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Editors

Daniel G. Bates and Judith Tucker

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Introduction

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Abstract

This volume utilizes contributions of some 21 recent articles published in the journal Human

Ecology together with other relevant research to present an overview of current environmental thought, research, and practices in this highly eclectic field. Each chapter has implications for the evaluation of current environmental policies and development efforts as each of the contributors addresses significant problems in how people manage their resources and cope with threats to their food security or well-being. Indeed, human ecology is a theoretical orientation that emphasizes the problem-solving significance of human culture and behavior, from food procurement to social support systems as well as political and religious life. In particular, it emphasizes the complex ways in which humans shape and are shaped by their environment. The perspective generally embraced in this book is that human ecology is part and parcel of the larger scientific field of ecology and not simply analogous to it. Although very much aware of the distinctive nature of human environmental interactions, we nevertheless must recognize that humans ultimately succeed, flourish, or fail in the same manner as other species.

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The term “ecology” (from the Greek “oikos” - house or habitation) to denote a scientific field was coined in 1870 by the biologist Haeckel and was understood by him to mean: “... the study of the economy, of the household, of animal organisms. This includes the relationships of animals with both the inorganic and organic environments, above all the beneficial and inimical relations that Darwin referred to as the conditions of the struggle for existence" (quoted in Netting 1977, p. 1). While ecology in general and human ecology in particular are rapidly growing foci among a wide panoply of scientific endeavors, they are not so much academic disciplines as they are perspectives or approaches to the interconnectedness and reciprocal behaviors of organisms in a given environmental setting. Thus, all ecological study is at once multidisciplinary. We will later be more specific about the basic building blocks of this very useful perspective, but it is sometimes helpful to note some fundamentals that are in fact so obvious they can be lost amid the intellectual trees. Foremost among these is that ecology in its most basic sense is rooted in two seemingly disparate but in reality integrated bodies of theory: physics and evolution.

In 1944, one of the founders of quantum mechanics, Erwin Schrodinger wrote an influential book entitled *What is Life*. As science writer, Jim Holt (2008, p. 17) puts it:

> Living things are made of matter, Schrodinger observed, yet they seem to violate the laws of physics. One of the most basic of these laws is the second law of thermodynamics, a universal tendency towards disorder. Entropy - a mathematical measure of the disorder present in a system - is always on the rise. Left on their own, things fall apart, run down, and become inert; they tend towards an equilibrial state of chaos and dissolution. This is a matter of cruel probability: as we all know from our own domestic lives, there are vastly more ways for things to be disordered than to be ordered, so it is far more likely that things will slip from orderly to disorderly rather than the reverse.

One clear implication of this observation is that all life on our planet is continually in a state of flux or transition. Secondly, stability, organization, and even continuity are simply artifacts of the time frame of the observer. The third implication is that all life is bound up in arrangements that depend on the sun or as Holt (2008, pp. 18-19), somewhat over lyrically, describes it:

> Terrestrial nature drinks up the sky's orderliness in a beautifully simple way. During the day, the earth gets energy from the sun in the form of photons of visible light. At night, the same amount of energy is dumped back out into space in the form of infrared photons, otherwise known as radiant heat.

Entropy always increases in any system that is cut off from outside influence; every living organism is exchanging with its environment. Energy absorbed returns as radiant heat; we take in ordered organic compounds and return them as less ordered or disordered waste. Plants on which directly or indirectly most terrestrial life depends are able to assemble organic compounds from solar energy through photosynthesis. All life forms exist in an "open system" dependent on external sources of energy. Most descriptions of life forms are simplifications treating these open systems as analytically closed - a convenience that sometimes unintentionally obscures the long-term dynamics of the phenomena studied.

For a century and a half virtually every serious naturalist and research biologist has embraced the second body of theory underlying ecology - evolution. All species of plants and animals tend to produce more offspring than the environment can support and this results in intense competition for living space, resources, and mates. Only a favored few survive long enough to reproduce. Darwin noted also that individual members of a species differ from one another physically. In contemporary iterations of evolutionary theory, it is understood that in a given population, some individuals may have genetically derived variant traits. These variations are said to be adaptive if they improve the animal or plant's chances of survival and thereby its reproductive fitness - the process of natural selection.

Today, evolutionary theory is at the very heart of all research in the biological and natural sciences. With the recent breakthroughs in modern genetics, population biology, and biochemistry, the utility of the "evolutionary synthesis," as it is now called, is established beyond doubt. However, while acknowledging the importance of evolution for the emergence of new species and biodiversity, general evolutionary processes were largely out of the picture in ecological or environmental research until fairly recently. This is because much ecological research is framed in what in evolutionary terms are very short-lasting interactions in which issues of genetic modifications within populations can be ignored. Today there is a significant line of inquiry variously called evolutionary ecology or behavioral ecology, which investigates the implications of natural selection models for human activities as diverse as territorial defense, common property management, foraging patterns, and mating choices are measured against the expectation that "individuals behave in such a way that their personal reproductive success and/or inclusive fitness is maximized" (Schutkowski 2007, pp. 13-14; for an expanded discussion, see also Bates 2005, p. 31ff., and Sutton and Anderson 2004).

While a discussion of contemporary evolutionary theory is beyond the scope of this book, it is worth emphasizing some basic ideas. First, any process or force that changes gene frequencies in a population results in what might be called an “evolutionary event,” be it ever so trivial, and most would agree that over the long term it is natural selection that has shaped all life forms on earth, including the neural systems we employ to study them. Natural selection is a cumulative process in that it “builds” on what is already present in the form of genetic information. Thus, complex, highly intricate structures may emerge from very simple foundations. As selection acts on existing material and in response to specific environmental pressures, it is always “opportunistic” - that is, adapting whatever is available to the exigencies of the day.

As noted, it is easy to overlook the fact that evolution is an ongoing process. All species are continually being shaped by evolutionary forces as individuals are added to the population by birth or removed by death or migration. Usually, the consequences of these changes are imperceptible by human measures based on life experience. But over periods geologists consider very short, perhaps as little as a few millennia, major changes can occur. For example, a recently discovered new species of perch-like fish, the arrow cichlid, was found to have evolved within the last 2,000-28,000 years in a lake formed in an extinct volcano’s crater on Lord Howe Island in the south Pacific when its ancestral population of Midas cichlids became isolated in the newly formed body of water (Zimmer 2008). The new species came to feed on a different diet, changed its body shape, and ultimately lost its ability to interbreed with members of the parent population. Scientists have long seen indisputable evidence for evolution in the fossil record, but only occasionally can they pinpoint the time of the emergence of a new living species. Of course, medical science continually deals with the consequences of rapid change due to natural selection in disease organisms such as flu viruses and HIV (see below).

The significance of this for ecology is that populations and their constituent members are always dynamic even if the changes are hidden by the time frame within which researchers necessarily work. Examples of such changes that appear to have occurred within recent times among modern humans, based on rapidly advancing DNA studies, include those affecting skin pigmentation, the ability to process certain sugars and alcohol, fatty acid metabolism, as well as genetic resistance to specific diseases such as malaria. These changes are occurring in different populations and clearly indicate that humans’ technological breakthroughs have not put them beyond the reach of evolutionary forces.

Another example of evolutionary adaptation, albeit a negative one from a human vantage point, is the HIV-AIDS pandemic. Researchers now are confident that the HIV-AIDS-causing virus arose in a central African population some 150 years ago through human-chimpanzee contact (bush meat is a significant dietary element among forest-dwelling peoples of the region). But the disease only reached epidemic proportions in the late twentieth century when urban centers attracted sufficient human carriers who lived long enough to transmit the deadly virus through multiple human–human contacts. Organisms, even viruses and bacteria, continually adapt opportunistically to their environments and thereby effect change over the long term.

Human Ecology Today

As natural scientists, ecologists are interested in three very broad questions. One, how does the environment affect the organism? Two, how does the organism affect its environment? Three, how does an organism affect other organisms in the environments in which it lives?

The quest for answers to these questions encompasses almost everything ecologists do. Human ecology links the subject matters of anthropology, biology, geography, demography, economics, and other disciplines in an attempt to understand relationships between people and their environments in terms of these three areas of inquiry.

In contemporary ecology there is never an assumption of timelessness or total isolation. While historical change and external influence might once have been regarded as annoying distractions from or distortions of indigenous systems, they have now become the focus of attention. Earlier ecologists tended to ask how traditional behaviors enabled a population to maintain itself in a specific environment, but today we are more likely to ask: What are the problems confronted by the population of this place? How do individual actors deal with them? And we are more likely today to be aware of the fact that not all members of the group may share the same problems to the same degree (see Eder, this volume). Ecologists draw on demographic and evolutionary theory as well as upon biological models derived from field ecology. Contemporary human ecology in addition emphasizes the role of decision-making at the individual level as people strategize and optimize risk, costs, and benefits.

The Nature of Ecological Systems

The ecosystem concept is a model for the cycles of matter and energy that include organic entities and their linkages to the inorganic. All organisms depend on energy and on matter. Such relationships, taken together, constitute a vast network of individuals exchanging the energy, nutrients, and chemicals necessary to life; humans and bacteria alike are involved in the same process.

The Components of the Ecosystem

As we have noted, all the energy that flows through an ecosystem comes ultimately from the sun. Depending on their role in the transfer of that energy, the organisms in an ecosystem fall into three categories: producers, consumers, and decomposers. The *producers* are the green plants that convert solar energy (negative entropy) and nutrients in the soil into food. The organisms that rely on plants, directly or indirectly, for food are the *consumers*. Some of these consumers (herbivores) live on the plants; others (carnivores) live on other animals; and yet others (omnivores) on a combination of both. A given ecosystem may support several levels of consumers. The *decomposers* are bacteria and fungi that break down dead organic matter, converting it to nutrients, which are deposited in the soil to be used by the plants. Thus, each of these three groups is dependent on the others. The decomposers provide nutrients for the producers, the producers for the consumers, and the dead producers and consumers for the decomposers.

Both matter and energy are constantly flowing among these elements. The transfer of matter - the nutrients - is cyclical. Producers, consumers, and decomposers process the same nutrients over and over. Energy flow is noncyclical. Energy is constantly being supplied at one end, by the sun, and constantly expended at the other end in nonreusable forms (primarily heat but also in gaseous emissions).

The usefulness of the ecosystem concept is, first, that it can be applied to any environment. Second, and more important, the ecosystem concept allows us to describe humans in dynamic interaction with one another, with other species, and with the physical environment. We can chart and quantify the flow of energy and nutrients and specify the interactions critical for the maintenance of any local population. Thus, the ecosystem concept gives us a way of describing how human populations influence and are influenced by their surroundings.

There is usually considerable apparent order and continuity in natural ecosystems. This is not surprising because, over time, the myriad component species of any ecosystem have come to mutually limit one another as they feed, reproduce, and die. The fact that ecosystems appear to persist through time does not mean, however, that they are static. Importantly, one must keep in mind that ecosystems are heuristic tools and not fixed entities in nature. Their scope or scale, components, and relationships are set by the observer depending on the object of interest at hand. Although most ecosystems are viewed as being in equilibrium or near equilibrium, in fact relations among the component populations are continually changing. It is a common methodology and analytical fallacy to attribute the raison d'être of any component of an ecosystem to its role in "maintaining" the system (see Jelinski, this volume).

Two concepts are used to describe continuity and change in ecosystems: resilience and stability. *Resilience* is a measure of the degree of change a system can undergo while still maintaining its basic elements or relationships. *Stability* is a measure of the speed with which a system returns to equilibrium after absorbing disturbances. Systems with high resilience but low stability may undergo continual and profound changes but still continue to exist as a system; that is, their constituent parts persist together even though they take a very long time to return to their initial states. Systems with high stability but low resilience, on the other hand, may show little change when suffering some disturbances but then collapse suddenly.

The Distinctiveness of Human Ecology

The ecosystem approach has contributed to understanding systemic change as well as the seeming persistence in equilibrium of some populations over long periods in their habitats. Archeologists and others concerned with landscape history on a large scale may not have ready access to data at the individual level but can make useful inferences using this model, as Stiner and Kuhn (in this volume) do in their insightful analysis of the Mediterranean Basin during the Paleolithic period. But there are limitations to this approach. Some have to do with theory; the ecosystem model is less useful for studies where the focus is on the outcome of individual actions. An equally important set of limitations concerns the treatment of populations within ecosystems in terms of the functional roles they purport to play in system processes such as "food chains" or "regulatory" agents. While the local population of a particular species can be described in a functional model, that is, as a food source, prey, predator, or population-limiting disease vector, this does not speak to causation. Malaria-bearing mosquitoes may, to use a Mediterranean example again, keep farmers out of coastal marsh lands in summer, thus creating pastures for transhumant herders in the winter, but as we have noted before that does not explain so much as describe a transient situation. The special attributes of the human species in particular pose problems for modeling local interactions as discrete or bounded systems.

Human distinctiveness becomes strikingly evident when we look at the habitats and niches that our species occupies. The *habitat* of a species is the area where it lives, its surroundings. Its *niche* is its "way of making a living," as defined by what it eats, what eats it, how it defends itself, and how it reproduces and rears its young. Most species are limited to a few habitats and a relatively narrow niche. By contrast, humans occupy an exceptionally broad culturally constructed niche and consequently live in an extremely wide range of habitats. Human niches can be rapidly transformed, thereby changing myriad other interspecific relationships. Indeed, there are very few habitats where human beings have not found a way to thrive, and judging from the archeological record, all bear witness to change in human habits and behavior.

Once humans enter a habitat, they tend to strongly affect the life chances and reproductive rates of the other populations through the use of technology. Although other species use tools, no other species has developed them to the extent humans have, nor depends on them to such a great extent for survival. If one were to look only at human morphology (large body size) and place in the food chain (analogous to top predator) one might conclude that human population densities would be quite low. At six and a half billion worldwide, this is obviously not the case. Human technologies have enabled us to create environments such as farms and cities which maintain very high population densities by greatly increasing the inflow and outflow of energy, materials, and information.

Much, if not most, technology has been developed explicitly to facilitate energy transfer, capture, and storage in ways unique to humans. A persistent focus in human ecology has been upon energy flows. Economists deal with energy indirectly, defining human labor productivity as the monetary value of what is produced (dollar value added per hour of work) by a unit of human labor. Ultimately, of course, all human societies are energy dependent and are power limited in some way. However, the nature of energy limits in the ecological system or economy varies greatly according to how the flow of energy is organized as well as to the technology employed. Leslie White (1949) was an early proponent of the idea that the nature of human society is structured by its ability to utilize extrasomatic sources of energy, and Howard Odum (1971) later developed a more ecologically directed model of societal energy flows.

As economies worldwide developed, they moved from being limited by power shortages in the form of human labor to being constrained by limits or costs of extrasomatic energy sources, mainly the availability of wood in the eighteenth century, coal in the nineteenth century, and oil today. Mechanized use of extrasomatic energy sources, fossil fuel or hydroelectric power, for example, distinguishes the technologically advanced societies. In the United States, about 230,000 kc of energy are expended per capita per year; in Burundi, central Africa, 24,000 are expended. Moreover, in the United States, only 10% of the country's "total time" (the population × 24 × 365) is allocated to work; in Burundi, 25% of the nation's "total time" is needed; in short, a Burundian worker must expend twice as much energy to extract a fraction of the usable energy that an American worker does. Where human labor constitutes the main "power supply," and energy to support it comes largely from standing biomass (crops, trees, etc.), as it does in at least 18 countries, there is little "spare" energy to devote to anything other than maintaining current infrastructure, reproduction, and food procurement (see Giampietro et al. 1993, pp. 229-260).

The implications for societal development and ecological relations in general can be measured in many ways at levels ranging from the individual worker to the individual and his or her dependents, groups of co-workers, up to the societal. Every society has energy *sources* and energy *converters* that generate power or useful work. In preindustrial or partially industrialized societies, energy sources are largely in standing biomass - the trees, plants, and animals available to support humans - which is converted into useful work via human labor, possibly supplemented by animal traction, to support the population and its material culture, but the power available for converting the biomass is limited. In the United States in the 1850s, 91% of energy expended came from standing biomass; today only 4% does, with the balance coming from extrasomatic sources, notably fossil fuels, converted into useful work by machinery. (See Pimentel et al., this volume, for why we cannot return to biofuels soon.) While industrial societies are limited by energy sources, nonindustrial societies are limited by the low rate at which energy can be converted with human labor only partially amplified by animals and machinery.

Another continuing concern in human ecology is how humans perceive themselves, other people, and their environments. We rely upon and are dramatically affected by our symbolic interpretations and representations of ourselves and those around us. Symbols guide the ways we interact with the organic and nonorganic elements of our environments by making them intelligible in ways specific to our cultures. In this volume, Jelinski, Lu, Palmer and Wadley, Cocks, and Peloquin and Berkes devote considerable attention to the complex and often slippery ways in which people deploy linguistic models of their environments. Of major importance to humans is the way we distinguish and act upon group differences symbolically and thus cultural diversity is an important element of our social environment. As a result of uniquely human communicative abilities, humans respond to environmental and other problems with greater behavioral rapidity and elasticity than other species. This is because language greatly enhances learning and the transmission of ideas. Language, even without writing, allows learning to be a cumulative process. As Daniel Dennett puts it, language allows humans to design adaptive arrangements that for other species would require vast periods of evolutionary time and space, if they were possible at all (1995).

Intraspecific exchange is another hallmark of the human species. Our propensity to engage in the exchange of goods, services, and information among widely separated individuals and groups has the effect of vastly extending the range of our resources and of our impacts upon them. It is rare today for a local population to rely entirely on local resources. With reference to what was often regarded as a self-sufficient foraging society, Edwin Wilmsen (1989), using archeological evidence associated with the San-speaking regions of Southwestern Africa, found that, far from being isolated, trade goods indicate that the foragers were integrated to a considerable degree into distant markets long before the present century (but see Yasuoka, this volume).

Human populations are socially differentiated in ways that are significant for ecological research. Political ecology is a subfield concerned with such issues (see Peet and Watts 1994 for a good introduction). In the following chapters, Loker, Crate, Cliggett et al., Eder, Pedersen and Benjaminsen, and Wutich all deal with how humans not only engage in a division of labor beyond that associated with age and gender roles, but also create systems of perpetuated subordination and inequality, such as caste, class, and other forms of social, economic, and political ranking. Such inequality has major environmental ramifications.

Consider Chinese agrarian society where for millennia farmers, laborers, and artisans were linked in a large-scale hierarchy of exchange via subordination, taxation or tribute, and entitlements according to rank. In any such system, the potential for widespread and amplifying famine, conflict, and disorder is great. A flood or the collapse of a large agricultural region due to weather or civil war can set in motion a cascade of forced migration, conflict, and civil collapse. The fact that there are no physical limits on the accumulation of wealth in a market economy, for example, has important consequences for the way that natural resources are exploited. And the fact that the nominal owners of resources control the means of exploiting them, but do not necessarily live and work near them, has important consequences for the people who do (see, for example, Loker, Cliggett et al., and Acheson and McCloskey, this volume). Thus, local people may be limited in their power to prevent their central government from granting rights to foreign companies to exploit local resources with little regard for indigenous peoples or long-term impacts (see Lu, this volume).

There are other ramifications of group differentiation. A population might deliberately destroy the resource base of a group they perceive as enemies and wish to dislodge - a classic stratagem of warfare. Or a local population might knowingly overexploit its own resources in the expectation of moving on to new ones, often at the expense of neighboring groups. While there are analogous examples from nonhuman populations, humans are clearly distinctive in the extent to which intergroup competition and subjugation take place.

The impact of cultural diversity, exchange, and perpetuated inequality on the ways that humans interact with environments has grown with time and with changes in human social organization since the earliest hominids developed tool technology. Throughout time, the pace of change has accelerated as well. Most human ecologists require conceptual tools beyond those of general ecology in order to address the factors that affect changing human relationships with their environments because of the influence of the complex relationships humans have with one another.