1966; Burch and DeLuca, 1984; Parker and Burch, 1992; Machlis *et al.,* 1997). This allocation of critical resources is rarely equitable. According to Machlis *et al.* (1997), unequal access to and control over critical resources is a consistent fact within and between households, communities, regions, nations, and societies. Five types of sociocultural hierarchies are critical to patterns and processes of human ecological systems: wealth, power, status, knowledge, and territory (Burch and DeLuca, 1984). *Wealth* is access to and control over material resources in the form of natural resources, capital (money), or credit. The unequal distribution of wealth is a central feature of human ecological systems. *Power* is the ability to alter others’ behavior through explicit or implicit coercion (Mann, 1984; Wrong, 1988). The powerful (often elites with political or economic power) typically have access to resources that are denied the powerless. One example is politicians who make land-use decisions or provide services for specific constituents at the expense of others. *Status* is access to honor and prestige and the relative position of an individual (or group) in an informal hierarchy of social worth (Lenski, 1966; Goode, 1978). Status is distributed unequally, even within small communities, and high-status individuals may not necessarily have access to either wealth or power. For instance, a minister or an imam may be respected and influential in a community even though he or she is neither wealthy nor has the ability to alter coercively other people's behavior. *Knowledge* is access to or control over specialized types of information (technical, scientific, religious, and so forth). Not everyone within a social system has equal access to different types of information. Knowledge often provides advantages in terms of access to and control over the critical resources and services of social institutions. Finally, *territory* is access to and control over critical resources through formal and informal property rights (Burch *et al.*, 1972; Fortmann and Burch, 1988; Bromley, 1991).

Processes of social differentiation of human ecological systems have a spatial dimension that is usually characterized by patterns of territoriality and spatial heterogeneity (Morrill, 1974; Agnew, 1987; Burch, 1988). As Burch (1988) notes, ''Intimate and distant social relations, high and low social classes, favored and despised ethnic, occupational, and caste groupings all have assigned and clearly regulated measures as to when and where those relations should and should not occur.'' When an ecosystem and landscape approach is combined, the research changes from an ecosystem type question of ''who gets what, when, how, and why?'' to a question of ''who gets what, when, how, why, and *where?* and, subsequently, ''what are the reciprocal relationships between spatial patterns and sociocultural and biophysical patterns and processes of a given area (Grove, 1997)?'' Furthermore, various processes of social differentiation occur at different scales and have corresponding spatial patterns and biophysical effects (Grove and Hohmann, 1992). For instance, Figure 5 illustrates our efforts to articulate, understand, and integrate different scales of regional urban-rural hierarchies (Fig. 5A): Morrill, 1974; Cronon, 1991; Rusk, 1993; Rees, 1997), the distribution of land uses within urban areas (Fig. 5B: Burgess, 1925; Hoyt, 1939, Harris and Ullman, 1945; Guest, 1977), the stratification of communities within residential land uses (Fig. 5C: Shevky and Bell, 1955; Timms, 1971; Johnston, 1976; Agnew, 1987; Logan and Molotch, 1987; Harvey, 1989), and the social differentiation of ownerships and households within communities (Fig. 5D: Fortmann, 1986; Fortmann and Bruce, 1988; Fox, 1992; Grove and Hohmann, 1992; Burch and Grove, 1993; Grove, 1995).

## Methods, tools, and techniques

Although the methods, tools, and techniques that we employed in our work in Baltimore, MD are based particularly upon community forestry techniques from international, rural areas [for example, Burch and DeLuca, 1984; Cernea, 1991; Conway, 1986; Parker and Burch, 1992; Rapid Rural Appraisal Handbook (RRA), 1987], the general procedure for inventorying a human habitat, setting, or locale is similar to the ecological analyses of other social species – size and structure of population, fecundity, fertility, hierarchy, social change, organization of the breeding and socializing unit, and so forth (Burch, 1978). Thus, just as we may want to understand the floral and faunal composition of an area, we may also want to know the social and/or organizational composition of an area. And, just as we may want to understand the biological mechanisms that regulate the flows and cycles of critical ecosystem resources, we may also want to know the social mechanisms that affect the flows and cycles and critical ecosystem processes (Burch and DeLuca, 1984; Parker and Burch, 1992; Grove, 1997).

However, a common confusion among many life scientists who do not study people or other social species is that measurements of human communities are difficult if not impossible. The difference is related more to complexity of the questions asked than the difficulty of the phenomena measured. Most nonhuman ecosystem studies have theoretical questions that require only simple, elementary measures, and it is precisely these simple, elementary measures of human communities that are most readily available and superior in accuracy to similar measures made in field studies of other animals (e.g.

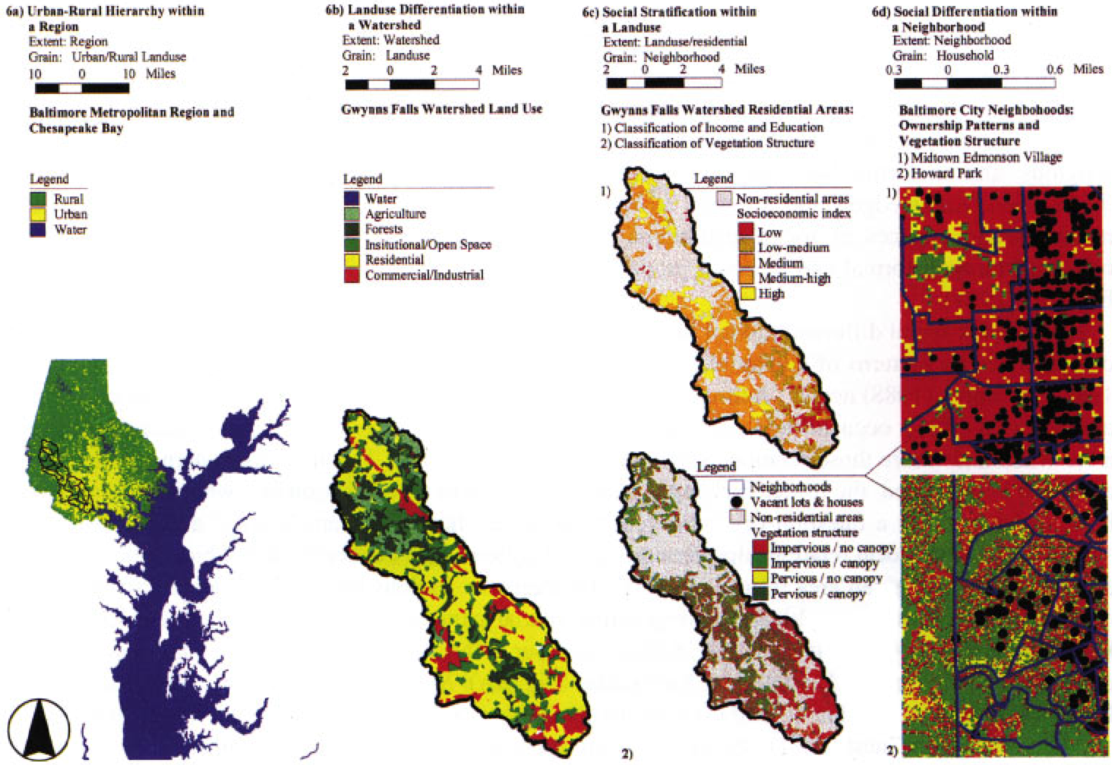


Figure 5. Examples of a hierarchical approach to social ecological differentiation (Baltimore, Metropolitan Region). (A) Global and regional urban-rural hierarchies; (B) distribution of land uses within urban areas; (C) stratification of communities within residential land uses; and (D) social differentiation of ownerships and households within communities.

population characteristics, patterns and processes, diets, time budgets, health, and actuarial dynamics: Burch, 1978).

A variety of research methods, tools and techniques are available and well documented for researchers to use to test their theories. For instance, researchers may use ethnographies and case studies, comparative studies, experimentation (direct manipulations), *ex post facto* (after the fact analyses), cross-sectional studies, and longitudinal studies (Isaac and Michael, 1990; Miller, 1991). Specific tools include key informant and focus group surveys, observational studies, and analyses of ‘‘social scats’’ – documents, records, and operational data from government agencies, private businesses, nonprofit organizations, and community groups. Finally, these tools can be applied using a variety of techniques that include social area analyses (re: VSA and patch dynamics), maps, transects, point surveys, seasonal calendars, flow diagrams of critical resources, decision trees, and Venn diagrams of organizational relationships (Burch and DeLuca, 1984; Conway, 1986; RRA, 1987; Cernea, 1991; Parker and Burch, 1992; Machlis *et al.*, 1994; Parker, 1994).

In sum, there are a variety of effective methods, tools, and techniques for human ecosystem and landscape analyses. We think that it is important to stress one point, however. The active participation of local people who may be affected by the Participatory Action Research (PAR: Whyte, 1984, 1991a, b), is critical to the success of any study. There are several reasons for this. First, local people often have empirical knowledge about the object or process of study that the researcher may not possess and this represents a learning opportunity for the researcher. In this case, local knowledge may facilitate or improve the research. Second, we propose that an ultimate goal of research is to improve the social well-being of the people who are affected by the research. Thus, their involvement in the research may help to improve the research and insure that the results are useful to their needs (Burch and Grove, 1996; Grove *et al.*, 1994). Finally, the participation of local people may provide them with additional means to understand, monitor, and evaluate their own ecosystem and thereby improve their capacity, if they choose, to manage on a day-to-day basis for ethereal abstractions such as sustainability, biodiversity, or biological integrity.

## Conclusion

We propose that urban ecosystems can not be understood fully by applying only ecological methods and models developed in less human-dominated ecologies. Nor do we propose that traditional social science dichotomies or continuums of urban-rural structure have sufficient analytical power. An urban ecosystem is a separate kind of biosocial system that shares certain theoretical similarities with other types of human ecological systems but also exhibits specific, unique properties. For example, although we may use universal ecosystem theories to study an alpine bog or coastal wetland system, our interest is to understand how these ecosystems are unique variations of common ecological themes. Similarly, this same approach to urban ecosystems avoids the notion of ‘‘human impact’’ favored by many biological scientists at one end of the spectrum and the ‘‘human centered approach’’ favored by many social scientists at the other. Our interest is to treat this unique type of ecosystem in its own right as neither an aberration nor an evolutionary end point of nature.

Consequently, we return to the original interactions that were common in the early development of plant, animal, and human ecologies of the 1920s and 30s, but with a difference. Our search is not for metaphorical similarities but for shared biosocial vocabularies and measures. Our interest is in the observed spatial patterns and processes of a particular ecosystem – unique, distinctive, and theoretically similar.

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