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Environmental Science / Environmental Design

Abstract

Environmental science has formed the central part of ecological discourse in architecture. It has been the primary force behind the work of various leaders in the ecological design community [1]. Gravity and the second law of thermodynamics set the stage for disseminating a vast array of scientific principles. Energy is plotted. Solar angles are graphed. Thermal flows are mapped. These science-based principles are fundamental to producing new green technologies and various shades of green in the plans and sections of our buildings [2]. And the science behind the environment continues to prosper. The challenge in architectural education however has been the development of more inclusive, creative, even conflictive understandings of ecology and environmental design that expand beyond the germane integration of environmental science principles and new green technologies.

This paper represents an extension of work in relation to a graduate level design studio recently taught at Georgia Tech with the aim of presenting more complex definitions and uses of ecology in architectural practice as a complement to the science behind the environment. Ultimately, the ideas and strategies described here hold potential for new forms of relationship between people, place, material and earth. The paper is organized into two parts. The first part identifies three major concerns: 1) the current predicament of peak global oil production; 2) the re-occurring problems associated with the mind-set separation of culture and nature; and 3) the untapped potential between ecology, creativity, and architecture. The second part places these concerns in practice, in the context of three green housing proposals located at Hulsey Yards, a 35-acre in-town, industrial urban site south of downtown Atlanta that is strategically placed along the Belt Line Atlanta Project, a 22-mile inner-city light rail loop and greenway currently the focus of a multi-million dollar study by the Georgia Department of Transportation [3].

PART ONE:
Identifying Concerns

Oil-Centered Development
The U.S. faces an epochal predicament: global oil production will peak within the next couple of years, if in fact it hasn't already peaked. According Kenneth S. Deffeyes, oil production peaked exactly on December 16, 2005, when cumulative production exceeded 1.0065 trillion barrels of oil [4]. Regardless of when oil production peaked or about to peak, this reality is especially significant because the U.S. consumes 19 of 75 million barrels of world oil produced every day, or 25.4% of total production, and because 90% of U.S. transportation energy comes from oil [5].

But at this very moment, the 100-year reign of crude oil is over, and following, the unsustainable economic and physical growth that it nurtured. By any measure of rational planning or public policy-making, this predicament is significant. The expansive, rapid and unchecked growth in the U.S. during the last 25 years, built on a seemingly endless supply of cheap oil, has produced

unforgiving amounts of low-density, greenfield development, homogenous, gated subdivisions, unparalleled long-distance travel routes, and unacceptable levels of air and ground-water pollution. The result of these actions is universally viewed with alarm as urban sprawl - the most destructive development pattern the industrialized world has ever seen, and perhaps the greatest misallocation of resources the world has ever known [6]. Such new, economically-driven development patterns are now a matter of real public health and require a fundamental re-thinking of the environment, in how it is conceived and made.

Culture-Nature Divide
Many environmentalists conceive of cities as antithetical to nature [7]. In contemporary calls for "green" or "ecological" architecture, the dichotomy between the urban and the wild has been thankfully less influential given the nature of the discipline – the production of spaces in which we will live and work. Environmental architecture thus can stand as a potentially important corrective to the prevailing green, anti-urban orthodoxy [8]. "Environmental architecture" may also represent one of our best hopes for insuring that broader aesthetic, moral and political imperatives for the human community do not get lost in our environmental science research to remake the world in a more sustainable form. Environmental architecture and design must emphasize that turning green does not necessarily just mean reproducing the patterns of natural systems in human developments, or only narrowly implementing new energy saving technologies in buildings in order to achieve a green goal [9].

If environmental architecture is to live up to its potential for overcoming the culture-nature divide in environmental thought, it should consistently operate on a more expansive notion of what counts as an "environment." Too often we find in even the more sober literature on this topic a sentiment that we achieve green principles in architecture and design when we follow environmental science, when we try to mimic non-human natural processes in construction and planning techniques by incorporating "principles inherent in the natural world" [10]. Such calls have produced several important developments such as the idea of "industrial ecology," the incorporation of "living machines" in building plans, various forms of bioremediation in design, such as the use of green roofs, and other endeavors aimed at abandoning ideal human geometries in favor of those that would more closely mimic more complex natural patterns [11].

Likewise, a thoroughly responsible environmental architecture would be one that not only efficiently captured energy savings but also embraced the history and potential of humanly created environments on their own terms, regardless of their conception of nature. If what counted as the best environmental architecture were those instances of these forms which did not only measure their success by whether they had followed nature, either in concept or application, but also took into account the larger context of the human environment in which these buildings were placed, then we would have a platform from which we could resist the easy assumption that the real core of "environmentalism" is something which either turns a blind eye to or actively excludes the urban. If what counted as the "environment" of concern also included human environments – as an extension of our unique biological and cultural capacities – then we would draw less of a line between environmental issues and other important social concerns. To do otherwise is to risk separating off a realm of "environmental" responsibility from other forms of social responsibility; it is to imply that care for nature is somehow distinct from attention to the welfare of the human community [12].

Environmentalism has long been connected to anti-urbanism. It is also no doubt connected to the larger prevailing anti-urban bias of most North Americans. The evidence against such a bias though is striking. We can bear witness to this in considering the case that New York City may well be the most sustainable city in the United States [13]. It is also the least likely place to be chosen as such in a survey. Studies of the conservation gains made during the late 1970s and early 1980s in the U. S. show that the lowest per capita per day consumption rate went to New York state ~ 215 BTUs on average ~ because so many residents live in New York City apartments, sharing walls and hence sharing heat, and do not own cars nor regularly use them if they own them. The highest energy consumption rate went to Alaska, with 1,139 BTUs on average, five-times as much energy is consumed as a New Yorker [14]. While this study only reports the outcome of one variable of measuring energy costs and savings, it is a critical one.

Assuming that population increases and consumption rates remain constant, moving away from density becomes one of the single biggest obstacles for achieving environmental sustainability. This does not mean that everyone should move to Manhattan to live more sustainably. It means that spaces across any scale, from small town to megalopolis, are better in relation to broader environmental priorities when they are more intensely urban. A consistent environmental perspective would have to embrace larger cities as one of the better examples of meeting such priorities because they provide an opportunity for greater numbers of people to live more sustainably without having to substantially change their lifestyle. While some states, such as Virginia and New Jersey, have taken stronger steps toward abating sprawl than in the past, such proposals unfortunately do very little to address the damage that has already been done by unsustainable suburban development.

Yet, many people and most environmentalists however would find the claim to the environmental advantages of densely populated cities absurd in part because the environmental advantages of some cities are lumped in too quickly with the clear disadvantages of sprawled cities like Los Angles and Las Vegas. Densely populated places like New York are seen as the antithesis of "the environment." On such a view, suburbs may come closer and exurbs closest to getting us back to nature. At least there access to green space is plentiful. If we are environmentally enlightened then we can learn the virtues of digging up our Kentucky bluegrass and replacing it with native plants – returning our small patch of the world to its original natural state.

So too, sustainable design ought not to be premised on the abandonment of forms of life which appear on the surface to be alien to our natural origins but which we know are inherently more sustainable. We do not need to altogether abandon the beneficial ways in which we have lived in order to build more sustainably. Accordingly, what counts as green or environmental architecture and design today is not limited to large-scale planning fantasies but more rigorously developed techniques of building and design which garner energy savings. In this way, green architecture can provide an answer to the broader anti-humanism and anti-urbanism of environmentalism, taking as its raw material the habitats in which we must necessarily find a home. We should also keep in mind that concerns over sprawl and the like are not based solely on environmental considerations but also for what these growth patterns do to destroy the fabric of the human community, something that is too easily forgotten in other fields of environmental

study [15]. The trick however is to ensure that those more reasonable proposals to make us more architecturally "natural" do not abandon what also makes us human.

Critical Engagement in Ecology and Architecture
Whereas ecology has changed and enriched the field of architecture substantially since Aldo Leopold's *A Sand County Almanac* (1949), and moreso with Ian McHarg's *Design with Nature* (1969), it has also been subject to a lack of critical reflection within ecological design circles. There is a countertendency to privilege the science behind the environment at the exclusion of ecological ideas. This has proven to be retrogressive and reductive, leading to environments full of images rather than significant places for dwelling.   The appropriation of ecology is just beginning to show signs of inventiveness and animistic forms of creativity. The failure of the field is evidenced by the prosaic and often trivial nature of much contemporary built work, whether it claims to be ecological in its design or not.

Moreover, it is ironic that the active life processes and forces of which ecology speaks are rarely paralleled in the modern architects' limited capacity to transfigure. This lack of imaginative depth and actual agency is compounded by often uncritical, reductive, and sometimes even exclusionary views of what is considered to be "natural" [16]. Although ecology has surfaced in contemporary public life in general, a culturally animate ecology – one that is distinct from a purely "scientific" ecology – has yet to emerge. That such an urgent development might derive form, and contribute to more animistic types of creativity than current frames of instrumentalism would allow points to a necessary dialogue between the scientific and artistic worlds. Such an emphasis asks that ecology inform and embrace those poetic activities that create meaningful relationships between people, place and earth [17]. An eco-imaginative architecture would be creative insofar as it reveals, liberates, enriches and diversifies both biological and cultural life. How then might the ecological idea precipitate imaginative and "world-enlarging" forms of creative endeavor? In turn, how might architectural creativity enrich and inform the ecological idea in the imagination and material practices of a people?

PART TWO:
Putting Ideas to Practice

Dismantling the Burden of Determinism
In a review of a dozen books published between 1996-2002 on sustainable architecture, historian Richard Ingersoll reaches the conclusion that in order to "dismantle the burden of determinism" associated with the ecological design movement, the emergence of a "dialectical ecologist" seems more valuable to the ecology movement today than all its good intentions or innovations [18]. Ingersoll drives the point home that decoupling the innovative eco-tech project from the urban one is futile.   He writes, "any theory of design and ecology must acknowledge that the bottom line of sustainability is not the individual [efficiently-designed] building but urbanism." For Ingersoll and others, without urbanism, all of the right eco-tech building in the U.S. will not add up to much.

And yet buildings worldwide, more than any other urban infrastructure, are responsible for about 40% of CO_2 emissions, the US being the largest culprit by far. Despite a US governmental pledge at the 1992 Earth Summit in Rio to reduce emissions of green house gases, air pollution is

increasing - over 60,000 Americans die each year from air pollution alone [19]. In 2000, carbon dioxide emissions were 14% higher than they were in 1990 [20]. By the year 2020, world population will have grown from six to eight billion. In effect, a reduction in energy consumption in buildings is a design imperative, especially from the world's largest consumer.

Atlanta Housing

For years, strong employment growth, warm weather and plenty of developable land has kept Atlanta at the top of the housing market nationally. Single-family construction continues to dominate the region's housing market. Over-building of multi-family units in the 1980's, changes in tax laws and low mortgage interest rates continued to cause single-family construction to dominate in the 1990's. Between 1990 to 2000, only 15% of the region's new housing units increase was multi-family [21]. Atlanta is currently the largest housing market in the country, with more than 70,000 total permits issued in the last 12 months, albeit nearly 58,000 or 83% of which were single-family permits. This accounted for 3.6% of all single-family construction in the country in 2004 [22]. The average median house size increased from 2,100 square feet to 2,227 square feet, while the median lot size decreased from .77 acres to .66 acres. Owner-occupied units with four or more bedrooms increased 77 percent, from 252,500 to 446,000 while owner-occupied households with two or fewer bedrooms decreased 6.7% from 123, 200 to 114,900 [23]. To accommodate this growth, builders have reached further and further into the outlying counties. Will this level of growth continue?

The ARC forecasts that some 2.3 million more people will move to the Atlanta region in the next 25 years [24]. How can region accommodate this growth and still maintain its high quality of life? What impact will 2.3 million more people really have?
- 1.7 million more jobs, and the traffic that goes with them
- Almost 300 million gallons of water used per day
- Almost 1 million new households, with more than half of the housing units yet to be built
- Tripling of the 60+ age segment

A 35-acre post-industrial, inner-city site became a space of reciprocity between collaborative and individual work for twelve graduate students in their final year of study. Students were encouraged to think in unconventional ways about making environmentally responsible buildings that contribute to vital, local place-making. The results of the research fed a range of issues including lifestyle, landscape, structures and materials. It also raised doubts and shed new light regarding many well-worn definitions of ecological architecture.

Hulsey Yards Design Studio

It is in the tensional space between the urban project and the ecological building one that prompted a "dialectical research method" for a graduate design studio located at Hulsey Yards in Atlanta, Georgia. Following environmental philosopher Allen Carlson's call for "an appreciation of paradoxes and dialectical relationships," a multi-phase eco-urban research agenda was developed where complexity and conflict could be nurtured [25]. Strategizing a critical approach to ecological design, the studio process set out to incorporate conflict and dissimilarity ~ conflating what James Corner calls "modernist dualities into fantastic worlds of mutuality, paradox and difference" [26].

Rather than object architectures - too often associated with contemporary green building despite all the right intentions - this studio sought out "environmental architectures," architectures associated with a new understanding of building as a field of competing ecological and cultural forces. Students were introduced to ecocriticism, or green criticism - one of the most recent interdisciplinary fields to have emerged in cultural studies. David Teague loosely defines ecocriticism as the study of the mutual constructing relationship between culture and the environment [27]. For Ursula Heise, it is defined as the role that the natural environment plays in the imagination of a cultural community. It examines how the concept of "nature" is defined, what values are assigned to it or denied it and why, and the way in which the relationship between humans and nature is envisioned. More specifically, it investigates how nature is used literally or metaphorically in certain literary or aesthetic genres and tropes. This analysis in turn allows ecocriticism to assess how certain historically conditioned concepts of nature and the natural, and particularly literary and artistic constructions of it have come to shape current perceptions of the environment [28].

In terms of environmental science, the studio was divided into three teams of four students. Each group was charged to investigate one the four elements - air, water, sun, and earth - extending the lessons they learned in their required environmental systems courses. They collected technical data, sorted it, and organized it into five categories: properties, principles, problems or issues, applications and design considerations. Each team also presented two case study projects that were driven in large part by the forces inherent to the element they studied – one at the urban scale and the other at the building scale. They were called upon to reveal both the conceptual ideas and specific strategies of the projects as they pertain to one of the elements.

A mapping method was used to solicit relationships between the two prior phases. Students were asked to brainstorm a list of connective measures, sort their conclusions into categories that made sense to them, and rate each item regarding how important they were to the place at hand. A questionnaire was given to the studio-wide group who developed a list of physical variables plausibly related to innovative outcomes. They rated the importance of those items, developed hypotheses and each selected one that became the basis of their individual design studio project.

Various subdivision strategies of Hulsey Yards - into streets and blocks - were developed. Each strategy weighed the role and relevance of the urban and ecological forces of the site. Differences in weight shaped alternative organizational strategies of the site. Each group of students was asked to propose a subdivision scheme [street and block configurations] on a 30-acre site adjacent between MLK Jr and Inman Park/Reynoldstown MARTA Stations. At Hulsey Yards, it was not immediately clear where the actual Beltine right-of-way would be located at Hulsey Yards. The subdivision schemes incorporated different positions of the Beltline. After a couple of weeks, studio members reached consensus around a combination of two of the four schemes, but eventually incorporated attributes of all four schemes. Each of the twelve students selected an individual block to design within the overall subdivision scheme. Blocks ranged in size from 100'x400', the smallest, to 200'x700', the largest.
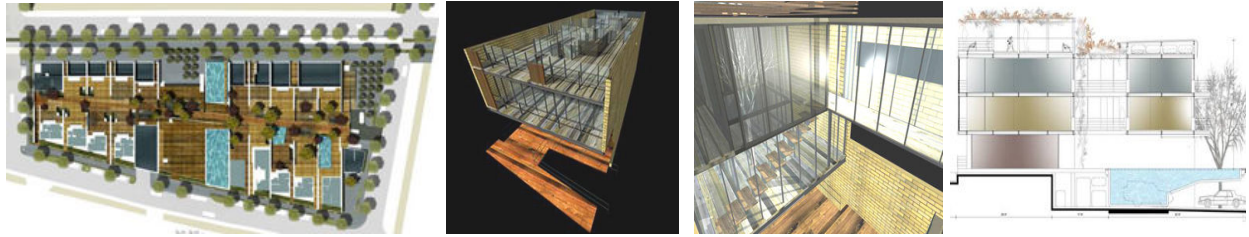
Project One

Figure 1: Court House

Court House integrates multi-story courtyards with rainwater cisterns and a series of communal domestic waste containers for organic gardening and recycling. Integral screening mechanisms using recycled honeycomb plastic panels provided privacy when needed. The primary communal floor is raised 5' above grade for cross-ventilation and surfaced with reused railroad ties. Cool air from the basement level is drawn up through the "vegetal" section of the courtyards [See Fig. 1].

The organizational structure of the 2.5 acre block was developed from two primary agendas: 1) passive cooling and 2) semi-cooperative living ~ part of the sustainability development initiative in addition to using technology to improve the quality of life and the environment. The "courtyard" as a space type served to address both ecological and social agendas. Design research on passive cooling associated with courtyard design, and on courtyard housing more generally, led to ecological and social agendas that were conflated in plan and in section. The courtyard provided opportunities for adjacent units to meet, as well as a heat source when closed during the winter months. Integral screening mechanisms using recycled honeycomb plastic panels provided privacy when needed. Taking advantage of the mild slope from south to north, a parking deck was sunk five feet below the high point of the site, taking advantage of the cool thermal properties of the earth. Located at the foot of the multi-story courtyards were integrated rainwater cisterns, as well as a series of communal domestic waste containers for organic gardening and recycling. The primary communal floor is raised 5' above grade for cross-ventilation and surfaced with reused railroad ties. Cool air from the basement level is drawn up through the "vegetal section" of the courtyards.
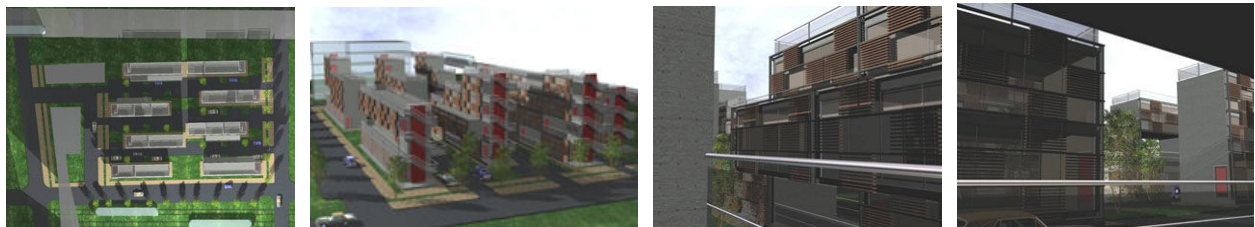
Project Two

Figure 2: Modular House

Modular House is based on a prefabricated modular room system to suit climate, site orientation, seasonal changes and client needs. Parts measuring 15' by 25' are cast in a factory and assembled on site thus minimizing construction waste. For optimal energy performance, walls and floors are made of insulated concrete containing as much as 50% recycled content, reducing the reliance on raw materials ~ combining aggregate from existing concrete on site with fly ash, an industrial by-product that would otherwise clog landfills. The light color of concrete reduces heat gain, reflects more light, and minimizes the urban heat island effect with savings of 18-20%.

Compound Elements is based on a prefabricated modular room system which can be configured in numerous ways to suit climate, site orientation, seasonal changes and client needs. Parts measuring 15' by 25' are cast in a factory and assembled on site thus minimizing construction waste. Each room measures 15' by 25' and is configured to accommodate various programmatic functions. Studios, 2-bedroom and 3-bedroom units each come with their own internal open space as well as a small outdoor open space adjacent to parking. Seeking increased housing densities without compromising solar access led to an overall density of 30 units per acre, considerably higher than the surrounding area [See Fig. 2]

The narrow housing units are oriented toward the sun and prevailing winds to maximize daylighting, cross-ventilation, as well as to take advantage of cool northern light. Fenestrations occur only on northern and southern facades while the east and west facing facades are used to accommodate services. The southern facades are fitted with double-glazed sliding doors and operable wooden screens to minimize heat gain, facilitate shading and privacy. Various forms of pervious pavement from on-site recycled concrete are used on all hard surfaces to maximize ground water drainage [29]. Accessible roofs also serve as storm water catchments, draining roof run-off to an underground filtration system for grey water uses. Water is heated using solar power.

For optimal energy performance, walls and floors are made of insulated concrete, with the following advantages: 1) insulated concrete is not subject to large daily temperature fluctuations; 2) heating and cooling costs can be lowered by 25%; 3) concrete's long life cycle, as it will not rust, rot, or burn, requiring less energy/resources over time to repair or replace; 4) insulated concrete may contain as much as 50% recycled content, reducing the reliance on raw materials ~ here combining aggregate from existing concrete on site with fly ash, an industrial by-product that would otherwise clog landfills [30]; 5) the light color of concrete reduces heat gain, reflects more light, and minimizes the urban heat island effect with savings of 18-20%.

Project Three

Figure 3: Light House

Light House incorporates Nanosolar SolarPly, a new 3D photovoltaic, solar electricity module in the design of the double roof system [31]. NSPV is 40 percent more efficient than standard SPV, delivering 120 watts per square inch at 110V. Integrated into the double roof system are a series of black rubber modules filled with water for hot water supply. The south-facing facade is equipped with specially-designed "light shutters" that reflect sunlight in the summer and maximize daylight in the winter. Eastern and western façades are characterized by panels with perforated metal screens. Various degrees of natural ventilation are accessed through perforated metal screens and sliding glass doors [See Fig. 3].

Bearing lightly on the earth, 80% of the project site of Light House remains pervious surface, applying a combination of ground surface textures including grass, gravel, grasscrete, and water retention areas. On-site water is retained into partially sunken aggregate parking areas that lead to horizontal retention troughs for filtration and grey water use. The staggered arrangement of the tower-dwellings produces the venturi effect, compressing the air through smaller passages, increasing it's velocity for optimal ventilation. The space "between" also maximizes daylighting, solar access, as well as generates complex views. The tower configuration also produces the stack effect. When the buildings are heated, the buoyant indoor air applies pressure to the envelope. As pressure increases with the height of the building, hot air rises and escapes at the top of the tower through "pressurized holes" in the double-skin roof system. The scheme was designed for smaller families, artists and artisans and students. Given the narrow dimension of the block and slope of the site, the "double-front" condition was one of the unique aspects of this scheme. By folding the ground, a slope is created to take advantage of the thermal constancy of the earth and to distinguish the residential and retail areas along the light rail.

Conclusion
Against perhaps too many green designers, a broader understanding of the environment ought to be respected and preserved beyond those that are merely green. This entails a kind of modesty about other competing criteria. A more contextually sensitive environmental architecture emerges out of a respect for the complexity of the human and natural condition. Embracing this complexity, with its built-in conflicts, ought to represent how we make human habitats. It is absurd to demand of any particular building that it embody every criteria we can come up with which would make it better. Encouragement of more responsible environmental design criteria is not a zero sum game. Built space always negotiates between competing demands and succeeds at some criteria better than others. This is in fact what makes particular spaces, and the people that occupy them, interesting, memorable, and inhabitable: it is their inherent complexity, their combination of success and failure in meeting competing expectations and demands that make them both human and natural.

Final density across Hulsey Yards was 30 units/acre. The lowest unit/acre on a single block was 20 and the highest 40. Density variation from block to block was perceived positively. Total added residential population on site was approximately 1,400 persons. In the end, maximum densities were trumped by seeking higher quality living conditions, defined in large part by creatively employing passive ecological design strategies. Overlaying urban agendas with ecological ones were demanding. Surprisingly the program type most familiar to students, namely multi-family housing, became the most difficult to grasp. This may be a by-product of

where most of our students grow up these days, the very problematic that this studio aimed to address.

In light of the current peak in oil production, Deffeyes concludes, "In a sense, the fossil fuels are a one time gift that lifted us up from subsistence agriculture and eventually should lead us to a future based on renewable resources" [32]. If the United States is to become a more sustainable place, existing under-developed urban territories have to be saved rather than abandoned on the way to making new projects. There is little point to build energy efficient buildings if transport and food miles are not first addressed. The bottom line of sustainability is not the individual low-entropy building but urbanism.

References

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[4] Kenneth S. Deffeyes, *What Happens When the Oil Runs Out*, The New York Times, March 25, 2005, update: February 11, 2006 at: http://www.princeton.edu/hubbert/current-events.html

[5] See U.S. Geological Survey

[6] Kunstler argues that the United States has developed a terrible pattern for human ecology, a poorly designed landscape of "automobile suburbs" that destroys economies, isolates us from one another, impoverishes our cities, and ravages our countryside. See Kunstler, James Howard, The Long Emergency: Surviving the Converging Catastrophes of the Twenty-first Century (New York: Atlantic Monthly Press, 2005).

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[13] Take for example New York's first "green skyscraper," the Conde Nast building at 4 Times Square. There is an attempt by the architects here to broadly aim to integrate human and non-human elements into a larger environmental rubric.

[14] U.S. Department of Energy, Energy Consumption Rate Data

[15] Dolores Hayden, *Building Suburbia: Green Fields and Urban Growth* (New York: Vintage Books, 2004), pp 225-29.

[16] Steiner, Frederick R. and George F. Thompson, eds., *Ecological Design and Planning* (New York: John Wiley & Sons, 1997).

[17] Ibid.

[18] Ingersoll, Richard, "A Post-Apocalyptic View of Ecology and Design," in *Harvard Design Magazine*, W.S. Saunders, ed., Sp/Su 2003, pp. 12-17.

[19] See Center for Disease Control (CDC) Active Community Environments Initiative (ACES) which suggests characteristics of our communities such as density of housing, availability of public transit and of pedestrian and bicycle facilities play a significant role in promoting public health.

[20] U.S. Census Bureau, 2000

[21] See: www.fanniemae.com/singlefamily/index.

[22] Atlanta Regional Commission, Housing Survey, 2004.

[23] 2004 American Housing Survey, U.S. Census Bureau.

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[27] Bennett, Michael and David W. Teague. *The Nature of Cities: Ecocriticism and Urban* Environments (Tucson: University of Arizona Press, 1999).

[28] Ibid.

[29] Concrete on site would also be recycled as grader asphalt base, crusher run or pipe bed material.

[30] In 2001, the concrete industry used 11,400,000 metric tons of fly ash, a by-product of coal combustion at electric power utility plants. The reinforcing steel in concrete is often recycled. Portland Cement Association.

[31] Nanosolar Inc., founded in 2002, has developed a commercial scale technology that can deliver solar panels at $1 per peak watt and solar electricity at 5 cents per kilowatt-hour. According to the CEO, Martin Roscheisen, the conversion efficiency (percentage of incident light energy converted to electrical energy) of the Nanosolar SPV cell was above 12 per cent for its first product prototypes.

[32] Kenneth S. Deffeyes, *Beyond Oil: The View from Hubbert's Peak* (London: Hill and Wang, 2005).