ANYBODY THERE? -- HELLO,HELLO --
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(ARCHITECTS, ECOLOGICAL FOOTPRINTS, AND RESPONSIBILITY)

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Human activity has encroached upon every realm of nature. Consequently, nature is no longer completely natural. The natural world is now under the domain of human planning and management policies. Even policies that direct minimal or no human intervention require management decisions. Given the role of stewards of nature, it would behoove us to understand its life-support processes and how they affect human health and well-being. To sustain ourselves, we must constantly maintain the conditions and processes of the natural world while simultaneously deriving from it our means of sustenance. That is what sustainability means.

The built environment in which almost all humans reside occupies only a small portion of the world's land area. However, in response to an increasing world population and increasing per capita demands for a better quality of life, the industries that provide the materials and products that constitute the built environment have had a far-reaching impact upon the natural world. The result is visible in our air, in our water, and on our land - a condition of global ecological stress.

The first task is to be aware of the magnitude of the problem. The impacts of human activity in the industrial age have recently (in geological time) increased in scale spatially and temporally, reaching far beyond a settlement or region and affecting the well-being of future generations and all other living things. This has never happened before at such a scale. Perhaps there are specific principles that can guide the design of the built environment while accommodating *both* natural life-support processes and human needs. To propose such a set of principles is one of the objectives of this article.

As designers of the built environment, architects, engineers, and planners bear a particular responsibility. The artifacts and land use patterns they design have enormous and heretofore undocumented and ignored impacts. Although the impact of building design and construction is significant (as we will discuss below), the Earth's current ecological condition is not, of course, entirely due to the actions of this group of individuals. The lifestyle of every citizen in the developed world has a major impact and the values that this late-20th-century lifestyle has engendered are driving us in the direction of major ecological degradation - soon. Consequently, we are fast approaching a situation where humankind's economic "progress" is straining the carrying capacity of the Earth's productive ecosystems. Humankind's total ecological footprint is fast outgrowing all productive land on Earth.

WHAT IS A PER CAPITA ECOLOGICAL FOOTPRINT?

A per capita ecological footprint is the amount of productive land required to support indefinitely one person at a particular level of resource consumption and waste assimilation. In an age of global markets, the productive land usually extends well beyond the boundaries of one's town, city, or region. The ecological footprint of humans and human settlements no longer directly coincides with their geographic location, but is dispersed worldwide.

Ecological footprint size varies with lifestyle (i.e., a person's level of consumption). A typical American single person, for example, needs more than 10 acres of productive land somewhere on Earth to support just the domestic needs of him or herself.[1] At present, the global average is less than 4 acres of productive land per person. Thus, for every person alive today to live the lifestyle of an average American would require at least 2 1/2 Earths not including the needs of all other living species.

To live the "American Dream" requires an even larger ecological footprint. For example, a "professional couple" living a lifestyle similar to most of us writing and reading this article requires almost 30 acres per person.[2] This is typical of a household that includes two cars, an average number of airplane flights per person per year, and two heads of household working (i.e., both professionals). After a little arithmatic, one realizes very quickly that the productive land in the U.S. can support only about 76 million individuals like us. That is approximately 30% our total present population.

WHAT IS THE UPSTREAM ECOLOGICAL IMPACT OF THE BUILDING INDUSTRY?

To date, efforts to minimize the ecological impact of the built environment have focused on the use phase (operation and maintenance) of buildings (e.g., energy efficiencient lighting). However, the use phase represents only one chapter in the building life-cycle story. The procurement of design services and building materials and products causes enormous off-site ecological impacts prior to the building's use. These impacts occur upstream during the source (mining), transport, process (manufacturing), and distribution life cycle stages of building materials and products.

To give just one example, consider the building industry's share of total upstream greenhouse gas (CO_2) emissions for all sectors of the U.S. economy.[3]

> a) It is the largest sector accounting for roughly 20% of total annual industrial emissions and 7% of the U.S. annual total.
> b) Upstream CO_2 emissions are 5 times direct emissions (for construction of the building) and 10-20 times greater than the annual operation (use) of the building.
> c) Within the building industry, the largest single material or product contributing to CO_2 emissions is portland cement-based ready-mix concrete (9%).

The impact during the upstream phases is not limited to atmospheric emissions. For example, water demands and water quality during the upstream life cycle stages are also critical. The building industry's role in U.S. water use is approximately 20% of the U.S. total volume.[4] This figure includes the water necessary for the manufacturing of all the products that go into buildings.

Looking at figures like these, it is evident that the practices of the building design and construction professions play a significant role in creating a range of global ecological problems. As a profession, architecture can point to a number of reasons for its lack of leadership in the realm of sustainable design: we do not have a substantial research arm to our profession, we are not taught anything about ecological issues in our schools, and, even if research is done, we do not have a procedure to incorporate its findings into educational programs or professional practice. These are plausible explanations. However, with a crisis approaching and the likelihood of sustainable practices being imposed through legislation and regulation, now is the time for architects and planners to become leaders rather than followers in developing new approaches to the design of the built environment.

DESIGN AS COMMUNICATION

Architects are communicators, trained to translate the sometimes abstract needs and desires of a client into physical space, to absorb information and transform it into the built environment. Architects need to expand upon that role to increase the client and user's sphere of experience to include the ecological impact of the entire life cycle of a building.

The power of humans to think beyond what child psycologists calls "object permanence" - the idea that something exists not only when we see but when it is hidden as well - is in some ways central to our ecological dilemma. In an overly complex world where we are overwhelmed with more information than we can process, an "out-of-sight, out-of-mind" outlook has created a condition of irresponsibility concerning the key processes that need to be understood. Comprehending the life cycle of resource flows of the built environment may bring human activity into closer harmony with nature's life-support processes. Expressing abstract information about ecological concerns in ways that clients and users a can understand, even participater and intertact with, is an important step toward enabling us to be stewards rather than plunderers of the natural world. This could be our most important professional role. How do we do this?

We have formulated a number of design tools that allow professionals to visualize the ecological impact of their design decisions, and in turn, to communicate that information to their clients and users. Some of these tools are finding a place in land-use planning and the design of several significant buildings. The techniques fall into four categories: upstream footprinting of environmental impacts; designing the building as an information feedback system; designing open building systems that are long lasting due to their ability to change function; and establishing a set of shared principles early on in a project that define sustainablity goals.

UPSTREAM FOOTPRINTING

Upstream footprinting is a process whereby specification decisions are linked directly to a hierarchy of environmental impacts according to CSI code. Then, using geographic information systems (GIS), those impacts are displayed county by county accross the U.S. This procedure is being used for the EpiCenter, a demonstration campus building at Montana State University in Bozeman, Montana, that is funded partially by the Natiuonal Institute of Standards and Testing and the State of Montana. The process enables the designer to see not only a detailed explanation of the environmental impact of materials and products used within a structure but shows where in the U.S. that impact occurred and how many times. The software literally links a specification decision to a spatial display of the ecological consequences of that decision across the country. Thirty nine basic building types are covered, such as residential, commercial, office, academic, and medical buildings. It is quite disturbing to realize that the manner in which we build single family residential buildings, for example, presently contributes to 23 air quality non-attainment zones. At the moment re-specification in order to alleviate impacts requires a secondary set of software.

INFORMATION SYSTEMS

Designing a building to perform as an information system is based on the supposition that if people are informed about the quantity of resources they are using, then they will alter their use patterns. The Nursing and Biomedical Science Building at the University of Texas Health Science Center in Houston, currently in the pre-design stages, is being designed with monitoring and feedback devices so that both individual and group resource consumption is understood during the use phase of the building. Several methods of design communication are being investigated including personalized and group monitoring of heating, cooling, and lighting energy costs, water consumption, solid waste recycling, and construction waste material re-use.

The limits of a resource's availability are determined by spatial boundaries increasing in scale from the office, to the floor, to the entire bulding, the site, the Houston metropolitan region, and finally the entire U.S. The objective is to balancee resource use within the smallest possible boundary. For example, all non-potable water use is limited by what the building roof rainwater catchment surfaces and storage tanks can provide. It was realized early on in the project that in order to come close to a zero impact, or resource-balanced, building that there needs to be a high reliance on the user's motivation and ability to vastly reduce resource consumption and not depend on technology alone to do the job.

OPEN BUILDING SYSTEMS

Open building systems are structures designed in such a manner that they can change function. The building itself becomes an armature so that users can modify and personalize space. Many studies have documented the improvements in productivity that occur when building users are given some degree of personalized control of the spaces they occupy.[5] Occupant control of such systems as HVAC and lighting has now been proven to actually save energy as compared to large zone systems. A raised floor in an office building is an example of an open building system component. However, building design in general has not incorporated many of these techniques nor has it considered disassembly methods such as those now common in office furnishing systems. Often, change and repair of buildings to accomodate newer and more efficient and responsive technologies has not been possible because many buildings cannot adapt to either spatial or utility system modifications and upgrades.

Housing, in particular, is notorous for its waste resulting from remodeling of structures that are difficult to re-arrange spatially. In response to this problem, we are designing an open system housing prototype for the Building America program of the U.S. Department of Energy. It is very similar to our office which is a state-funded demonstration "green building." The protoype house is part industrialized - a recycled content steel, post and beam armature, and part regional - non-bearing infill materials such as strawboard. The attachment potential to the armature-type structure also allows retrofitting of a wide range of support technologies such water harvesting systems and solar and waste treatment technologies at the home scale.

SHARED GUIDELINES

Central to the idea of design as communication is a shared vision of what ought to be. Establishing a set of guidelines at the beginning of the architecture and engineering process is required for any major gains to be made in sustainable building design. As developed for the UT Houston project, these guidelines range from design strategies to economic procedures to basic laws of system dynamics. These principles are summarized on page **. There will probably be many questions as to what exactly some of them mean. We look at this list as an ongoing endeavor and would appreciate any feedback, suggestions, or improvements.

We conclude this article by emphasizing that design has a crucial role to play in communicating the vital functions and relationships of the built environment and connecting them to the natural world. In fact, it could well be that our most important role in the design of buildings is to make compatible the needs of the users - which are always changing - and the functions of the environment - which are always being encroached upon. In a sense, our task is to make the invisible visible, or to manifest those things which, in the past, we paid little attention to. Such a vision about the purpose of our profession may make good architectural design more commonplace and give it a pivotal role in shaping our global future.

Psychologists tell us that the increase in human's conceptual space - our understanding of the world - has gone through several revolutions.[6] The time will come, they tell us, when each individual will truly understand the basic conditions and processes that determine our long term survival, whereupon a world union or a global compassionate society could occur. This might happen when the world's population reaches 9-10 billion people. Many ecologists have predicted that global ecological collapse could occur at a population of around 12 billion people. It seems as though our role is clear. Architects have the ability to promote - through design – the conceptual evolution of humans; to increase our understanding of the world around us so that we reach global understanding before we reach global collapse.

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