Ecomimesis: A Model for Sustainable Design

Lillian C. Woo[1]

Abstract

Background. In the last fifty years there have been scientific empirical evidence that climate change and environmental degradation are increasing and over 500 international agreements with goals to stem the deterioration of the land, sea, and air. Despite all the evidence and treaties, climate change is getting worse with ever increasing air and water pollution, soil and ocean degradation, and ecosystem decline. Method and results. Based on both extensive research and monitoring of the harmful contributors to the environment and specific components of the ecosystem and current design remedies to ameliorate that damage, this paper provides an analysis of the negative anthropogenic impact on various parts of the ecosystem and proposes ecomimetic design solutions to mitigate and repair environmental degradation. This article focuses on these major components of the ecosystem: biodiversity, spatial efficiency, homeostasis and its subsets of cybernetics, succession, and continuity. These components are described with emphasis on the damage inflicted by anthropogenic actions. Each section will include proposed ecomimetic solutions to repair and mitigate the damage. Conclusion. While there is no single solution to the environmental challenge, ecomimesis represents a comprehensive and achievable approach toward slowing and correcting environmental decline. It is different from other design models because it considers all the major components of the ecosystem and designs the manmade ecosystem to minimize adverse effects and help stabilize the environment. Using nature as its template, ecomimesis conserves, repairs, and improves existing ecosystems. Ecomimesis is a new and broad approach to ecodesign.

Keywords: Climate change, Ecomimesis, Ecosystems, Sustainable design

[1] Director, Ecodesign Research Center, W Hyannisport, Massachusetts, USA

1. Introduction

For the last fifty years scientific research from private and public groups has shown that climate change and environmental degradation have been the result of an increased world population, economic development and industrialization, and the changes in social and cultural norms. Although these three fundamental components were highlighted in Gro Harlem Bruntland's report in 1987 for the United Nations, Our Common Future, which warned of the urgency to protect the world's environment and natural resources, the pace of economic growth and depletion of natural resources continues to gain momentum without regard to the health of the environment and the world population.

Although the effects of greenhouse gases have dominated research and public policy in recent years because of the global warming they cause, there are many other harmful contributors to the environment. These other factors and their negative impact on various parts of the ecosystem will be the focus of this article.

This article will discuss the following ecosystem components: biodiversity, spatial efficiency, and homeostasis which includes subsets of succession, cybernetics, and biogeochemical cycles. To retain stability within an ecosystem, each component must contribute its part. If any component is damaged or eliminated, the entire ecosystem goes into flux until it regains equilibrium by adjusting to its new composition.

Following a detailed description of the damage inflicted by anthropogenic actions on each component, there will be proposed ecomimetic solutions to repair and mitigate the environmental damage.

2. Ecomimesis

Ecomimesis is the term used to describe the design of manmade ecosystems that imitate ecosystems in nature. Ecomimesis emulates the properties, structure, functions and processes of natural ecosystems in designing and constructing the manmade ecosystem. By using nature as its template, ecomimesis is ecologically driven to conserve, repair and improve existing ecosystems, to re-establish ecosystem stability, and to preserve regional biodiversity and habitats through continuity of functions and connectivity.

What distinguishes ecomimesis from other sustainable design programs is its scope. Other sustainable design programs usually focus on only a few aspects of the built structure or environment, such as energy conservation, carbon footprint, or flood control. Ecomimesis analyzes the whole ecosystem, the impact of human activities on that particular ecosystem, and creates designs which minimize the damage to the natural ecosystem. The inclusion of the entire ecosystem and the impact of human activities on the ecosystem result in anthropogenic structures and resource use that minimize damage and intrusion to the existing ecosystem.

In creating a built environment within nature’s ecosystem, ecomimesis attempts to mimic the ecological cycles, networks, relationships between components, and diversity of local plants, animals, and environmental conditions so that built structures, community, or society impose a minimal disruption of the natural balance of the system. All aspects of the built environment – site use, architectural and landscape designs and master planning, product designs, material selection and use, types of energy systems, waste generation and management, forestry, and agriculture, for example - must be analyzed and incorporated into ecomimetic designs so that the resulting designs are systematically integrated physically and spatially with the existing ecosystem. The creation of new eco-sensitive manmade structures can also assist in reclamation efforts to restore cities and environments to a more congenial state with the natural ecosystem.

Ecomimetic designs of the built environment will become a mirror image of the designs of natural, self sustaining, and self correcting ecosystems, if the principles that govern the balance and interdependence of a natural ecosystem are used as a model for manmade environments. By using ecomimetic design for architectural and other manmade ecosystems to duplicate the properties, structure, functions, and processes of ecosystems in nature, a benign integration between the two ecosystems can be achieved.

Other benefits of ecomimesis are the reduction and restoration of damage to the environment and a positive impact on ecosystems. Some of the benefits would include strengthening biodiversity, purifying water and bodies of water, reducing polluting emissions, reducing waste, stabilizing biogeochemical cycles and the nutrients in the soil, using land more efficiently and carefully, and limiting manmade ecological footprints. (Yeang, Ecodesign Manual, 45-58).

3. Ecosystem

An ecosystem is essentially a set or collection of organisms that lives within a certain space determined by a specific environment. Each ecosystem community is a complex of species, their physical environment, and all their interrelationships in a particular unit of space. The species interact with each other and with the energy and abiotic components (air, water, soil) of that physical environment. Ecosystems vary in size and location, such as aquatic, coastal, coral reefs and ponds, deserts, forests, rain forests, grassland, tundra and others. The ecosystem types are determined and influenced by climate.

The primary elements that constitute the fundamental structures and organization of ecosystems include biodiversity, spatial efficiency, ecological cybernetics, homeostasis, succession, energy, and biogeochemical cycles. Each element is necessary for the continuity and balance of an ecosystem. If any part is disrupted from its natural ability to adapt and adjust, other parts will also be affected.

Every ecosystem is subject to and controlled by external and internal factors. External factors influence the structure of the ecosystem through climate and its temperature and rainfall, geological material that determines mineral nutrients in the soil, and topography that establishes microclimates and water sources and retention. Internal factors include processes, disturbances, and changes that affect its composition and stability. Among them are primary production of organic material through photosynthesis, energy flow, decomposition and nutrient cycling.

An ecosystem's stability depends on its ability to maintain and sustain its existing elements. Those elements, the internal and external factors are mentioned above. In addition, ecosystem equilibrium is dependent on its ability to survive natural disasters like floods and hurricanes, land erosion, desertification caused by heat and drought, and degradation of the soil.

Researchers estimate that approximately 40-50% of the land surface of Earth has been degraded by anthropogenic activities, 66% of marine fisheries have been overfished, carbon dioxide in the atmosphere has increased more than 30% since the beginning of industrialization, and almost 25% of the Earth's bird population are now extinct. (Vitousek et al., 277: 494-499)

4.1. Ecosystem: Biodiversity

4.1.1. Background

In any given area biodiversity is determined by number of species that can adapt and survive in a specific ecosystem. Ecologists estimate that there are approximately 1.7 million species that have been described and probably another 10-30 million species that exist but have not been described.

Most of the world's 1.7 million species are concentrated near the equator, particularly in tropical rain forests and coral reefs. Only 10-15% of the world's species live in North America and Europe. The Malaysian Peninsula, for example, has 8,000 species of flowering plants while Britain, with an area twice that, has only 1,400 species. South America, on the other hand, has over 200,000 species of plants. (Cunningham, 108; United Nations Environment Programme. Convention on Biological Diversity. June 1992.)

The general view among biologists and ecologists is that ecosystems with more kinds of different species are stronger than those with fewer species because more species strengthen an ecosystem's resiliency and ability to adapt to changes. (Moffatt, 1996.) In some ecosystems the diversity helps create a stronger homoeostasis by providing greater numbers of species that can assist in processing food through their complex webs. In other ecosystems diversity can result in wide population swings for individual species, and in some cases, these species become extinct. (Bush,169; Moffat,1996; Cunningham, 108.)

The preservation of biodiversity of a specific area is controlled by two major factors: 1) the abiotic components: minerals, climate, soil, water, and sun. and 2) the biotic components: the types of organisms and their interactions, the balance of producers, consumers, decomposers, and integrators, the food chain, factors that affect population growth, and community properties. Changes to any of these factors can affect the ecobalance and ultimately the existing biodiversity of a given ecosystem.

4.1.2. Findings: Human impact on ecosystems and biodiversity

Human actions have caused a number of dramatic changes to a variety of ecosystems. Humans use and modify natural ecosystems through agriculture, forestry, recreation, urbanization, and industrialization, and in the process of these activities, both the balance of ecosystems and their ability to support indigenous species are adversely affected.

Current biodiversity losses are primarily caused by disruptions of ecosystem balances. If one element breaks down or is disrupted, the balance of the entire ecosystem is threatened. Most of the disruptions that have resulted in the loss of biodiversity are caused by human activity: habitat alteration or destruction, deforestation, human overpopulation, introduction of new species and genetically modified organisms, pollution, and climate change. (Eni Scuola.net/.)

World Wildlife Global has estimated that the rapid loss of species is somewhere between 1,000 and 10,000 times higher than it would have been from natural extinction. (McLamb, 2013.)

In 2014 World Wildlife Fund issued its biennial Living Planet Report, which measures trends in three areas: populations of more than 10,000 vertebrate species, human ecological footprint, and biocapacity. The data compiled by WWF indicates that between 1970 and 2010 populations of mammals, birds, reptiles, amphibians, and fish around the world decreased by 52%. Specifically, in the forty year span, 39% of terrestrial wildlife, 30% of marine wildlife, and 76% of freshwater wildlife are gone. While high income countries showed a 10% increase in biodiversity, middle income countries showed an 18% decline, and low income countries showed the biggest decline in biodiversity, 83%. (Roberts et al, 2014.)

Human impact on biodiversity can be summed up with the acronym, HIPPO: 1) Habitat fragmentation and destruction 2) Invasion of non-native species 3) Pollution 4) Human population and 5) Over harvesting. We can also add climate change and the domino effect of all these factors. (Miller, 132)

Habitat fragmentation and destruction Fragmentation and degradation of natural habitats and the environment are directly related to resource consumption and land use changes. For example, tropical forests are being cut at a rate of 0.6 to 2% per year, and it has been estimated by the United Nations Environment Programme that half of remaining forests will be lost or degraded in 25 to 83 yrs. The number of extinctions caused by human domination of ecosystems has been steadily increasing since the start of the Industrial Revolution. Current research indicates that about 50% to 84% of the Earth's surface (excluding Antarctica and Greenland) has been lost by filling in wetlands, and converting grassland and forests to crop fields and urban areas. (UN Global Biodiversity Outlook 4 2011-2020, 11-13)

In U.S. at least 95% of virgin forests in the lower 48 states have been logged for lumber and converted to agriculture, housing, industry. 98% of tall grass prairie in the Midwest and Great Plains have disappeared, and 99% of California's native grassland and 85% of its original redwood forests are gone. More than half of U. S. wetlands have been destroyed. (Cal State University, 2009.)

Invasion of non-native species and decline of natural key predators. The spread of non-native species threatens many local species with extinction and pushes the world's biota toward a more homogeneous and widely distributed sub-set of survivors. Climate change threatens to force species and ecosystems to migrate toward higher latitudes, with no guarantee of suitable habitat or access routes.

In 2016 Nature World News reported the results of a study that found that fish are migrating toward the poles and away from the equator because of warming temperatures. The study also found that plants and trees are also shifting out of temperate zones as temperatures rise. The research team concluded that the plant and fish migration will have adverse effects on poor nations in the world. (Catherine Arnold, 2016.)

Researchers indicate that fresh water ecosystems are currently the most threatened ecosystems. With the destruction of natural barriers, invasive species take over the ecosystem, destroying the native species. The rampant spread of invasive species has been attributed to human activities. (http://www.conserve-energy-future.com/what-is-biodiversity)

Pollution Human impact on abiotic components has included toxicity, global warming, increased ozone, increased carbon dioxide, increased greenhouse gases, fragmentation and degradation of biogeochemical, water and hydrologic cycles, air and their impacts on climate change and environmental pollution, and interference with normal cycling and flows of energy in ecosystems.

Population Humans are the only species whose population keeps growing beyond an ecosystem's ability to support it. With all other species, overpopulation results in dying back until the environment can accommodate it. Human beings have overcome this natural limitation by changing their physical environment. As a consequence, the ever increasing human population has resulted in greater and greater demands for food, shelter, and settlements, and products that steadily consume more than their share of resources. As a result, the natural balance of the environment has been damaged. Urban sprawl has resulted in increased paved surfaces and increased heat island effects. At the same time, there are fewer open fields, forests, marshlands, and other natural habitats. Similarly, commercial farming and forestry have created monocultures, adversely affecting the soil, ground water, rivers, and other bodies of water and extant species through the use of chemical fertilizer and pesticides.

Overharvesting of nonrenewable resources In a closed ecosystem there is no waste. Everything is used by some member of an ecosystem, and there is a circular pattern of using resources. Humans, on the other hand, practice a linear pattern of resource use: extract a resource, convert it for use, consume it, and throw it away after it is no longer wanted or useful. This practice has resulted in an accumulation of waste and depletion of nonrenewable resources. Many manmade products, that are discarded when their usefulness is completed but whose residual material do not decompose quickly or easily, are another source of waste. Ecomimesis design must adopt nature's way of using, reusing, and reintegrating materials.

4.1.3. Proposed ecomimetic designs to maintain ecosystem diversity

Ecomimesis seeks biointegration of the abiotic (inorganic) and biotic (organic) components, composition, and processes of the built environment with the natural environment to form a mutually beneficial ecosystem. Ecomimesis can help maintain ecosystem diversity through the following designs and actions:

1. Design to minimize fragmentation of ecosystems. Enhancing biodiversity of the designed system can be achieved through conservation of existing continuities and linkages of ecosystems, through the creation of new ecological corridors, eco-bridges, eco-undercrofts, land bridges, hedgerows, enhanced horizontal integration, and interconnectivity over terrain.

2. Design to minimize the distance between habitat patches and maintain the size of habitat patches. Design processes are affected by the character of the landscape, its size, shape, and patterns. Species composition and abundance will suffer as the size of habitat patches decreases. The amount of connectivity needed between patches varies from species to species and depends on the abundance of the focal species, its spatial arrangement and movement capabilities. (Yeang, Ecodesign Manual,41.)

3. Practice ecomaster planning. Both the site and its context should be based on maintaining the functions and connectivity within an ecosystem and repairing or restoring damaged

ecosystems rather than on a fixed perception of the environment determined at the time of site analysis. Ecomaster planning differs from conventional master planning because it stresses a seamless and benign biointegration of the human ecosystem and the natural one. (Yeang, Ecomasterplanning, 16-18.)

4. Design a green infrastructure which is a network of interconnected natural areas and open spaces within the site which are linked to those outside it. This can heal landscapes, repair ruptures, reconnect parts, and can create an ecoinfrastructure.

5.Designate use of renewable resources. Use renewable sources only at the rate at which they can renew themselves, and do not use non-renewables faster than renewable substitutes can be developed, such as making plastics from plants and fuel from corn. In a stable ecosystem, prey species are never completely eliminated, and food plants are allowed to grow back.

6. Balance abiotic and biotic components in design systems to preserve biodiversity

a. Integrate a designed system's inorganic mass with biomass and design for rehabilitation of degraded ecosystems.
b. Buildings should include complements of roof gardens, vegetation inside and outside that interface with a built system's inorganic constituents to form a whole. (Todd and Todd,110.)
c. Balance interdependent living and non-living components so that there is a continuum interacting as a whole. Human made systems need to mimic the integrated balance of abiotic parts (built components which are mainly inorganic) in ecosystems with biotic constituents.

7. Enact public laws and regulations, and international treaties to protect biodiversity.

4.2. Ecosystem: Spatial efficiency

4.2.1. Background

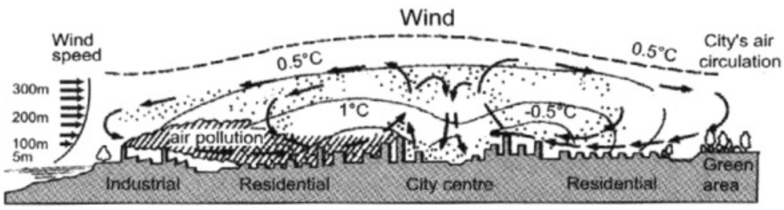
Natural ecosystems combine compact spatial efficiency with high structural diversity among species of plants, animals, and abiotic factors in order to maintain a healthy functioning ecosystem. The essential natural conditions are climate and resources. Just as closed loop ecosystems have no waste because at least one species uses waste products produced by other species, they also do not take up more space than they need to maintain their balance.

4.2.2. Findings: Anthropogenic impact on spatial efficiency

Before the Industrial Revolution, humans lived mainly in rural areas where they supported themselves through natural resources- farming, hunting, mining, herding, fishing. Although there were many large cities in the world before the Industrial Revolution, urban areas developed and grew very quickly as the base of the economy changed from agricultural to industrial. More people moved to urban areas as societies and urban culture grew, labor became more specialized, and cities became more complex in their functions and governance Today there are great concentrations of human beings occupying every part of the globe that is habitable.

l. A major anthropogenic impact on spatial efficiency has been urban sprawl. This has resulted in increased population density, paved surfaces, and heat island effects. Urban sprawl in the developed world has created unlimited outward extension, low density development, and leapfrog development that changes land use from farmland and natural areas and forests to commercial and residential development and extensive manmade infrastructure, widespread strip malls and big box shopping centers, decaying city centers, congestion, heat island effect, excess use of non-renewable energy sources, water run-off, and atmospheric warming (Cunningham, 345.)

2. Governmental bodies have added to the urban ecology by creating policies that have often favored and encouraged urban over rural areas as drivers of economic development (Cunningham, 339-342.)



Heat-island effect in cities

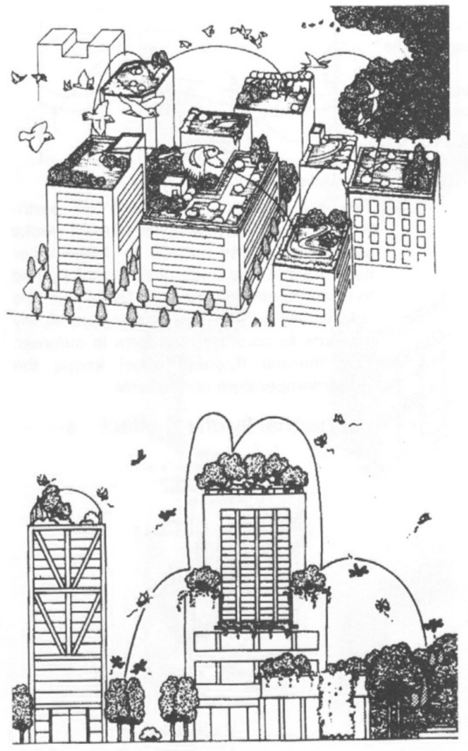
Figure 1. Heat island effect in cities (Yeang, and Woo, 117-118.)

4.2.3. Proposed ecomimetic designs that can emulate ecosystem spatial efficiency

1. Design and build compact structures and communities to maintain species diversity, ecological interactions among species (functional diversity) and to occupy space as efficiently as the plants and animals in the specific ecosystem.

2. Establish and further develop urban policies in the developed world that redesign cities so that they are spatially more efficient. (Cunningham, 347.)

3. Designer should research ecological history of site and establish an ecological baseline for planning design to protect and restore disturbed or degraded ecosystems



Roof gardens and sky courts create new urban habitats

Figure 2. Roof gardens and sky courts that create new urban habitats (Yeang and Woo, 215.)

4. Design to reduce heat island effect of the built environment on the ecology of the locality. Reducing and improving urban micro-climate impacts (Yeang, *Ecodesign Manual,* 161.) Roof gardens and sky courts create new urban habitats.

5. Plan and construct compact use of space in building and development, synthesis of nature and neighborhoods, compact development of multifunctions to decrease the time spent to conduct business and living. (Todd and Todd, 115-118.)

6. Design to achieve integration with the environment, such as vertical integration: designing for multilateral integration of the designed system with ecosystems.

7. Design for temporal integration: use of non-renewable and renewable resources at rates less than the natural rate at which they regenerate. Designer needs to know how an ecosystem is structured: interdependence, change, cycling of ecosystems, soil, and composition in order to minimize damage, or even enhance, ecological connectivity that can be beneficial. Can use indicator species to measure environmental conditions and changes within built ecosystem. (Noss, (2005), 355-364.)

8. Establish urban planning and public policy based on l) limited city size or cities organized in modules; 2) greenbelts in and around cities to promote more efficient land use; 3) determine in advance where developments will take place within ecological systems; 4) locate shopping and services within walking distances of homes; 5) encourage walking; 6) promote more diverse and flexible housing as an alternative to conventional detached houses; 7) encourage

city self-sustainability with locally grown food, waste and water recycling, 8) encourage cluster housing which preserves at least half of a site as natural areas; 9) encourage “smart growth” that makes use of in-fill development and mixed use of land. (Cunningham, 347)

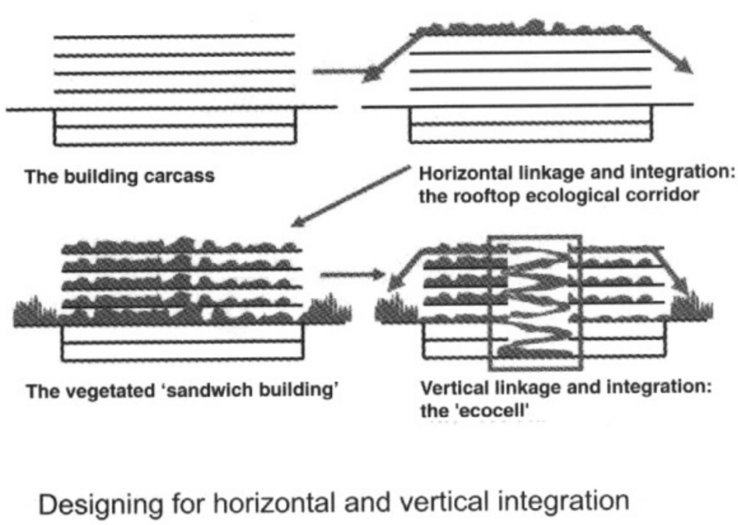


Figure 3. Horizontal and vertical integration (Yeang and Woo, 252.)

4.3. Ecosystem: Homeostasis

4.3.1. Background

Although it has not received as much public discussion as energy and biodiversity during the present attention to climate change, homeostasis, together with its subsets of cybernetics, succession, and continuity, is a component that accurately reflects the increasing vulnerability of ecosystems to maintain a natural balance.

Ecosystem homeostasis is the equilibrium state that results from environmental elements that must remain relatively stable. Among those are the biogeochemical cycles (carbon, oxygen, nitrogen, sulfur, and hydrology), soil, reabsorption, and reuse of materials and their effect on the composition of the ecosystem. These cycles are pathways through which chemical elements move through the biotic and abiotic compartments of Earth. The movement and storage of these chemicals allow living organisms to use them. Additions of new or foreign elements to an existing ecosystem change ecosystem dynamics. (Biology Dept., University of Illinois (2009); Biology Dept., University of Hamburg, (2003).) These changes affect the number of species, interactions among the species, and population size and can alter an ecosystem's ability to support the original interdependence among all the members of an ecosystem. In other words, the symbiotic balance of interconnection and interdependence among ecosystem components becomes disordered and unbalanced. When that happens, ecosystem succession results in a change in species composition and community structure because of the changes in the physical environment. (Drudy et al., (1973), 331-368.)

Disruption or degradation to the ecosystem throws the ecosystem out of balance. The disruption of ecosystems can be caused by natural disturbances such as fire, floods, and droughts among others.

Other factors that interrupt ecosystem homeostasis are anthropogenic activities that disrupt biogeochemical cycles, contribute to eutrophication of bodies of water, increase global warming, and deplete natural resources.

Changes in biotic and abiotic conditions lead to a cascade of effects which ecosystem components process and exchange through new information (cybernetics). The time it takes for a system's return to homeostatic balance depends entirely on the length and severity of the interruptions of the ecosystem. (Odum,(1969); Smith, 613, 619, 627.)

Sustained in large part by both internal and external factors that help to maintain populations within the carrying capacity of the environment, homeostatic equilibrium is established through the exchange of new information and interlocking feedback loops which can reduce entropy of ecosystem components. (Odum, (1969); Patten and Odum, (1981), 886-895.) For example, the biotic information network on the semiannual great migrations in Africa depends on grazing, population density, attack-avoidance, prey abundance, natural selection, overcrowding. Nutrient cycling can provide information (feedback) about overshoots and destructive oscillations. These conditions regulate the health and stability of an ecosystem community and determine its stability. (Volkov et al., 2006.)

Ecosystems have the ability to resist limited changes resulting from human activities The ability of ecosystems to recover from small changes minimizes and sometimes negates the impacts of human actions. In many instances, though, human activities can overwhelm the recuperative capacity of natural systems

4.3.2. Findings: Human impact on ecosystem homeostasis

An ecosystem's homeostasis is altered by anthropogenic activities that create disturbances, fragmentation, damage to the atmosphere, disruption of cycles and abiotic and biotic components.

The depletion or alteration of natural resources or polluting the soil and air ecosystems may change the structure of the species by eliminating certain species from that particular ecosystem and by changing the composition of biodiversity in it.

Pollution is created by the burning of fossil fuels, using toxic substances that can be either airborne or discharged into the soil, and discharging wastes into water bodies.

Biogeochemical cycles have been altered through the extensive use of pesticides and chemical fertilizers. The Green Revolution, which was designed to increase crop production in underdeveloped countries, unwittingly contributed to the negative effects of monoculture. In addition to new crop hybrids suited for various climates, heavy use of chemical fertilizers, herbicides, insecticides in both developed and underdeveloped countries has disrupted the soil's biogeochemical cycles and edaphic factors. Among the most serious changes have been: 1) increased susceptibility to diseases; 2) low tolerance to stresses of drought or temperature; 3) reduced resistance to insects; 4) famines resulting from crop failures; 5) decreased soil fertility and increased soil erosion; 6) increased habitat for pest species and reduced habitat for beneficial species. The same monoculture that disturbs homeostasis also has a negative impact on an ecosystem that leads to succession. (Gillis, 2009; North Carolina General Assembly.)

A 2016 study found that climate change is making it more difficult to grow staple crops in sub-Saharan Africa, with maize, beans, and bananas most at risk. Scientists with the CGIAR Research Program on Climate Change, Agriculture and Food Security indicated that 40% of the maize growing areas will need to be transformed with either new types of crops or abandonment of crop farming. The heat and drought conditions in this region of Africa make it necessary to replace the threatened crops with more heat tolerant crops within the next ten years. Adaptation to climate change has become urgent in high risk countries like Guinea, Zambia, Senegal, Burkina Faso, Niger, Ghana, Namibia, Botswana, Zimbabwe, and Tanzania. The current situation affects not only the food supplies for these countries but also their economic markets and social changes. (Rowling, 2016.)

In addition to agricultural runoff, sewage, paper and textile mills and food processing have stimulated oxygen consumption in water by decomposers, like aerobic bacteria and algae. As biochemical oxygen demand (BOD) in bodies of water increases through the oxygen consumed in the decomposition process, other aquatic organisms are robbed of the oxygen they need to live. The resulting eutrophication increases algal blooms and produces reduced water clarity, periods of hypoxia, loss of seagrass beds and coral reefs, and ecological changes in food webs.

By burning coal, oil, and natural gas, humans are adding carbon dioxide to the atmosphere much faster than the atmosphere can absorb it. Burning forests to create agricultural land also converts organic carbon to carbon dioxide gas. While oceans and land plants absorb part of the carbon dioxide, the rest is added to the atmosphere.

The sulfur, nitrogen, phosphorous, and oxygen, hydrologic, and carbon cycles have all added elements to croplands as fertilizers that have resulted in the elimination of indigenous vegetation, destruction of wetlands, eutrophication, soil erosion, and alteration of water quality. (Carnegie Mellon; Environmental Literary Council; Houghton; International Fertilizer Industry Association; H T Odum.)

Overuse or depletion of natural resources like overgrazing and pasture degradation, overfishing and replacement of commercially valuable fish by trash fish, and forest depletion through overharvesting or through fires have contributed to instability to ecosystem homeostasis.

Many human designed methods to integrate manmade ecosystems with natural processes of succession have been harmful to natural ecosystems. In dealing with rural and urban ecosystems, for example, human designers have ignored the natural process of ecological succession, preferring their own intensive inputs- built structures and infrastructures, intense use of artificial fertilizer- to maintain farmlands and cities and to develop urban sprawl haphazardly. These practices, in essence, are examples of human environmental succession in industrialized countries.

Conversely, in economically underdeveloped countries with long standing traditional societies, there remain many centuries' old practices that take advantage of ecological succession in ways that allow them to use fewer inputs.

4.3.3. Proposed ecomimetic designs to maintain or restabilize homeostasis

In order to maintain and ensure that the ecosystem factors needed for homeostasis are healthy and balanced, designs for the manmade ecosystem must include space efficiency and continuity, well functioning cybernetics, connectivity, and biogeochemical balances in soil and water. The following design recommendations are extensive because of the breadth and depth of elements needed to maintain and repair the balance of homeostasis.

1. Designs that maintain the balance of abiotic and biotic components in an ecosystem buildings through incorporated greenwall systems are good examples.

2. Ensure that energy source is renewable and materials can be reused when designing the built environment.

3. Design for efficient use of materials by l) designing to minimize amount of material used, resource depletion, and waste; 2) designing for adaptive use of buildings; 3) designing for disassembly–recycle, reintegrate, reuse, conserve non-renewable materials, and use renewable materials; 4) Using materials with a low ecological impact. This includes low toxic materials, non-chemical materials, natural biodegradable alternatives, such as plastics from corn.

4. Design roads and other built structures to minimize disruption of soil and biogeochemical cycles. Pollution absorbing concrete and porous paving for parking lots are examples.

5. Assess the overall design (product, structure, infrastructure) for the level of environmental integration over its life cycle.

6. Since ecosystems use energy efficiently, manmade ecosystem designs should also include efficient operations of a building's environmental system through their robotic and automated building systems based on current technology.

7. Utilize deep plan, double envelope, double layered façade, ecocell, green roof, light pipes, and light shelf designs for new structures.

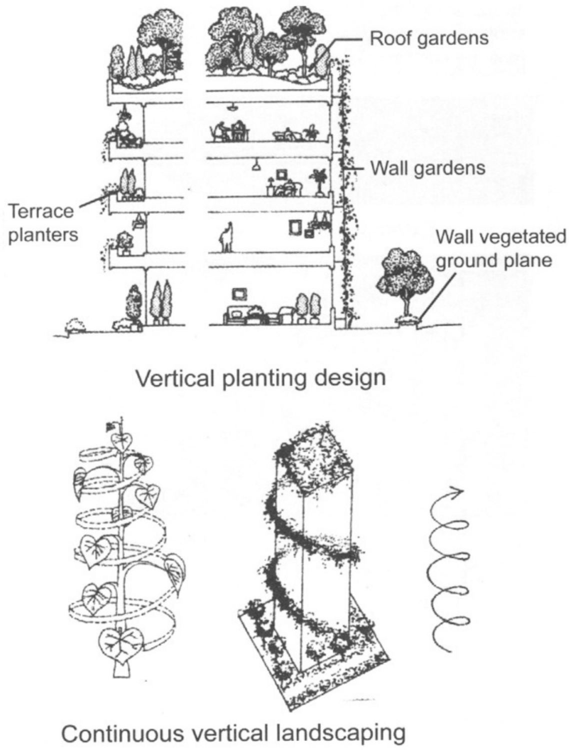


Figure 4. Illustration of green wall systems. (Yeang and Woo, 39.)

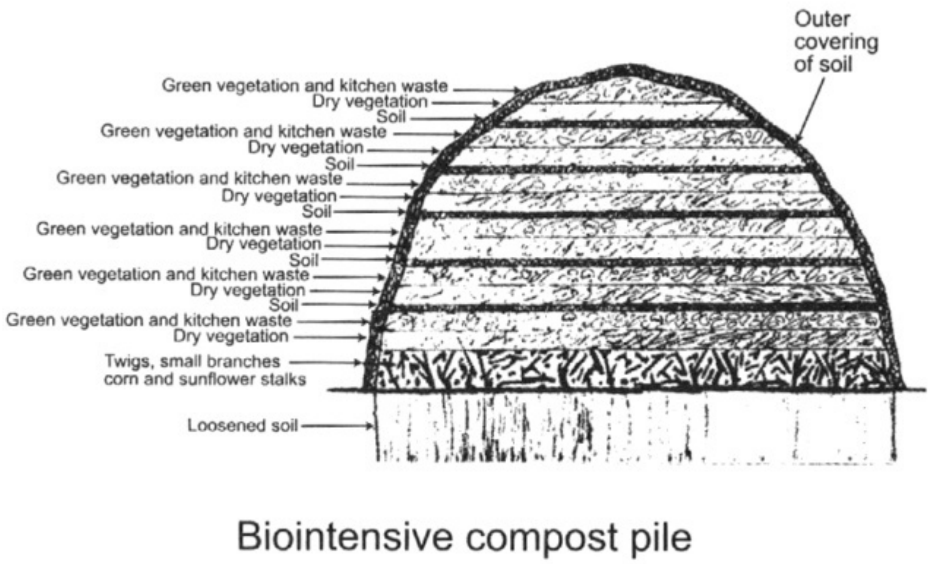


Figure 5. Biointensive compost pile (Yeang & Woo,59.)

8. Design urban areas to reduce the use of ecosystem and biospheric services, such as bioclimatic urban type structures that consider climatic conditions.

9. Design sustainable urban renewal projects for cities that have become polluted through industry and whose natural resources have been damaged.

10. Ecomasterplan with a blue infrastructure -a sustainable drainage system to manage surface water run-offs so that it stays on site; water management and conservation within the built environment. (Yeang, Ecomasterplanning, 24ff.)

11. Create local, regional, state, and national planning policies that regulate development and manage lands on the basis of the ecosystem concept. Ecosystem management would include the integration of ecological, economic, and social principles to manage biological and physical systems that protect long term ecological sustainability, natural diversity, biogeochemical cycles, and the productivity of the land. This approach would recognize that there is no dichotomy between humanity and the environment. (Barker, 1996.)

12. Creation of public policy that addresses the landscape as a whole; recognizes whole farm or whole watershed as one ecological unit. This kind of policy would create soil conservation regulations for not only agricultural land but also urban-rural landscapes. The same is true of watershed protection.

a. Strengthen existing regulations and laws, such as required environmental impact statements that precede project approval; clean air and water laws; pesticide control laws; toxic substances control acts; conservation, forest, coastal, and endangered species laws among others.

b. New public regulations to correct current imbalances that are detrimental to ecosystem functions, such as gas-exchange, water-purification, nutrient-cycling.

13. Enact take back laws in countries that are not currently have them.

14. Ecosystems treat waste by absorbing detritus constructively back into nature. Ecosystems demonstrate that as biomass increases, more recycling loops and complex interactions are needed to prevent it from collapsing. Design human built environments to contain more recycling loops and interactions. An ecosystem becomes more self-contained as it matures. It circulates what it needs within the system without losing any matter to the outside environment. Using this principle, ecomimesis designs the built environment so that materials are continuously reused and recycled and are more connected to the evolutionary process of life rather than making isolated, disconnected, inanimate objects of consumer natural materials.

15. Design for wastewater and sewage treatment and recycling systems so that waste is treated at its source. This can be done by controlling and integrating human waste and other emissions, capturing storm runoffs, reusing municipal wastewater for irrigation.

16. Design and construction of bioswales, filtration strips, retentions ponds, sustainable drainage (SUDS), lagoons. Rainfall and surface water runoff into bodies of water and the sea can be eliminated.

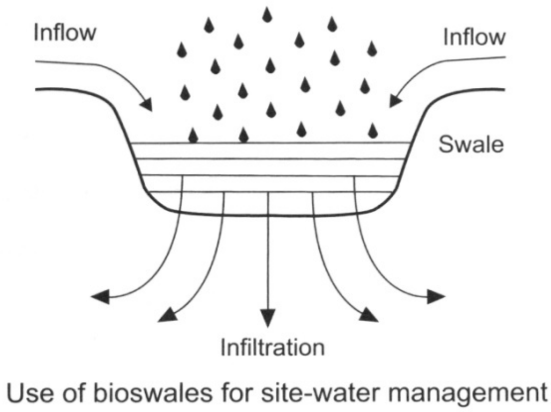


Figure 6. (Yeang and Woo, 37.)

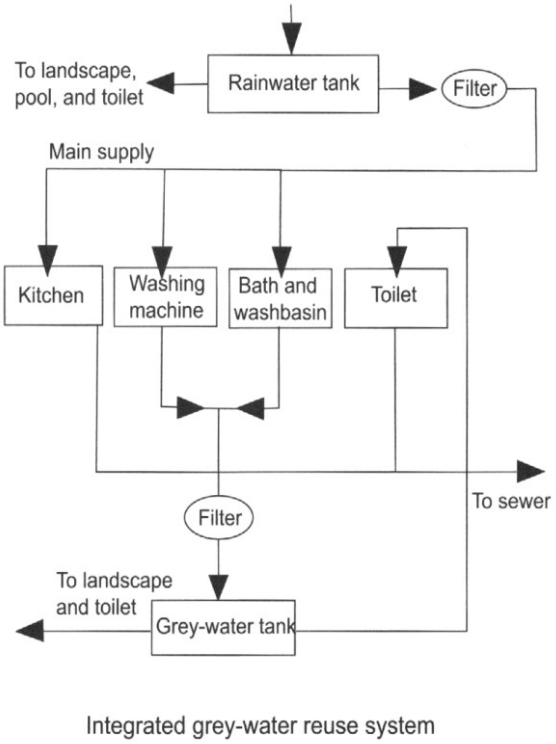


Figure 7. Integrated gray water reuse system (Yeang and Woo, 113.)

17. Construct water holding areas and treatment to return water to it source, decrease runoff, and pollution of bodies of water.

18. Design for water conservation, recycling harvesting, such as rainwater, to conserve water.

19. Design for wastewater and sewage treatment and recycling systems.

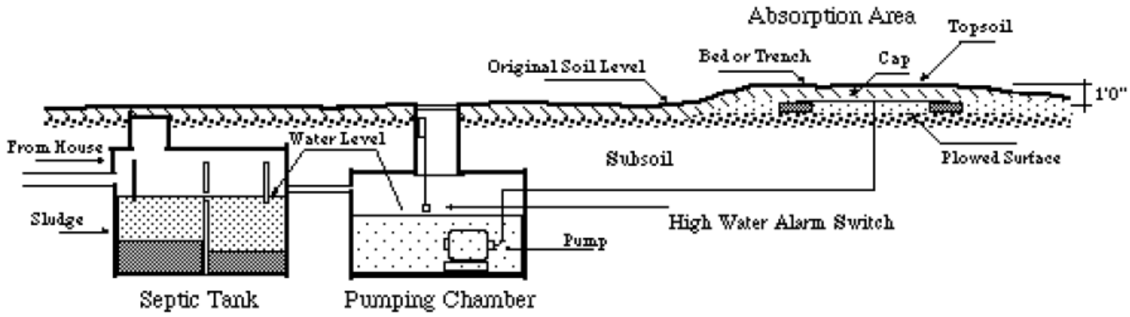


Figure 8. Illustration shallow trench section view (Yeang & Woo, 213.)

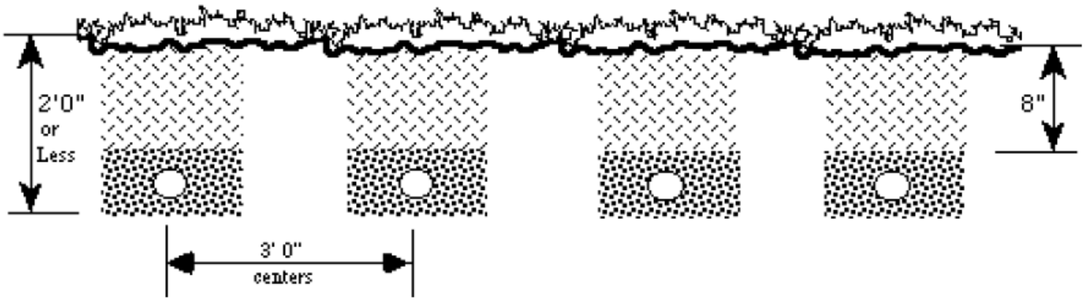


Figure 9.

20. Design wetlands for wastewater treatment, irrigation leach fields, aerobic wastewater treatment (Todd et al. (1996).)

21.Design shallow mound or shallow trench gray water systems

22. Design and use living machines to treat waste ecomimetically. Living machines are living organisms of all types that are housed in a casing or structure made up of lightweight materials. Living machines can be designed to produce food or fuels, treat wastes, purify air, regulate climates of perform a combination of these tasks at the same time. (Tood and tood, 167-176).

23. Utilize solid and hazardous waste treatment-injection wells, integrated waste management, gasification, evapotranspiration.

24. Design environmental restoration of devastated land by using the processes of natural succession. This requires an understanding of the specific ecosystem and the sequence of rehabilitation beginning with primary succession's most resilient organisms that can grow under adverse conditions, the gradual development of food chains that evolve from short simple ones into more complex chains, and recycling of wastes and nutrients This understanding will also improve the economic efficiency of those efforts.

25. Use non-chemical, natural alternatives to chemical pesticides. This would include natural predators and development of new plants that resist pests.

26. Restore and maintain the biogeochemical cycles:

a. Stabilize oxygen cycle by decreasing runoff from agriculture, sewage, paper and textile mills, food processing that increase carbondioxide and ozone at the ground level.
b. Stabilize nitrogen cycle and decrease eutrophication by decreasing use of chemical fertilizers and emissions of greenhouse gases.
c. Stabilize phosphorous cycle and decrease algal blooms and eutrophication by decreasing the use of detergents with a high phosphorous content.
d. Stabilize sulfur cycle by decreasing the use of fossil fuels.
e. Stabilize hydrologic cycle by designing systems that ensure that water remains in the ecosystem of its origin, maintain wetlands, prevent flooding, prevent soil erosion.

27. Design for management of outputs from the built environment and their integration with the natural environment to minimize pollution and maximize biointegration. In an ecosystem, there are no such things as pollutants because the toxins are not stored or transported in bulk. At the systems level they are synthesized and used as needed only by individual species. Toxins are dealt with by organisms in soils with the ecosystems where they are broken down.

28. Design alternatives to traditional farming to stabilize, rehabilitate,and decrease pressures on the soil. Some examples are alley cropping, hydroponic agriculture, aquaponic agriculture, permaculture, building integrated food production.

29. Design for food production and independence. Design to promote urban agriculture and permaculture.

30. Design urban agriculture (Todd and Todd, 118-127.) Design to minimize waste based on the recycling properties of the ecosystem. This would include warehouse farms for cities and suburbs, rooftop gardens, street orchards, bus stop aquaculture.

31. Design ecofarms –diverse interacting components derived from horticulture, orchardry, livestock husbandry, aquaculture, bioshelters, and field crops. (Todd, and Todd, 145-151.) This includes bio-intensive soil management and intensive planting techniques.

32. Ecosystems treat waste by absorbing detritus constructively back into nature. Ecosystems demonstrate that as biomass increases, more recycling loops and complex interactions are needed to prevent it from collapsing. Design human built environment to contain more recycling loops and interactions. An ecosystem becomes more self-contained as it matures. It circulates what it needs within the system without losing any matter to the outside environment. Using this principle, ecomimesis designs the built environment so that materials are continuously reused and recycled and is more connected to the evolutionary process of life rather than making isolated, disconnected, inanimate objects of consumer natural materials.

33. Design for continuity by reducing ecosystem and biospheric services and impacts on the global environment (systemic integration)

This extensive list of ecomimetic designs and activities represent basic starting points for designs that can be done to stabilize homeostasis of ecosystems.

5. Conclusion

This article has focused on the inseparable relationships between the various components of an ecosystem and how human actions have damaged and altered the natural balance of ecosystems. Anthropogenic activities have modified ecosystems not only through industrialization and economic development but also through population growth. As a result, there has been deforestation, desertification, contamination of bodies of water, altered soil fertility, and pollution and global warming from the use of fossil fuels.

The findings cited in this article clearly show that human activities have had seriously negative effects on specific components of an ecosystem: biodiversity, spatial efficiency, and homoeostasis and its subsets of cybernetics succession, and continuity. The findings underscore the combined impact of human activities on ecosystems and their future ability to support an ever growing population without a dramatic change in the way that we design and use our manmade ecosystem.

The discussion of the various aspects of an ecosystem, the effects of anthropogenic activities, and proposed solutions through ecomimesis lead to a simple conclusion: Ecomimetic design can slow the rate at which humans are altering nature for their own purposes. Ecomimesis can also help stem the despoilation of ecosystems and assist in repairing them by adopting natural circular processes rather than linear ones in creating anthropogenic structures and communities.

The notion of ecomimesis and its inclusion of the entire ecosystem and the impact human activities have on the natural ecosystem represents an innovative design paradigm that utilizes both new scientific solutions and respect for the stability of the natural ecosystem. Rather than resolving problems of individual segments of the ecosystem, ecomimesis is a more holistic design approach for the built environment that demonstrates the feasibility of restoring the natural balance in the environment while also meeting the ever expanding needs of society and economy around the world.

Just the Industrial Revolution was made possible and flourished with advances in technology, present day scientific and technological developments can work toward minimizing the climate change and rehabilitating nature that have been harmed by the centuries of industrial development, lack of conservation of resources, and population growth. Creative ecomimetic solutions. such as artificial photosynthesis, non-toxic batteries, and Solar Sewage Walls and living machines to treat waste, are being continually developed and refined by researchers, scientists, and inventors worldwide. Ecomimesis as a sustainable design strategy can be an integral part and major contributor to stabilizing and rehabilitating our natural world at the same time that it addresses the needs of growing economies and populations around the world.

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Received: 11 July 2013 • **Revised**: 6 April 2016 • **Accepted**: 11 April 2016