See also: Application of Ecological Informatics; Artificial Neural Networks; Multilayer Perceptron.

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Human Ecology: Overview

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Introduction

We interact with each other and with our physical environments. We are biological creatures who depend upon the living landscape to sustain us. Plants and animals are affected by our actions, and our existence is impacted by plants and animals. We exist within complex sets of interactions – that is, we live in an ecological world.

Learning to perceive the world as a never-ending system of interactions – that is, to think about our surroundings and our relationships with our environments and each other ecologically – is challenging. Such thinking forces us to rethink our views of economics, politics, and business. It suggests different ways to plan and design. In economics, for example, an ecological view suggests a much more complex set of relationships than supply and demand: supply of what and where from and at what cost, not only in dollars but to other species and other generations. Ecological understanding can also confront our values and religious beliefs, although most faiths address human connections to the natural world and stewardship responsibilities for future generations.

Ecology is, by definition, the reciprocal relationship among all organisms and their biological and physical environments. People are organisms. As a result, we can ask, Is the use of human as a modifier to ecology necessary?

Human with ecology helps reinforce the reality of our place in environments. Human ecology seeks to understand the multiple interrelationships between the human species and our environments. Human ecology is broader than biology, but also is grounded in biological concepts. The transdisciplinary field can be defined as the study of the complex and varied system of interactions between people and their environments.

Brief Early History of Human Ecology

Many overlaps between the social and biological sciences existed at the end of the nineteenth century and during the early twentieth century. Ecological concepts were prominent in both geography and sociology. Human ecology was recognized as a unique field of geography. Geographers went so far as declaring "geography as the science of human ecology." Early twentieth-century geographers sought to make clear the relationships existing between natural environments and the distribution and activities of people. However, this approach unfortunately became linked with environmental determinism which suggested that our surroundings shape everything from skin color to behavior. These concepts led to rather simplistic, and even racist, notions about how environments shaped cultures, and environmental determinism was discredited in the 1920s.

Also during the 1920s, urban sociologists adapted ecological concepts to explain settlement patterns and human interactions in cities. Called the Chicago School, these sociologists adapted observation methods from anthropology to describe urban life and culture. They described Chicago as a series of concentric rings from the central business district to the commuter zone on the periphery. They also used the ecological concept of succession to describe how these zones build up one after another as a city grows. These sociologists suggested how various groups of people succeed others in the concentric zones. This small group of sociologists used ecological concepts more as metaphors than as a tool for scientific analysis. As a result, the connections between the two disciplines were not deep, in spite of promising beginnings. Meanwhile, the advances in geography were overshadowed by the environmental determinism criticisms. As a result, human ecology faded to the margins of geography and became a historical footnote in sociology for several decades.

Increasingly, the social sciences became disconnected from the physical sciences and, by extension, from the material world. The focus of the social sciences shifted from ecological models to the embrace of economic, political, and demographic approaches where the role of natural forces was more subtle. In order to bolster the validity of their science, some researchers emphasized quantitative analysis that favored data about people over the observation of the human condition. Meanwhile, ecologists, especially those in North America, concentrated on the study of natural, nonhuman environments. Some one-third of the land in the United States is in public ownership, enabling wildlife and vegetation research on vast expanses with little human interruption.

There are many ironies in this disconnection. For example, the Greek root for both ecology and economics is the same: *oikos*. Both disciplines involve the study of the household. Ecology is the study of the environmental house, including all its inhabitants, in which we live and in which we place our human-made structures and domesticated plants and animals. Economics is the study of the household of money. As we can track the flow of money, we can also illuminate other movements in the places where we live. But beyond their common Greek root, economics and ecology diverged with few clear connections persisting.

Beginning in the 1960s, the general public became alarmed by population growth and the consequences of pollution on water, air, and land quality. Biologists and ecologists used human ecology to emphasize how people are subject to the same environmental limitations as other animals. Also during this time, anthropologists used the term to help explain the impact of environment on culture. Ecologically oriented anthropologists adapted concepts like population regulation and energy flow to explain community organization. In general, early use of ecological concepts in human ecology depended on traditional views of nature, such as the tendency of systems to evolve toward a steady state.

This past suggests the ongoing utility of human ecology. By understanding the interactions and interrelationships between people and their environments, human ecology can help to:

- consider and plan for the long-term consequences of human actions;
- avoid disastrous surprises resulting from environmental phenomena such as floods, earthquakes, tornadoes, wildfires, and tsunamis;
- generate ideas for dealing with environmental challenges and opportunities; and
- create a livable and sustainable relationship with the environment.

However, to realize this utility, it is necessary to understand changes in ecological thinking generally and how human ecology fits within this ever-changing discipline.

Toward a New Ecology

Since the first Earth Day in April 1970 and the rise of the modern environmental movement, social scientists have rediscovered the environment while biologists have probed social interactions. Meanwhile, several ecologists have addressed human communities, and planners and architects have attempted to provide syntheses to shape human communities. In addition to the stimulus from popular culture, as expressed in wide-ranging areas from politics to music, advances in theory through computing technologies, urban morphology (the study of how cities are structured physically), landscape studies, and ideas about complexity have contributed to this renewed interest in the environment by social scientists. From within the biological sciences, research has altered conventional views about organism–environment interactions. Increasingly, ecologists consider human influences on their environments.

This new human ecology emphasizes complexity over reductionism, focuses on changes over stable states, and expands ecological concepts beyond the study of plants and animals to include people. This view differs from the environmental determinism of the early twentieth century. The new ecology addresses the complexity of human interactions rather than how a specific physical environment shapes human anatomic variations. Because people form part of its scope, new ecology may be viewed as human ecology, or the evolution of traditional ecology to reconsider human systems.

New ecology represents a significant reorientation that has occurred in the field of biological ecology. For example, new ecology embraces disequilibria, instability, and even chaotic fluctuations in natural and human-impacted biophysical environments. Two primary changes have occurred in new ecology, differentiating it from its traditional progenitor. The first shift is from an equilibrium perspective, where local populations and ecosystems are viewed as in balance with local resources and conditions, to a disequilibrium perspective where history matters and populations and ecosystems are continually being influenced by disturbances. The second change is from considering populations and ecosystems as relatively closed or autonomous systems, independent of their surroundings, to viewing both populations and ecosystems as open that are strongly influenced by the input and output, or flux, of material and individuals across system borders.

Traditional ecology relied on the assumptions that nature could achieve balance and that ecosystems functioned as closed systems. Natural plant communities evolved through several stages, climaxing in a steady state, according to traditional theory. Since ecologists studied plants and animals in forests, deserts, and other environments relatively removed from human settlements, their interactions could be isolated for study within closed systems.

New ecology challenges both assumptions. Living systems are viewed as changing and complex rather than stable and balanced. In addition, the boundaries between communities blur. Open systems possess fluid, overlapping boundaries across several spatial scales from the local to the global.

Ideas Contributing to a New Human Ecology

Ecology lends itself to reinvention, to reinterpretation. Relationships link things, and how we view connections among elements changes. As early as the 1950s, anthropologists called for a 'new ecology'. The ideas leading to the more recent, expanding view of ecology have come from many sources and a variety of disciplines, including anthropology. The catalysts for change include advances in technologies, the study of urban morphology and landscape ecology, a broader understanding of chaos theory, and increased interest in issues of sustainability. The emergence of urban ecology exemplifies a beginning in the synthesis of these sometimes divergent catalysts. Urban ecology focuses on organism–environment interactions within cities and other human settlements. By concentrating on urban areas, the interests of the new ecological perspective are woven closer together.

Fresh ways to observe nature, primarily as a result of computer and remote-sensing technologies, have altered our understanding of functions, structures, and patterns. These new (and evolving) technologies are yielding a deeper perspective, because many events can be considered simultaneously in a connected network.

A computer technology especially valuable for revealing complex, ecological relationships is geographical information systems, known by its abbreviation GIS. These computer software programs allow analysis to study overlapping spatial data and map the results. For example, the home range of a tiger beetle species can be mapped then compared with a similar map for a species of brown bear. In turn, both can be overlaid on the migration routes of Canada geese and the extent of a coniferous forest and so on. GIS emerged concurrently with new ways to see and to record the surface of the planet, such as remote-sensing technologies. Whereas GIS programs map information, remote sensing creates imagery of phenomena on the Earth's surface.

As the Apollo astronauts approached the moon, they relayed images back to Earth unlike anything previously seen. The hypnotic pictures of the moon riveted our attention, of course, but the photographs of the blue-green orb of Earth were perhaps even more profound. Continents and water bodies were clearly visible beneath swirls of clouds, but borders had disappeared (**Figure 1**). No longer would we see Earth in the manner of the little globes in our classrooms. NASA continues to produce images of the planet, as do other governmental and private remote-sensing groups. In fact, NASA broadcasts continual images of our planet on its own television network.

Remote-sensed information is collected through satellites or high-flying aircraft. The images can be enhanced with computers to reveal specific phenomena, such as land cover, land use, and fault lines. Climate patterns can be tracked and future weather events forecasted. Remote sensors can also be linked to on-the-ground monitoring stations. Such connections allow phenomena to be observed through time. For example, a drainage basin can have several stream-monitoring gauges, which may be linked to a central data collection center. In turn, satellites may be able to collect rainfall and snowpack information daily that can be combined with the field data to predict future water supplies.

Figure 1 Blue Marble. Credit: NASA Goddard Space Flight Center Image by Reto Stöckli (land surface, shallow water, clouds). Enhancements by Robert Simmon (ocean color, compositing, 3D globes, animation). Data and technical support: MODIS Land Group; MODIS Science Data Support Team; MODIS Atmosphere Group; MODIS Ocean Group. Additional data: USGS EROS Data Center (topography); USGS Terrestrial Remote Sensing Flagstaff Field Center (Antarctica); Defense Meteorological Satellite Program (city lights).

The use of GIS and remote-sensing technologies has spread rapidly among scientists during the past few decades. A geologist can overlay a map of bedrock on an aerial photograph to determine where a fault line intersects with settlement. Additional technologies likely will open more possibilities. For example, visualization techniques present three-dimensional representations of objects. Such visualization can be combined with GIS to show places more holistically. The maps of the geologist and the ecologist can be rendered in three dimensions to illustrate the relationships among phenomena such as aquifers, wildlife corridors, and land use. The Internet opens opportunities, too. For instance, a team of American students can work with a group of Italians in a virtual studio, and share GIS maps and photographs of a place, say, in Africa. Furthermore, one can use websites such as Google Earth for an aerial photograph and a map of almost anywhere on the planet.

Information stored and communicated via computers reveals more and more about our interactions, with each other and with our worlds. GIS combined with real-time satellite images and the Internet provides the equivalent of a central nervous system for the planet. Humans can aspire to provide the brain for that system. How we apply our brains to use these technologies and this information will transform how we live and, therefore, the patterns of our settlements.

As the information landscape advances, we can gain a better understanding of human ecology. For example, satellite imagery can produce daily climate information for settlements. GIS can be used to map these data over time and enable the climate information to be overlaid on land-use and land-cover maps. This process reveals how we use the land and how what we plant on its surface affects urban climate. In this way, GIS and remote-sensing technologies enable us to visualize relationships. Since human ecology is essentially about relationships, our ecological understanding advances as we reveal previously unseen connections.

We especially gain insights into urban places. Urban morphology involves the study of human settlement patterns. People create nonurban settlements as well, ranging from farmsteads and rural villages to mines and ski lodges. While suburbia might lack urbanity, it is often classified as urban by geographers. Farmsteads and suburbia have specific morphologies as well which are important to understand. However, since we live in the first urban century, the morphologies of cities and metropolitan regions especially merit attention. Population trends indicate that the world is becoming more urban. For the first time in human history, over half the world's population lives in metropolitan regions. As the planet has urbanized, the structure of urban areas has attracted increased attention by scholars from many disciplines.

Urban morphology evolved from both the disciplines of geography and architecture in Europe, where a rigorous and thorough mapping of the physical structure of cities was promoted. Mapping revealed what the Italians call *tessuto*, or the tissues of the city – that is, clusters of structures, vegetation, and roadways that hold the urban body together. The Dutch use a similar concept and their word for tissue, *weefsel*, to describe urban tensegrity. The influence of urban morphology has spread among geographers, architects, and planners in Europe, North America, and Asia. Urban morphologists advocate reading the city as a text, or as a cultural palimpsest, to reveal culture.

Landscapes possess power such as both a cultural and a natural palimpsest. Landscapes offer a scale where social and physical processes and pattern can become evident. We see landscapes and all our senses react to their well-being.

Landscape ecology focuses on the ecological relationships at the landscape scale. Landscape ecology is a study of the structure, function, and change in a heterogeneous land area composed of interacting ecosystems. European scientists advanced landscape ecology before their American counterparts. The landscapes of Europe have been more densely settled than in North America, and, as a result, the human influence was recognized quickly by European scientists. American ecologists are more accustomed to studying relatively pristine landscapes. The refinement of the landscape ecology discipline, coupled with increased suburban sprawl nationwide, has changed this situation as more American ecologists acknowledge human interactions with natural systems. As landscape ecology has evolved through multiple interactions among European, American, and Australian contributors, it has crystallized into something new and powerful. Human settlements form mosaic-like patterns on landscapes and this land mosaic vision makes the landscape readily accessible to scientists, especially ecologists.

We can see change and interactions in landscapes. Edges – or interfaces – between land uses can be especially sensitive and rich. In rapidly growing regions, edges are unstable and conflicting. New homes replace farmland. The land sells relatively cheaply. The open land provides an attractive backdrop. Agriculture practices create dust and noise. Farming often depends on chemicals that have consequences for human health. Suburbanites possess different lifestyles and expectations that vary dramatically from those of their rural neighbors. Such landscape change lends itself to scientific analysis. For example, ecologists can ask, What interactions are driving the change and what patterns are resulting?

A growing interest in the ecologies of urban areas provides evidence of a coalescence of these catalysts for change. In the United States, National Science Foundation (NSF) established two urban Long Term Ecological Research (LTER) projects in 1997. Before setting up these projects in the Baltimore and Phoenix metropolitan regions, NSF located LTERs in nonurban places. Remote locations presented ideal places for ecologists to explore the traditional concept of stable states in relatively closed systems. Increasingly, influential American ecologists began to urge NSF to consider the ecology of metropolitan regions too in order to pursue the study of more complex systems. Urban ecological systems present multiple challenges to ecologists, including pervasive human impact and extreme heterogeneity of cities, and the need to integrate social and ecological approaches, concepts, and theories.

The Baltimore and Phoenix LTERs offer contrasting urban conditions. Baltimore, located in the northeastern region of the United States, is an older city than Phoenix and has a more dense urban fabric. The Sun Belt location of Phoenix offers a city developed as a result of automobile, airplane, air conditioning, and refrigeration technologies. Whereas growth in Baltimore is rather slow, population expansion in the Phoenix metropolitan region leads the nation. The humid Chesapeake Bay contrasts the arid Sonoran Desert. As a result, the Baltimore and Phoenix LTERs can help us understand constants in urban conditions as well as specific variations resulting from the natural surroundings and from the period of settlement.

Thus far, there has been relatively little interaction between the urban ecology camp dominated by scientists and the urban morphologists led by architects and planners. Geographers are present in both groups and likely will form bridges. The substance of such spans can be provided through better-understanding human ecology.

Human ecology is important if we are serious about sustainable development – that is, economic progress that meets all of our needs without leaving future generations with fewer resources than those we enjoy – a way of living from nature's income rather than mining its capital account. Sustainability requires that human communities are adaptable to change, that natural processes and landscape functions are protected, and that resources are conserved for future generations. To be adaptable, communities need to be resilient. We must understand the organization – the function, structure, and processes – of the communities that we inhabit in order to lay the foundations for the future.

Perhaps the growing interest in sustainable development – in seeking to make communities more livable – derives from a sense that we are living in places where something is out of whack. Perhaps the creative impulse derives always from a dread of the future, the feeling that the world may not improve for our children, and our desire to fend off doom to improve things for those who follow. To sustain things, we must keep them from falling apart, now and in the future. All around us, things indeed appear to be coming apart at the seams. Where once children played in the park, now homeless people sleep. Where there was once a vibrant downtown, there are now vacant lots.

The farm field, the park, the downtown; the convenience store, the homeless people, the vacant lots, all form pieces in larger mosaics, larger processes. In itself, the field or the convenience store is neither good nor bad. Both, however, are part of larger systems that may be either healthy or sick, that is, either capable of sustaining themselves or not. The individual farm field contributes to a regional agricultural system. The crops produced in the field help sustain the regional economy. The crops support not only the farm family that produces them, but the local co-op that processes the crop for the market and the tractor dealer as well. The convenience store has an asphalt parking lot. Its impervious surface contributes to regional drainage and flooding problems because of increased runoff. Because the parking lot is black, it adds to the urban heat island effect resulting in summer discomfort among nearby residents. The understanding of how living systems are organized from the local to the regional provides a means for assessing their capabilities to adjust to change.

Nested Networks

Living systems are organized hierarchically and communicate through feedback networks. The elements within a system may vary greatly in organization. According to urban morphologists, urban form can be understood at different levels of resolution. Commonly, four are recognized, corresponding to the building/lot, the street/block, the city, and the region. A building may be tall or short, with a pitched roof or a flat one, brick or wood or adobe. A lot, a street, or a block may be narrow or wide, straight or curved. A city may be densely settled or spread out. A region can be defined by a river or a mountain or a coastline or all three and by other factors.

Hierarchies help us understand how people are connected with one another – the basic idea of community. To understand human ecologies, the most relevant levels of organization include habitat, community, landscape, region, nation and state, and Earth or ecosphere. These levels present different, yet interconnected, scales of analysis. Each level possesses a history and a literature of analysis and debate. The habitat includes the building and lot. The community is comprised of buildings, lots, streets, and blocks. Landscapes can be urban, suburban, rural, and wild. Regions are hodgepodges of landscapes, while the distinctions between regions, and often those between states and nations, are even more blurred. But there is less ambiguity about the ends of the Earth.

Each level of human organization (nation, state, region, county, and city) is an element in a larger system, but is also comprised of smaller geographic units like neighborhoods and communities, which are, in turn, collections of single households. Home and work places form the habitats for people and are further divided into cells we call rooms. Hierarchy may be seen as a framework, a system of nested networks.

A critical feature of these nested networks is an asymmetric interaction in between levels. The larger, slower levels maintain constraints within which faster levels operate. There are, however, circumstances when slower and larger levels in ecosystems become briefly vulnerable to dramatic transformation because of small events and fast processes. Large, slow levels tend to keep things in place. Small, fast levels initiate changes when the larger levels are not functioning effectively.

Viewing the world hierarchically does not necessarily imply seeing it through a machine-like lens. Rather, it is to suggest components of a vocabulary to read our surroundings, our world.

Traditional ecology was commonly grounded in the assumption that somehow nature is in balance. Even the most casual observation of the human condition indicates that we are seldom balanced in our affairs. Nonequilibrium represents an important change in thinking. An equally, or perhaps even more important change derives from viewing environments at multiple, interacting scales. Landscape-level ecology, in particular, provides spatial form and function to nature's flows and human activities. New ecology, a deeper understanding of interactions at various scales, holds the prospect for better, although more complex, approaches to sustainable resource management, nature conservation, and environmental protection as well as the arts of environmental design and planning.

Practical Applications of Applied Human Ecology

Since the 1970s, natural and social scientists initiated multidisciplinary research addressing practical problems related to the environment. For example, the United States and many other nations require an environmental impact analysis of the consequences of larger projects. Such analyses are often performed by multidisciplinary teams, with human ecology providing a common set of concepts among disciplines.

Human ecology can also assist community and regional planning. For example, the Phoenix, Arizona (USA) metropolitan region is well known for its rapid growth and its suburban sprawl. Much of the post-World War II development has occurred in a similar pattern of low-density, single-family homes that is highly dependent on the automobile.

Beginning in the 1990s, city officials sought to encourage different patterns of development for North Area which comprised 20% of the land within the city. Using corridor, path, and matrix principles from landscape ecology, 28% of the most environmentally significant areas in the 110 square mile North Area were preserved as open space. Through an analysis of current and potential residents, three future settlement patterns, instead of one, were suggested for the rest of the North Area. In suitable places along transportation corridors, greater urban density was recommended that included green ribbons of natural drainage. In other locations, a very low-density, low-impact rural desert settlement was suggested.

Since people in Phoenix are attracted to suburban development, suitable areas for such settlement were identified. However, a new form of desert suburban development was designed. This settlement would be aligned with natural drainage systems, preserve native vegetation and wildlife habitat, encourage the planation of native species, reduce the amount of impervious surfaces for roadways, use natural building materials with a local color palette, and keep building heights below the tree line (Figures 2 and 3).

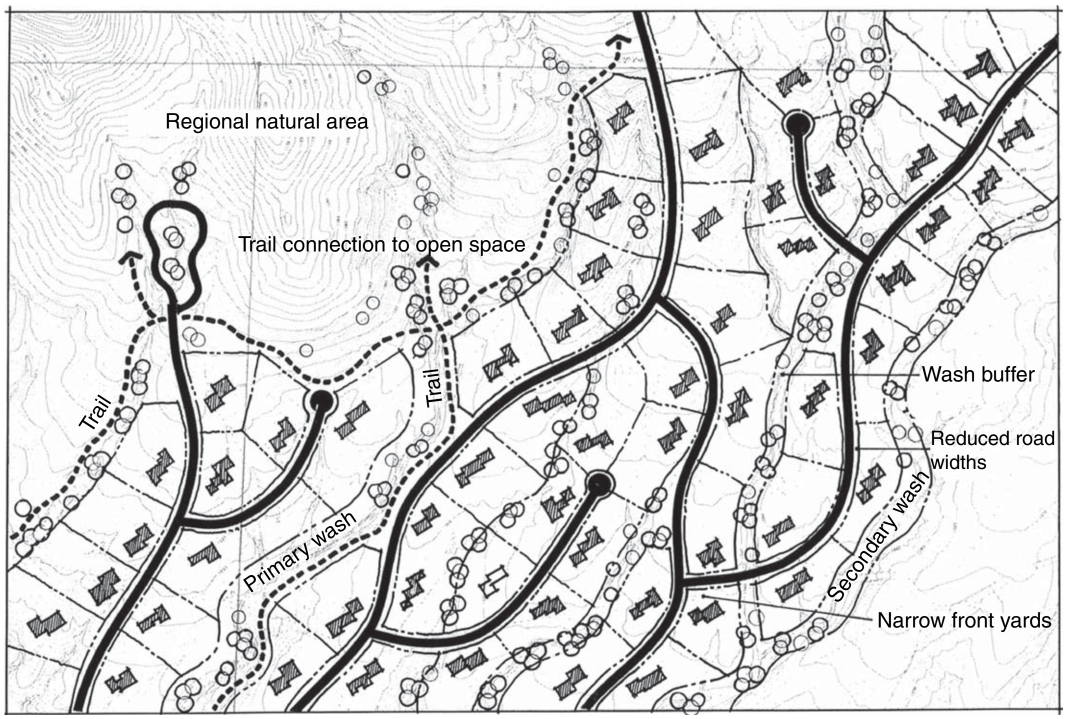


Figure 2 Open space systems. Based on desert washes used to create a new form of suburban development in North Phoenix. From Steiner F (2000) *The Living Landscape: An Ecological Approach to Landscape Planning*. New York: McGraw-Hill.

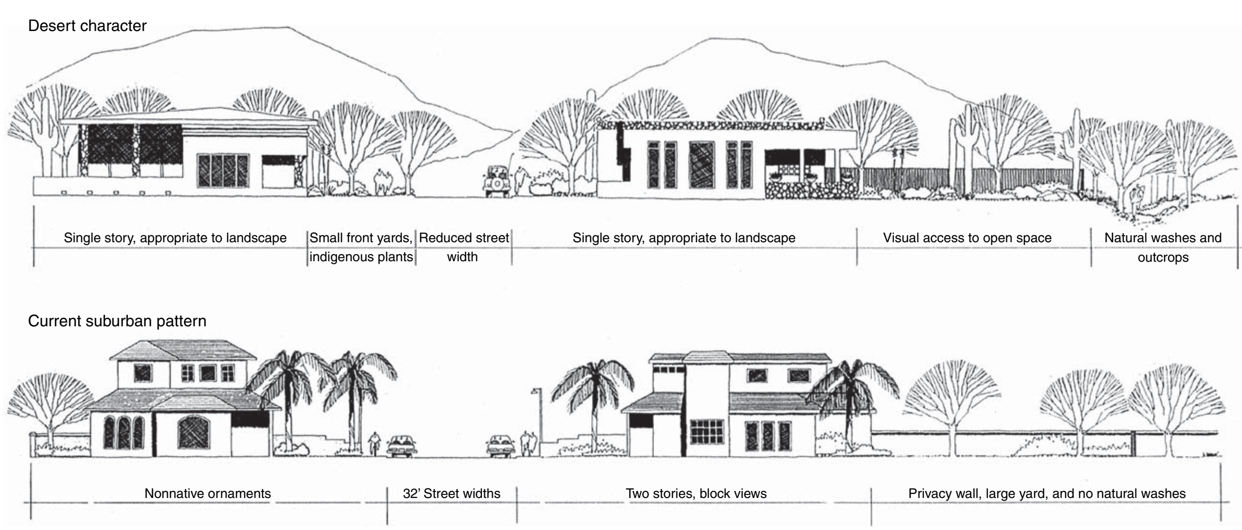
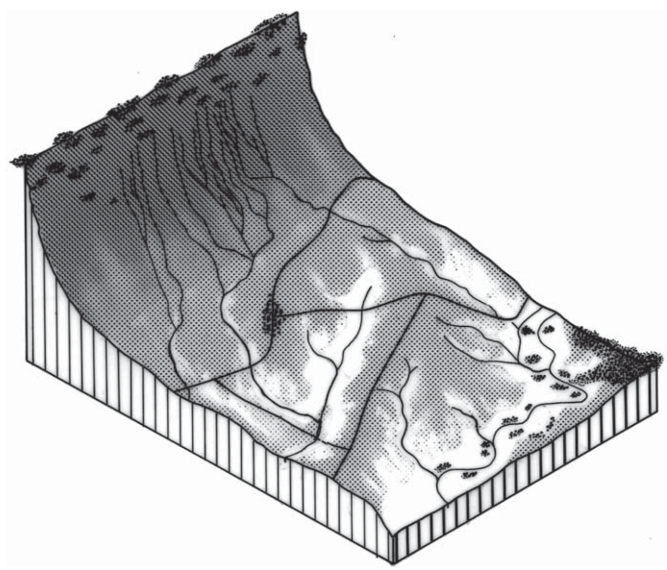


Figure 3 Comparison of current suburban pattern in North Phoenix to one integrated with the desert. From Steiner F (2000) *The Living Landscape: An Ecological Approach to Landscape Planning*. New York: McGraw-Hill.

Around the world from Arizona, Kenya is also experiencing a growing population and declining natural resources. A multidisciplinary team of Kenyan and Dutch researchers conducted extensive landscape and human ecology analyses which led the Green Town program. The motto of the program was 'make every town a green town'. In all, some 29 small towns across Kenya became involved in the effort which included considerable ecological training of local officials.

The Green Town program emphasized locally derived, sustainable designs. Shaded market areas were suggested as well as agroforestry practices to produce fuel and food. In addition to increasing fuel wood and food products, the agroforestry techniques reduced soil erosion and storm water runoff. The Green Town program suggested strategies for urban tree plantation as well as ways for individual homes to collect rainwater (**Figures 4** and **5**).



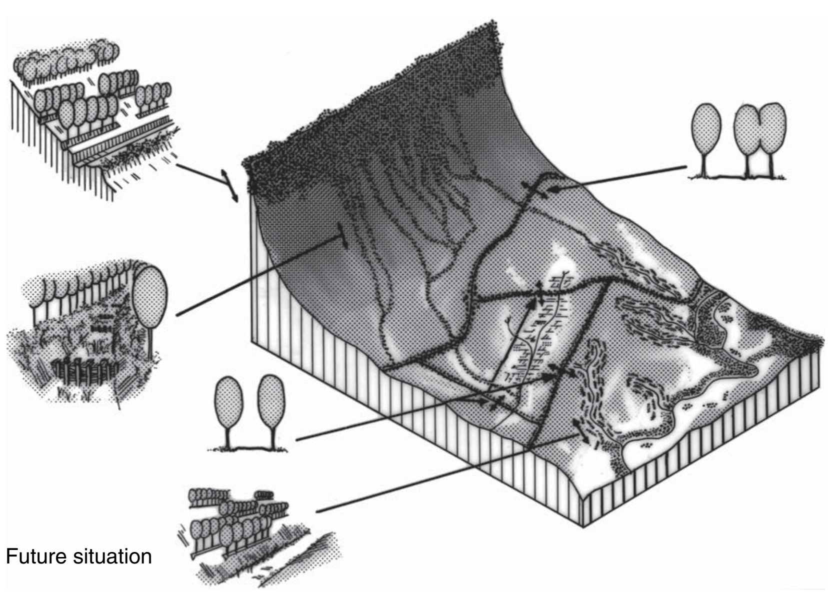


Figure 4 Before and after of Kenyan hillside integrating agroforestry systems to produce food and wood while controlling storm runoff and soil erosion. From Duchhart I (2007) *Designing Sustainable Landscapes: From Experience to Theory.* Wageningen: Wageningen University.

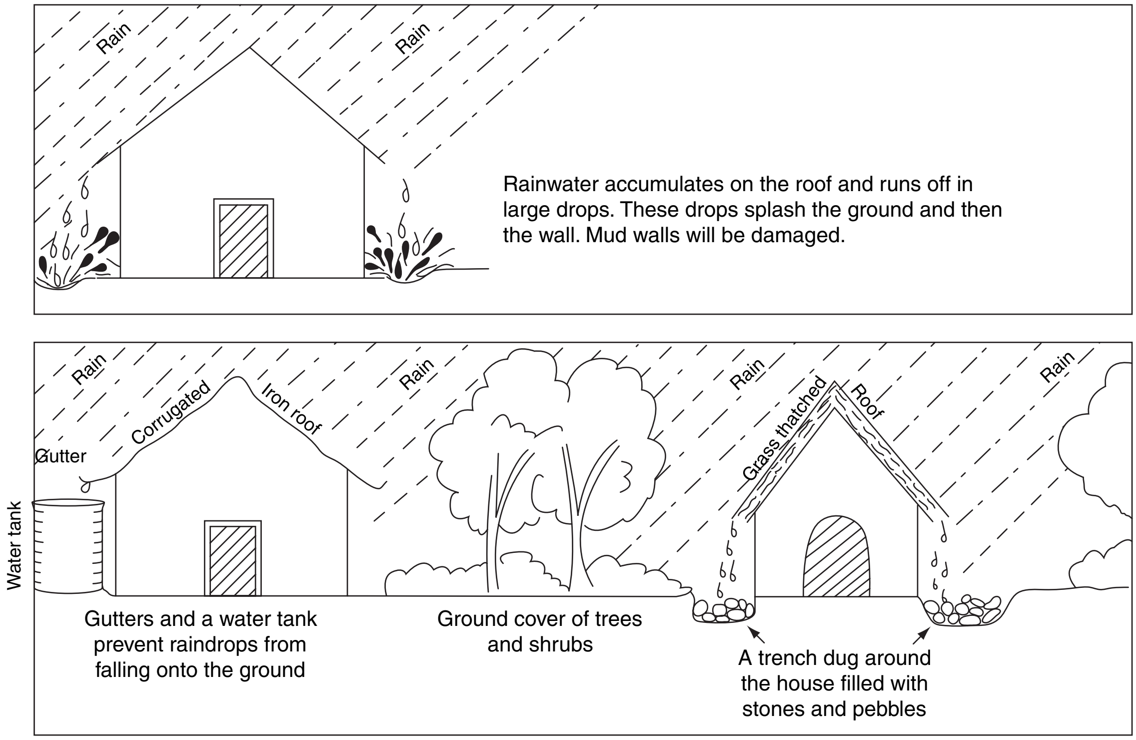


Figure 5 Strategies for collecting rainwater in Kenya. From Duchhart I (2007) *Designing Sustainable Landscapes: From Experience to Theory.* Wageningen: Wageningen University.

Summary

Human ecology involves the interrelationships among people, other organisms, and their environments. Human ecology emphasizes complexity and change. Urban morphology and landscape ecology offer two approaches to study the structure, function, and processes of human settlements. Hierarchy also aids in the understanding of how people organize themselves spatially on various scales from the individual room within a house, office, school, or factory to the neighborhood and community on to the region, state or province, and nation. Applied human ecology presents many practical applications including the analysis of the environmental impacts from specific, proposed projects to the planning of communities and regions.

See also: Adaptive Management and Integrative assessments; Ecological Footprint; Limits to Growth; Monitoring, Observations, and Remote Sensing – Global Dimensions; Precaution and Ecological Risk; Sustainable Development.

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