Architecture, Ecological Design, and Human Ecology

DAVID ORR, PH.D.
Oberlin College

"We shape our buildings, thereafter they shape us."
—Winston Churchill

From the 35th floor of a downtown office tower that dominates the new Atlanta skyline, one can see two problems that all architects of high rise buildings face. The question is how to bring the thing to an end gracefully before gravity and money do so. Some architects just quit, hence the flat roof. But most embellish the finale in various ways with one kind of flourish or another, each somewhat more outlandish than the one built the year before. The result, what some call "an interesting skyline," is a kind of fever chart of the collected psyches of architects and their clients that shape the modern megalopolis. The results, however, are more than just show. These are the buildings that contribute greatly to traffic congestion, poverty, climatic change, pollution, biotic impoverishment, and land degradation. If less visually dramatic, the same could be said of the designers of the modern suburb and shopping mall. In both cases the problem is that the art and science of architecture and related applied disciplines has been whittled down by narrow gauge thinking.

The importance of regarding architecture in a larger context lies in the big numbers of our time. We have good reason to believe that humankind will build more buildings in the next fifty years than in the past five thousand. Done by prevailing design standards, we will cast a long shadow on the prospects of all subsequent generations. No longer can we substitute cheap fossil energy for design intelligence or good judgement. The implications for the education of architects and the design professions generally are striking. Let me propose three.

First, the esthetic standards for design will have to be broadened to embrace wider impacts. Designers ought to aim to cause no ugliness, human or ecological, somewhere else or at some later time. For education, this means that the architectural curriculum must include ethics, ecology, and tools having to do with whole systems analysis, and least-cost, end-use considerations. Further, educational standards need to include a more sophisticated and ecologically grounded understanding of place and culture.

Second, it should be recognized that architecture and design are fundamentally pedagogical. Churchill had it right: we are shaped by our buildings and landscapes in powerful but subtle ways. The education of all design professions ought to begin in the recognition that architecture and landscapes are a kind of crystallized pedagogy that informs well or badly, but never fails to inform. Design inevitably instructs us about our relationships to nature and people that makes us more or less mindful and more or less ecologically competent. The ultimate object of design is not artifacts, buildings, or landscapes, but human minds.

Third, architecture and design ought to be seen in their largest context that has to do with health. At the most obvious level 'sick buildings' reflect not simply bad design but a truncated concept of design. A larger design perspective would place architecture and landscape architecture as subfields of the art and science of health with more than passing affinity for healing and the holy.

Architecture is commonly taught and practiced as if it were only the art and science of designing buildings, which is to say merely as a technical subject at the mercy of the whims of clients. I would like to offer a contrary view that architecture ought to be placed into a larger context as a subfield of ecological design. The essay that follows might best be considered as a series of notes on the boundaries of this larger field of design. Earlier forays into this area by van der Ryn and Cowan (1996) laid the groundwork for a more expansive view of the design professions. I intend to build on that foundation to connect design professions, and the education of designers to the larger issues of human ecology.

THE PROBLEM OF HUMAN ECOLOGY

Whatever their particular causes,[1] environmental problems all share one fundamental trait: with rare exceptions they are unintended, unforeseen, and sometimes ironic, side effects of actions arising from other intentions. We intend one thing and sooner or later get something very different. We intended merely to be prosperous and healthy but have inadvertently triggered a mass extinction of other species, spread pollution throughout the world, and triggered climatic change—all of which undermines our prosperity and health. Environmental problems, then, are mostly the result of a miscalibration between human intentions and ecologi-

cal results, which is to say that they are a species of design failure.

The possibility that ecological problems are design failures is perhaps bad news because it may signal inherent flaws in our perceptual and mental abilities. On the other hand, it may be good news. If our problems are, to a great extent, the result of design failures the obvious solution is better design, by which I mean a closer fit between human intentions and the ecological systems where the results of our intentions are ultimately played out.

The perennial problem of human ecology is how different cultures provision themselves with food, shelter, energy, and the means of livelihood by extracting energy and materials from their surroundings (Smil, 1994). Ecological design describes the ensemble of technologies and strategies by which societies use the natural world to construct culture and meet their needs. Since the natural world is continually modified by human actions, culture and ecology are shifting parts of an equation that can never be solved. Nor can there be one correct design strategy. Hunter-gatherers lived on current solar income. Feudal barons extracted wealth from sunlight by exploiting serfs who farmed the land. We provision ourselves by mining ancient sunlight stored as fossil fuels. The choice is not whether human societies have a design strategy or not, but whether it works ecologically or not and can be sustained within the regenerative capacity of the ecosystem. The problem of ecological design has become more difficult as the human population has grown and technology has multiplied. It is now the overriding problem of our time affecting virtually all other issues on the human agenda. How and how intelligently we weave the human presence into the natural world will reduce or intensify other problems having to do with ethnic conflicts, economics, hunger, political stability, health, and human happiness.

At the most basic level, humans need 2200 to 3000 Calories per day, depending on body size and activity level. Early hunter-gatherers used little more energy than they required for food. The invention of agriculture increased the efficiency with which we captured sunlight permitting the growth of cities (Smil, 1991, 1994). Despite their differences, both showed little ecological foresight. Hunter-gatherers drove many species to extinction and early farmers left behind a legacy of deforestation, soil erosion, and land degradation. In other words, we have always modified our environments to one degree or another, but the level of ecological damage has increased with the level of civilization and with the scale and kind of technology.

The average citizen of the United States now uses some 186,000 Calories of energy each day, most of it derived from oil and coal (McKibben, 1998). Our food and materials come to us via a system that spans the world and whose consequences are mostly concealed from us. The average food molecule is said to have traveled over 1300 miles from where it was grown or produced to where it is eaten (Meadows, 1998). In such a system, there is no way we can know the human or ecological consequences of eating. Nor can we know the full cost of virtually anything that we purchase or discard. We do know, however, that the level of environmental destruction has risen with the volume of stuff consumed and with the distance it is transported. By one count we waste more than one million pounds of materials per person per year. For every 100 pounds of product, we create 3200 pounds of waste. (Hawken, 1997, 44) Measured as an "ecological footprint" i.e., the land required to grow our food, process our organic wastes, sequester our carbon dioxide, and provide our material needs, the average North American, by one estimate, requires some 5 hectares of arable land per person per year (Wackernagel and Rees, 1996). But at the current population level the world has only 1.3 hectares of useable land per person. Extending our lifestyle to everyone, would require the equivalent of two additional Earths!

Looking ahead, we face an imminent collision between a growing population with rising material expectations and ecological capacity. At some time in the next century, given present trends, the human population will reach or exceed 10 billion, perhaps as many as 15-20 percent of the species on earth will have disappeared forever, and the effects of climatic change will have become manifest. This much and more is virtually certain. The immediate problem is simply that of feeding, housing, clothing, and educating another 4-6 billion people and providing employment for an additional 2 to 4 billion without wrecking the planet in the process. Given our inability to meet basic needs of one-third of the present population there are good reasons to doubt that we will be able to do better with the far larger population now in prospect.

THE DEFAULT SETTING

The regnant faith, however, holds that science and technology will find a way to do so without our having to make significant changes in our philosophies, politics, economics, or in the directions of the growth oriented society. Rockefeller University professor, Jessie Ausubel, for example, asserts that:

> *after a very long preparation, our science and technology are ready also to reconcile our economy and the environment . . . In fact, long before environmental policy became conscious of itself, the system had set decarbonization in motion. A highly efficient hydrogen economy, landless agriculture, industrial ecosystems in which waste virtually disappears: over the coming century these can enable large, prosperous human populations to co-exist with the whales and the lions and the eagles and all that underlie them (Ausubel, 15).*

We have, Ausubel states, "liberated ourselves from the environment." This view is similar to that of futurist, Herman Kahn several decades ago when he asserted that by the year 2200 "humans would everywhere be rich, numerous, and in control of the forces of nature" (Kahn and Martel, 1976). In its more recent version, those believing that we have liberated ourselves from the environment cite advances in energy use, materials science, genetic engineering, and artificial intelligence that will enable us to do much more with far less and eventually transcend ecological limits altogether. Humanity will then take control of its own fate, or more

accurately, as C. S. Lewis once observed, some few humans will do so, purportedly acting on behalf of all humanity (1970, 67-91).

Ausubel's optimism coincides with the widely held view that we ought to simply take over the task of managing the planet (*Scientific American*, 1989). In fact the technological and scientific capability is widely believed to be emerging in the technologies of remote sensing, geographic information systems, computers, the science of ecology (in its managerial version), and systems engineering. The problems of managing the Earth, however, are legion. For one thing the word 'management' does not quite capture what the essence of the thing being proposed. We can manage, say, a 747 because we made it. Presumably, we know what it can and cannot do even though they sometimes crash for reasons that elude us. Our knowledge of the Earth is in no way comparable. We did not make it, we have no blueprint of it, and will never know fully how it works. Second, the target of management is not quite what it appears to be since a good bit of what passes for managing the Earth is in fact managing human behavior. Third, under the guise of objective neutrality and under the pretext of emergency, management of the Earth is ultimately an extension of the effort to dominate people through the domination of nature. And can we trust those presuming to manage to do so with fairness, wisdom, foresight, and humility and for how long?

Another, and more modest, possibility is to restrict our access to nature rather like a fussy mother in bygone days keeping unruly children out of the formal parlor. To this end Professor Martin Lewis proposes what he calls a "Promethean environmentalism" that aims to protect nature by keeping us away from as much of it as possible (Lewis, 1992). His purpose is to substitute advanced technology for nature. This requires the development of far more advanced technologies, more unfettered capitalism, and probably some kind of high-tech virtual simulation to meet whatever residual needs for nature that we might retain in this Brave New World. Professor Lewis dismisses the possibility that we could become stewards, ecologically competent, or even just a bit more humble. Accordingly, he disparages those whom he labels "eco-radicals" including Aldo Leopold, Herman Daly, and E. F. Schumacher who question the role of capitalism in environmental destruction, raise issues about appropriate scale, and disagree with the directions of technological evolution. Lewis' proposal to protect nature by removing humankind from it, however, raises other questions. Will people cut off from nature be sane? Will people who no longer believe that they need nature be willing, nonetheless, to protect it? If so, will people no longer in contact with nature know how to do so? And was it not our efforts to cut ourselves off from nature that got us into trouble in the first place? On such matters Professor Lewis is silent.

Despite the pervasive optimism about our technological possibilities, there is a venerable tradition of unease about the consequences of unconstrained technological development from Mary Shelley's *Frankenstein* to Lewis Mumford's critique of the "megamachine." But the technological juggernaut that has brought us to our present situation, nonetheless, remains on track. We have now arrived, in Edward O. Wilson's view, at a choice between two very different paths of human evolution. One choice would aim to preserve "the physical and biotic environment that cradled the human species" along with those traits that make us distinctively human. The other path, based on the belief that we are now exempt from the "iron laws of ecology that bind other species," would take us in radically different directions, as "*Homo proteus* or 'shapechanger man'" (Wilson, 1998; 278). But how much of the earth can we safely alter? How much of our own genetic inheritance should we manipulate before we are no longer recognizably human? This second path, in Wilson's view, would "render everything fragile" (298). And, in time, fragile things break apart.

The sociologist and theologian, Jacques Ellul, is even more pessimistic. "Our machines," he writes, "have truly replaced us." We have no philosophy of technology, in his view, because "philosophy implies limits and definitions and defined areas that technique will not allow." (1990: 216) Consequently, we seldom ask where all of this is going, or why, or who really benefits. The "unicity of the [technological] system" Ellul believes, "may be the cause of its fragility" (1980: 164). We are "shut up, blocked, and chained by the inevitability of the technical system, at least until the self-contradictions of the "technological bluff," like massive geologic fault lines, give way and the system dissolves in "enormous global disorder." At that point he thinks that we will finally understand that "everything depends on the qualities of individuals" (1990: 412).

The dynamic is, by now, familiar. Technology begets more technology, technological systems, technology driven politics, technology dependent economies, and finally, people who can neither function nor think a hair's breadth beyond the limits of one machine or another. This, in Neil Postman's view, is the underlying pattern of western history as we moved from simple tools, to technocracy, to "technopoly." In the first stage, tools were useful to solve specific problems but did not undermine "the dignity and integrity of the culture into which they were introduced" (Postman, 23). In a technocracy like England in the 18th and 19th centuries, factories undermined "tradition, social mores, myth, politics, ritual and religion." The third stage, technopoly, however, "eliminates alternatives to itself in precisely the way Aldous Huxley outlined in Brave New World." It does so "by redefining what we mean by religion, by art, by family, by politics, by history, by truth, by privacy, by intelligence, so that our definitions fit its new requirements" (48). Technopoly represents, in Postman's view, the cultural equivalent of AIDS, which is to say a culture with no defense whatsoever against technology or the claims of expertise (63). It flourishes when the "tie between information and human purpose has been severed."

The course that Professor Ausubel and others propose fits into this larger pattern of technopoly that step by step is shifting human evolution in radically different directions. Professor Ausubel does not discuss the risks and unforeseen consequences that accompany unfettered technological change. These, he apparently believes, are justifiable as unavoidable costs of progress. This is precisely the kind of thinking which has undermined our capacity to refuse technologies that add nothing to our quality of life. A

system which produces automobiles and atom bombs will also go on to make super computers, smart weapons, genetically altered crops, nano technologies, and eventually machines smart enough to displace their creators. There is no obvious stopping point, which is to say that having accepted the initial premises of technopoly the powers of control and good judgement are eroded away in the blizzard of possibilities.

Advertised as the essence of rationality and control, the technological system has become the epitome of irrationality in which means overrule careful consideration of ends. A rising tide of unanticipated consequences and "normal accidents" mock the idea that experts are in control or that technologies do only what they are intended to do. The purported rationality of each particular component in what E. O. Wilson calls a "thickening web of prosthetic devices" added together as a system lacks both rationality and coherence. Nor is there anything inherently human or even rational about words such as "efficiency," "productivity," or "management," that are used to justify technological change. Rationality of this narrow sort has been "as successful—if not more successful—at creating new degrees of barbarism and violence as it has been at imposing reasonable actions" (Saul, 32). Originating with Descartes and Galileo, the foundations of the modern worldview were flawed from the beginning. In time, those seemingly small and trivial errors of perception, logic, and heart cascaded into a rising tide of cultural incoherence, barbarism, and ecological degradation that have now engulfed the earth. Professor Ausubel's optimism, notwithstanding, this tide will continue to rise until it has finally drowned every decent possibility that might have been unless we choose a more discerning course.

ECOLOGICAL DESIGN

The unfolding problems of human ecology, in other words, are not solvable by repeating old mistakes in new and more sophisticated and powerful ways. We need a deeper change of the kind Albert Einstein had in mind when he said that the same manner of thought that created problems could not solve them. We need what architect Sim van der Ryn and mathematician, Steward Cowan define as an ecological design revolution. Ecological design in their words is "any form of design that minimize(s) environmentally destructive impacts by integrating itself with living processes . . . the effective adaptation to and integration with nature's processes" (van der Ryn and Cowan, 1996, x, 18). For Landscape architect, Carol Franklin ecological design is a "fundamental revision of thinking and operation" (Franklin, 264). Good design does not begin with what we can do, but rather with questions about what we really want to do (Wann, 22). Ecological design, in other words, is the careful meshing of human purposes with the larger patterns and flows of the natural world and the study of those patterns and flows to inform human actions (Orr, 1994, 104).

Amory Lovins, Hunter Lovins, and Paul Hawken, to this end propose a transformation in energy and resource efficiency that would dramatically increase wealth while using a fraction of the resources we currently use (1999). [1] Transformation would not occur, however, simply as an extrapolation of existing technological trends. They propose, instead, a deeper revolution in our thinking about the uses of technology so that we don't end up with "extremely efficient factories making napalm and throwaway beer cans" (Benyus, 262). In contrast to Ausubel, the authors of Natural Capitalism propose a closer calibration between means and ends. Such a world would improve energy and resource efficiency by, perhaps, ten-fold. It would be powered by highly efficient small-scale renewable energy technologies distributed close to the point of end-use. It would protect natural capital in the form of soils, forests, grasslands, oceanic fisheries, and biota while preserving biological diversity. Pollution, in any form, would be curtailed and eventually eliminated by industries designed to discharge no waste. The economy of that world would be calibrated to fit ecological realities. Taxes would be levied on things we do not want such as pollution and removed from things such as income and employment that we do want. These changes signal a revolution in design that draws on fields as diverse as ecology, systems dynamics, energetics, sustainable agriculture, industrial ecology, architecture, and landscape architecture. [2]

The challenge of ecological design is more than simply an engineering problem of improving efficiency—reducing the rates at which we poison ourselves and damage the world. The revolution that van der Ryn and Cowan propose must first reduce the rate at which things get worse (coefficients of change) but eventually change the structure of the larger system. As Bill McDonough and Michael Braungart argue, we will need a "second industrial revolution" that eliminates the very concept of waste (McDonough & Braungart, 1998). This implies, in their words, putting "filters on our minds, not at the end of pipes." In practice, the change McDonough proposes implies, among other things, changing manufacturing systems to eliminate the use of toxic and cancer causing materials and the development of closed loop systems that deliver "products of service" not products that are eventually discarded to air, water, and land-fills.

The pioneers in ecological design begin with the observation that nature has been developing successful strategies for living on Earth for 3.8 billion years and is, accordingly, a model for:

- Farms that work like forests and prairies,
- Buildings that accrue natural capital like trees,
- Waste water systems that work like natural wetlands,
- Materials that mimic the ingenuity of plants and animals,
- Industries that work more like ecosystems, and
- Products that become part of cycles resembling natural materials flows.

Wes Jackson, for example, is attempting to redesign agriculture in the Great Plains to mimic the prairie that once existed there (Jackson, 1980). Paul Hawken proposes to remake commerce in the image of natural systems (Hawken, 1993). The new field of industrial ecology is similarly attempting to redesign manufacturing to

reflect the way ecosystems work. The new field of "biomimicry" is beginning to transform industrial chemistry, medicine, and communications. Common spiders, for example, make silk that is ounce for ounce 5 times stronger than steel with no waste byproducts. The inner shell of an abalone is far tougher than our best ceramics (Benyus, 97). By such standards, human industry is remarkably clumsy, inefficient, and destructive. Running through each of these is the belief that the successful design strategies, tested over the course of evolution, provide the standard to inform the design of commerce and the large systems that supply us with food, energy, water, and materials, and remove our wastes (Benyus, 73).

The greatest impediment to an ecological design revolution is not, however, technological or scientific, but rather human. If intention is the first signal of design, as Bill McDonough puts it, we must reckon with the fact that human intentions have been warped in recent history by violence and the systematic cultivation of greed, self-preoccupation, and mass consumerism. A real design revolution will have to transform human intentions and the larger political, economic, and institutional structure that permitted ecological degradation in the first place. A second impediment to an ecological design revolution is simply the scale of change required in the next few decades. All nations, but starting with the most wealthy, will have to:

- Improve energy efficiency by a factor of 5-10;
- Rapidly develop renewable sources of energy;
- Reduce the amount of materials per unit of output by a factor of 5-10;
- Preserve biological diversity now being lost everywhere;
- Restore degraded ecosystems;
- Redesign transportation systems and urban areas;
- Institute sustainable practices of agriculture and forestry;
- Reduce population growth and eventually total population levels;
- Redistribute resources fairly within and between generations; and
- Develop more accurate indicators of prosperity, wellbeing, health and security.

We have good reason to think that all of these must be well underway within the next few decades. Given the scale and extent of the changes required, this is a transition for which there is no historical precedent. The century ahead will test, not just our ingenuity, but our foresight, wisdom, and sense of humanity as well.

The success of ecological design will depend on our ability to cultivate a deeper sense of connection and obligation without which few people will be willing to make even obvious and rational changes in time to make much difference. We will have to reckon with the power of denial, both individual and collective, to block change. We must reckon with the fact that we will never be intelligent enough to understand the full consequences of our actions, some of which will be paradoxical and some evil. We must learn how to avoid creating problems for which there is no good solution technological or otherwise (Hunter, 1997; Dobb, 1996) such as the creation of long-lived wastes, the loss of species, or toxic waste flowing from tens of thousands of mines. In short a real design revolution must aim to foster a deeper transformation in human intentions and the political and economic institutions that turn intentions into ecological results. There is no clever shortcut, no end-run around natural constraints, no magic bullet, and no cheap grace.

THE INTENTION TO DESIGN

Designing a civilization that can be sustained ecologically and one that sustains the best in the human spirit will require us, then, to confront the wellsprings of intention, which is to say human nature. Our intentions are the product of many things at least four of which have implications for our ecological prospects. First, with the certain awareness of our mortality, we are inescapably religious creatures. The religious impulse in us works like water flowing up from an artesian spring that will come to the surface in one place or another. Our choice is not whether we are religious or not as atheists would have it, but whether the object of our worship is authentic or not. The gravity mass of our nature tugs us to create or discover systems of meaning that places the human condition in some larger framework that explains, consoles, offers grounds for hope, and, sometimes, rationalizes. In our age, nationalism, capitalism, communism, fascism, consumerism, cyberism, and even ecologism have become substitutes for genuine religion. But whatever the ism or the belief, in one way or another we will create or discover systems of thought and behavior which give us a sense of meaning and belonging to some larger scheme of things. Moreover, there is good evidence to support the claim that successful resource management requires, in E. N. Anderson's words, "a direct, emotional religiously 'socialized' tie to the resources in question" (1996;169). Paradoxically, however, societies with much less scientific information than we have often make better environmental choices. Myth and religious beliefs, which we regard as erroneous, have sometimes worked better to preserve environments than have decisions based on scientific information administered by presumably "rational" bureaucrats (Lansing, 1991). The implication is that solutions to environmental problems must be designed to resonate at deep emotional levels and be ecologically sound.

Second, despite all of our puffed up self-advertising as Homo sapiens, the fact is that we are limited, if clever, creatures. Accordingly, we need a more sober view of our possibilities. Real wisdom is rare and rarer still if measured ecologically. Seldom do we foresee the ecological consequences of our actions. We have great difficulty understanding what Jay Forrester once called the "counterintuitive behavior of social systems" (Forrester, 19ck) We are prone to overdo what worked in the past, with the result that

many of our current problems stem from past success carried to an extreme. Enjoined to "be fruitful and multiply," we did as commanded. But at six billion and counting, it seems that we lack the gene for enough. We are prone to overestimate our abilities to get out of self-generated messes. We are, as someone put it, continually overrunning our headlights. Human history is in large measure a sorry catalog of war and malfeasance of one kind or another. Stupidity is probably as great a factor in human affairs as intelligence. All of which is to say that a more sober reading of human potentials suggests the need for a fail-safe approach to ecological design that does not over tax our collective intelligence, foresight, and goodness.

Third, quite possibly we have certain dispositions toward the environment that have been hardwired in us over the course of our evolution. E. O. Wilson, for example, suggests that we possess what he calls "biophilia" meaning an innate "urge to affiliate with other forms of life" (Wilson, 1984, 85). Biophilia may be evident in our preference for certain landscapes such as savannas and in the fact that we heal more quickly in the presence of sunlight, trees, and flowers than in biologically sterile, artificially lit, utilitarian settings. Emotionally damaged children, unable to establish close and loving relationships with people, sometimes can be reached by carefully supervised contact with animals. And after several million years of evolution it would be surprising indeed were it otherwise. The affinity for life described by Wilson and others, does not, however, imply nature romanticism, but rather something like a core element in our nature that connects us to the nature in which we evolved and which nurtures and sustains us. Biophilia certainly does not mean that we are all disposed to like nature or that it cannot be corrupted into biophobia. But without intending to do so, we are creating a world in which we do not fit. The growing evidence supporting the biophilia hypothesis suggests that we fit better in environments that have more, not less, nature. We do better with sunlight, contact with animals, and in settings that include trees, flowers, flowing water, birds, and natural processes than in their absence. We are sensuous creatures who develop emotional attachment to particular landscapes. The implication is that we need to create communities and places that resonate with our evolutionary past and for which we have deep affection.

Fourth, for all of our considerable scientific advances, our knowledge of the Earth is still minute relative to what we will need to know. Where are we? The short answer is that despite all of our science, no one knows for certain. We inhabit the third planet out from a fifth-rate star located in a backwater galaxy. We are the center of nothing that is very obvious to the eye of science. We do not know whether the Earth is just dead matter or whether it is, in some respects, alive. Nor do we know how forgiving the ecosphere may be to human insults. Our knowledge of the flora and fauna of the Earth and the ecological processes that link them together is small relative to all that might be known. In some areas, in fact, knowledge is in retreat because it is no longer fashionable or profitable. Our practical knowledge of particular places is often considerably less than that of the native peoples we displaced. As a result, the average college graduate would flunk even a cursory test on their local ecology, and stripped of technology most would quickly founder.

To complicate things further, the advance of human knowledge is inescapably ironic. Since the enlightenment, the goal of our science has been a more rational ordering of human affairs in which cause and effect could be empirically determined and presumably controlled. But after a century of promiscuous chemistry, for example, who can say how the 100,000 chemicals in common use mix in the ecosphere or how they might be implicated in declining sperm counts, or rising cancer rates, or disappearing amphibians, or behavioral disorders? And having disrupted global biogeochemical cycles, no one can say with assurance what the larger climatic and ecological effects will be. Undaunted by our ignorance, we rush ahead to re-engineer the fabric of life on earth! Maybe science will figure it all out. But I think that it is more probable that we are encountering the outer limits of social-ecological complexity in which cause and effect are widely separated in space and time and in a growing number of cases no one can say with certainty what causes what. Like the sorcerer's apprentice, every answer generated by science gives rise to a dozen more questions, and every technological solution gives rise to a dozen more problems. Rapid technological change intended to rationalize human life tends to expand the domain of irrationality. At the end of the bloodiest century in history, the enlightenment faith in human rationality seems overstated at best. But the design implication is, not less rationality, but a more complete, humble, and ecologically solvent rationality that works over the long-term.

Who are we? Conceived in the image of God? Perhaps. But for the time being the most that can be said with assurance is that, in an evolutionary perspective humans are a precocious and unruly newcomer with a highly uncertain future. Where are we? Wherever it is, it is a world full of irony and paradox, veiled in mystery. And for those purporting to reweave the human presence in the world in a manner that is ecologically sustainable and spiritually sustaining, the ancient idea that God (or the gods) mocks human intelligence should never be far from our minds.

ECOLOGICAL DESIGN PRINCIPLES

First, ecological design is not so much about how to make things as it is how to make things that fit gracefully over long periods of time in a particular ecological, social, and cultural context. Industrial societies, in contrast, operate in the conviction that "if brute force doesn't work you're not using enough of it." But when humans have designed with ecology in mind there is greater harmony between intentions and the particular places in which those intentions are played out that:

- Preserves diversity both cultural and biological
- Utilizes current solar income
- Creates little or no waste
- Accounts for all costs

- Respects larger cultural and social patterns

Second, ecological design is not just a smarter way to do the same old things or a way to rationalize and sustain a rapacious, demoralizing, and unjust consumer culture. The problem is not how to produce ecologically benign products for the consumer economy, but how to make decent communities in which people grow to be responsible citizens and whole people who do not confuse what they have with who they are. The larger design challenge is to transform a society that promotes excess consumption and human incompetence, concentrates power in too few hands, and destroys both people and land. Ecological design ought to foster a revolution in our thinking that changes the kinds of questions we ask from "how can we do the same old things more efficiently" to deeper questions such as:

- Do we need it?
- Is it ethical?
- What impact does it have on the community?
- Is it safe to make and use?
- Is it fair?
- Can it be repaired or reused?
- What is the full cost over its expected lifetime?
- Is there a better way to do it?

The quality of design, in other words, is measured by the elegance with which we join means and worthy ends. In Wendell Berry's felicitous phrase, good design "solves for pattern" thereby preserving the larger patterns of place and culture and sometimes this means doing nothing at all (Berry, 1981. 134-145). In the words of John Todd, the aim is "elegant solutions predicated on the uniqueness of place."[3] Ecological design, then, is not simply a more efficient way to accommodate desires as it is the improvement of desire and all of those things that effect what we desire.

Third, ecological design is as much about politics and power as it about ecology. We have good reason to question the large scale plans to remodel the planet that range from genetic engineers to the multinational timber companies. Should a few be permitted to redesign the fabric of life on the earth? Should others be permitted to design machines smarter than we are that might someday find us to be an annoyance and discard us? Who should decide how much of nature should be remodeled, for whose convenience, and by what standards? In an age when everything seems possible, where are the citizens or other members of biotic community who will be effected by the implementation of grandiose plans? The answer is that they are now excluded. At the heart of the issue of design, then, are procedural questions that have to do with politics, representation, and fairness.

Fourth, it follows that ecological design is not so much an individual art practiced by individual "designers" as it is an ongoing negotiation between a community and the ecology of particular places. Good design results in communities in which feedback between action and subsequent correction is rapid, people are held accountable for their actions, functional redundancy is high, and control is decentralized. In a well designed community, people would know quickly what's happening and if they don't like it, they know who can be held accountable and can change it. Such things are possible only where: livelihood, food, fuel, and recreation are, to a great extent, derived locally; when people have control over their own economies; and when the pathologies of large-scale administration are minimal. Moreover, being situated in a place for generations provides long memory of the place and hence of its ecological possibilities and limits. There is a kind of long-term learning process that grows from the intimate experience of a place over time.[4] Ecological design, then, is a large idea but is most applicable at a relatively modest scale. The reason is not that smallness or locality has any necessary virtue, but that human frailties limit what we are able to comprehend, foresee, as well as the scope and consistency of our affections. No amount of smartness or technology can dissolve any of these limits. The modern dilemma is that we find ourselves trapped between the growing cleverness of our science and technology and our seeming incapacity to act wisely.

Fifth, the standard for ecological design is neither efficiency nor productivity, but health beginning with that of the soil and extending upward through plants, animals, and people. It is impossible to impair health at any level without affecting that at other levels. The etymology of the word health reveals its connection to other words such as healing, wholeness, and holy. Ecological design is an art by which we aim to restore and maintain the wholeness of the entire fabric of life increasingly fragmented by specialization, scientific reductionism, and bureaucratic division. We now have armies of specialists studying bits and pieces of the whole as if these were, in fact, separable. In reality it is impossible to disconnect the threads that bind us into larger wholes up to that one great community of the ecosphere. The environment outside us is also inside us. We are connected to more things in more ways than we can ever count or comprehend. The act of designing ecologically begins with the awareness that we can never entirely fathom those connections and with the intent to faithfully honor what we cannot fully comprehend and control. This means that ecological design must be done cautiously, humbly, and reverently.

Sixth, ecological design is not reducible to a set of technical skills. It is anchored in the faith that the world is not random but purposeful and stitched together from top to bottom by a common set of rules. It is grounded in the belief that we are part of the larger order of things and that we have an ancient obligation to act harmoniously within those larger patterns. It grows from the awareness that we do not live by bread alone and that the effort to build a sustainable world must begin by designing one that first nourishes the human spirit. Design, at its best, is a sacred art reflecting the faith that, in the end, if we live faithfully and well, the world will not break our hearts.

Finally, the goal of ecological design is not a journey to some utopian destiny, but is rather more like a homecoming. Philosopher, Suzanne Langer, once described the problem in these words:

> *Most people have no home that is a symbol of their childhood. not even a definite memory of one place to serve that purpose. Many no longer know the language that was once their mother-tongue. All old symbols are gone . . . the field of our unconscious symbolic orientation is suddenly plowed up by the tremendous changes in the external world and in the social order. (Langer, 292)*

In other words, we are lost and must now find our way home again. For all of the technological accomplishments, the twentieth century was the most brutal and destructive era in our short history. In the century ahead we must chart a different course that leads to restoration, healing, and wholeness. Ecological design is a kind of navigation aid to help us find our bearings again. And getting home means remaking the human presence in the world in a way that honors ecology, evolution, human dignity, spirit, and the human need for roots and connection.

CONCLUSION

Ecological design, then, involves far more than the application of instrumental reason and advanced technology applied to the problems of shoehorning billions more of us into an earth already bulging at the seams with people. Humankind, as Abraham Heschel once wrote, "will not perish for want of information; but only for want of appreciation . . . what we lack is not a will to believe but a will to wonder." (Heschel, 37) The ultimate object of ecological design is not the things we make but rather the human mind and specifically its capacity for wonder and appreciation.

The capacity of the mind for wonder, however, has been all but obliterated by the very means by which we are passively provisioned with food, energy, materials, shelter, health-care, entertainment, and by those that remove our voluminous wastes from sight and mind. There is hardly anything in these industrial systems that fosters mindfulness or ecological competence let alone a sense of wonder. To the contrary these systems are designed to generate cash which has itself become an object of wonder and reverence. It is widely supposed that formal education serves as some kind of antidote to this uniquely modern form of barbarism. But conventional education, at its best, merely dilutes the tidal wave of false and distracting information embedded in the infrastructure and processes of technopoly. However well intentioned, it cannot compete with the larger educational effects of highways, shopping malls, supermarkets, urban sprawl, factory farms, agribusiness, huge utilities, multinational corporations, and nonstop advertising that teaches dominance, power, speed, accumulation, and self-indulgent individualism. We may talk about how everything is ecologically connected, but the terrible simplifiers are working overtime to take it all apart.

If it is not to become simply a more efficient way to do the same old things, ecological design must become a kind of public pedagogy built into the structure of daily life. There is little sense in only selling greener products to a consumer whose mind is still pre-ecological. Sooner or later that person will find environmentalism inconvenient, or incomprehensible, or too costly and will opt out. The goal of ecological design is to calibrate human behavior with ecological realities while educating people about ecological possibilities and limits. We must begin to see our houses, buildings, farms, businesses, energy technologies, transportation, landscapes, and communities in much the same way that we regard classrooms. In fact, they instruct in more fundamental ways because they structure what we see, how we move, what we eat, our sense of time and space, how we relate to each other, our sense of security, and how we experience the particular places in which we live. More important, by their scale and power they structure how we think, often limiting our ability to imagine better alternatives.

When we design ecologically we are instructed continually by the fabric of everyday life—pedagogy informs infrastructure which in turn informs us. The growing of food on local farms and gardens, for example, becomes a source of nourishment for the body and instruction in soils, plants, animals, and cycles of growth and decay (Donahue, 1999). Renewable energy technologies become a source of energy as well as insight about the flows of energy in ecosystems. Ecologically designed communities become a way to teach about land use, landscapes, and human connections. Restoration of wildlife corridors and habitats instructs us in the ways of animals. In other words ecological design becomes a way to expand our awareness of nature and our ecological competence.

Most importantly, when we design ecologically we break the addictive quality that permeates modern life. "We have," in the words of Philosopher Bruce Wilshire,

> *"encase(d) ourselves in controlled environments called building and cities. Strapped into machines, we speed from place to place whenever desired, typically knowing any particular place and its regenerative rhythms and prospects only slightly."*

We have alienated ourselves from "nature that formed our needs over millions of years [which] means alienation within ourselves." (Wilshire, 18) Given our inability to satisfy "our primal needs as organisms" we suffer what he calls a deprivation of ecstasy that stemmed from the 99% of our life as a species spent fully engaged with nature. Having cut ourselves off from the cycles of nature, we find ourselves strangers in an alien world of our own making. Our response has been to create distractions and addictive behaviors as junk food substitutes for the totality of body-spirit-mind nourishment we've lost and then to vigorously deny what we've done. Ecstasy deprivation, in other words, results in surrogate behaviors, mechanically repeated over and over again, otherwise known as addiction. This is a plausible, even brilliant, argument with the ring of truth to it.[5]

Ecological design, finally, is the art that reconnects us as sensuous creatures evolved over millions of years to a sensuous, living,

and beautiful world. That world does not need to be remade but rather revealed. To do that we do not need research as much as the rediscovery of old and forgotten things. We do not need more economic growth as much as we need to re-learn the ancient lesson of generosity, which is to say that the gifts we have must move, that we can possess nothing. We are only trustees standing for only a moment between those who preceded us and those who will follow. Our greatest needs have nothing to do with possession of things but rather with heart, wisdom, thankfulness, and generosity of spirit. And these things are part of larger ecologies that embrace spirit, body, and mind—the beginning of design.

Design in its largest sense joins a variety of disciplines around the issue of how we provision six (soon to be 8-10 billion people) with food, energy, water, shelter, health care, and materials and do so sustainably and fairly on a planet with a biosphere. Design is not just about how we make things, but rather how we make things that fit harmoniously in an ecological, cultural, and moral context. It is therefore about systems, patterns, and connections. It is also a part of a long-term conversation between ecologists and designers of the built environment and technosphere the essence of which is whether design becomes yet one more clever way to make end-runs around natural systems or is disciplined and informed by an understanding of nature. At its best, design is a field of applied ethics that joins perspectives, and disciplines that otherwise remain disparate and often disjointed. Problems of environmental justice, for example, are unsolvable unless a morally robust design intelligence is applied to the design of food systems, energy use, materials flows, waste cycling in ways that do not compromise standards of fairness and human dignity. Justice, in this perspective, is a design problem, but it is also a criterion for design and a result of good design. But design itself requires both robust ethics and mastery of design skills and analytic abilities.

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NOTES

[1]Our ecological troubles have been variously attributed to Judeo-Christian religion (Lynn White), our inability to manage common property resources such as ocean fisheries (Garrett Hardin), lack of character (Wendell Berry), gender imbalance (Carolyn Merchant), technology run amuck (Lewis Mumford), disenchantment (Morris Berman), the loss of sensual connection to nature (David Abram), exponential growth (Donella Meadows), and flaws in the economic system (Herman Daly).

[2]The roots of ecological design can be traced back to the work of Scottish biologist, D'Arcy Thompson and his magisterial *On Growth and Form* first published in 1917. In contrast to Darwin's evolutionary biology, Thompson traced the evolution of life forms back to the problems elementary physical forces such as gravity pose for individual species. His legacy is an evolving science of forms evident in evolutionary biology, biomechanics, and architecture. Ecological design is evident in the work of Bill Browning, Herman Daly, Paul Hawken, Wes Jackson, Aldo Leopold, Amory and Hunter Lovins, John Lyle, Bill McDonough, Donella Meadows, Eugene Odum, Sim van der Ryn, and David Wann.

[3]The phrase is John Todd's, see John and Nancy Todd, From Eco-Cities to Living Machines: Principles of Ecological Design (Berkeley: North Atlantic Books, 1994).

[4]George Sturt, once described this process in his native land as "The age-long effort of Englishmen to fit themselves close and ever closer into England . . . "(Sturt, p. 66).

[5]See also David Abram's remarkable book The Spell of the Sensuous. New York: Pantheon.