CHAPTER 1

Introduction

No man is an Island, entire of it self; every man is a piece of the Continent, a part of the Main; if a clod be washed away by the sea, Europe is the less, as well as if a promontory were, as well as if a manor of thy friends or of thine own were; any man's death diminishes me, because I am involved in Mankind; And therefore never send to know for whom the bell tolls; It tolls for thee.

—Devotions upon Emergent Occasions, Meditation 17
John Donne

In *Devotions upon Emergent Occasions,* the seventeenth-century English metaphysical poet John Donne wrote, "No man is an Island, entire of it self." Through this statement, Donne asserted that we all share a common humanity. In today's increasingly complex and interrelated world, not only is no man an island but, similarly, no building stands alone. Every building exists within an environmental context upon which it not only acts but which also has an impact upon the building. Due to today's increased complexity and interrelatedness, no building can be constructed as a microcosm. The people in charge of every building project must consider the impact it will have on the environment into which it will be placed, locally and globally.

Donne's assertion that no man is an island is also an affirmation of sustainability. *Sustainability* is commonly interpreted to mean living in such a way as to meet the needs of the present without compromising the ability of future generations to meet the needs of the future.[1] It is frequently compared to the Native American concept of consultation with the as yet unborn future generations for their input on significant decisions—decisions that might affect them. Sustainability is a social concept in that it considers the needs of the unborn. It is an environmental concept in that it addresses the effect of pollution and resource management (or lack thereof) on Earth's ecological systems. Further, it is an economic concept in that it seeks to quantify the tolerable limits for consumption such that we can live on Earth's interest instead of depleting the principal. It is a perspective that focuses on systems and relationships instead of objects.

The term *sustainability*, once rare to find in a dictionary, has in the last few years begun to appear with more regularity. While the spell check on your personal computer may stumble over the word, many online dictionaries such as yourdictionary.com and OneLook.com now include the term. *Sustainability* can also now be found in online encyclopedias such as Wikipedia. Use of the term has quickly become widespread. Another term that has come into common usage is *high-performance building*. A high-performance building is one whose energy, economic, and environmental performance is substantially better than one designed by standard practice. It is a building that is healthy to live and work in and that has a relatively low impact on the environment.[2] The term *green* has also become part of our working vocabulary. It is now used not only as a name for a particular color but as an adjective meaning "environmentally friendly." It refers to the color of lush, healthy, unpolluted vegetation. Some local and regional programs use *blue* in a similar manner to indicate the idea of cool, clean, unpolluted water or air. *Brown* is indicative of dirty, barren, polluted areas, and has entered the industry vocabulary as a term referring to contaminated sites, *brownfields*. Like the terms *sustainability, green,* and *high-performance building, integrated design* is now in common usage. Integrated design describes a process used to design and construct a building in such a manner so as to promote sustainability. The integrated design process encourages all members of the building team to work together from the earliest stages of project development to achieve high performance and sustainability in the design. *Green,* like the other terms, has entered the vernacular. Thus, *a green building* is not, the shade of paint, but on the impact the building has on the environment. Simply stated, a green building is one that is located and constructed in a sustainable manner and that is designed to allow its occupants to live, work, and play in a sustainable manner.

The growth of interest in green buildings has led to the development of rating systems such as the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED®) Green Building Rating System and in green building material rating systems such as the National Institute of Standards and Technology's (NIST) BEES (Building for Environmental and Economic Sustainability) program.

Over the last decade, interest in green issues among those in both the building industry and the general public has grown considerably. Today, the proliferation of green articles, conferences, publications, websites, electronic newsletters, and projects attest to an increasing consciousness. We have been made aware, in no uncertain terms, that we are a dirty and wasteful species. Each of us has had to accept responsibility for our part.

The United States generates more waste than any other nation. Each day, we produce enough garbage to fill 63,000 garbage trucks, which "lined up . . . would stretch from San Francisco to Los Angeles (about 400 miles)."[3] For many American schools, the amount of money spent on trash disposal is at least equal to that spent on textbooks.[4] The building industry alone accounts for approximately 20 percent of the waste stream.[5] "The U.S. Environmental Protection Agency (EPA) estimates that approximately 136 million tons of building-related [Construction & Demolition (C&D)] debris were generated in 1996—the majority from demolition (48 percent) and renovation (44 percent). New construction generated only 8 percent of building-related C&D debris."[6] "The United States Geological Survey has estimated that construction accounts for 60 percent of all materials used in the United States for purposes other than food and fuel."[7]

We waste energy. The U.S. Department of Energy has estimated that improvements in the energy efficiency of buildings, utilizing existing and readily available technologies, could save $20 billion annually in the United States and create 100,000 new jobs.[8] A significant percentage—40 percent—of the world's energy usage is dedicated to the construction and operation of buildings.[9] Even more is indirectly mandated by the thoughtless siting of buildings relative to each other. Urban sprawl has been denigrated for its negative impact on quality of life. People regularly complain about the time devoted to traveling across town or the unfortunate aesthetics of their surroundings. However, as environmentalists will quickly tell you, urban sprawl is guilty of damaging the environment both directly and indirectly. It directly damages the environment as inexpensive fringe property is hastily and wastefully paved over, and indirectly as the hundreds of thousands of energy-burning vehicles drive past to conquer the next bit of fringe real estate.

We also waste our natural resources. Over 50 percent of the wetlands of the contiguous United States have been destroyed—filled, contaminated, or otherwise "reclaimed."[10] The destruction of wetlands and other natural resources has become much more efficient with technological advances. In recent decades, " . . . the average annual rate of deforestation worldwide was approximately equivalent to an area the size of the state of Georgia."[11] James Lovelock, creator of the GAIA theory[12], has predicted that, at current rates of deforestation, we will have lost 65 percent of all the forest of the tropics by the end of this century. This is a critical threshold. "When more than 70 percent of an ecosystem is lost, the remainder may be unable to sustain the environment needed for its own survival."[13] The building industry commandeers 3 billion tons of raw materials annually—40 percent of total global use.[14] It uses almost half of all the mined, harvested, and dredged raw materials each year! It also diverts 16 percent of global fresh water annually.[15] Most of the earth's water is located in our oceans and is too salty for residential, commercial, or industrial use. Only 3 percent of the water on the planet is fresh, and most of that is located in polar ice. Of all the water on the planet, only about 0.003 percent is readily available as fresh water for human use.[16] The 16 percent annual usage estimate accounts for the quantity of water required to manufacture building materials and to construct and operate buildings. It does not reflect the impact of the building industry on the quality of water. It is entirely possible that future estimates of the percentage of available fresh water will decrease as we continue to contaminate our limited supply.

At some point, with continued unlimited growth, demand will exceed our resources. But at what point? There is a great deal of debate over the exact numbers. How much fossil fuel do we have left? Enough for 10 years? 100 years? Determining the exact limit causes genuine concern because we want to know how much we can use—and, of course, how much is it going to cost.

According to the United Nations Population Fund reports, from the beginning of time until 1950, the world population grew to almost 2.5 billion people; from 1950 to 1990, that population doubled; and by 2050, the world will add almost 2.5 billion people, an amount equal to the world's total population in 1950.[17] The same resources we are now using will have to support nearly 9 billion people. Each additional person requires food, clothing, shelter, and assorted amenities. Most of this growth is anticipated in Asia and in developing countries. Currently, these areas do not have the same standard of living that developed nations do, but they are actively attempting to acquire it. Also, these areas produce the majority of the raw materials, the renewable and nonrenewable resources that developed nations use to achieve their higher standard of living. As available resources per capita decrease, the costs will increase; there is even a question as to whether or not the developing nations, as they industrialize and acquire not only the need for but also the capacity to process their raw materials, will continue to supply raw materials to the previously developed nations.

A simple objective comparison of available resources to increasing human demands indicates that the system, as currently functioning, cannot continue indefinitely. Use of nonrenewable resources must stop, either voluntarily or involuntarily. Proponents of sustainability opt for the voluntary method.

Sustainable approaches focus on two questions:

1. What are we using?
2. How well are we using it?

What we are using may be perpetual resources, resources that are "virtually inexhaustible on a human time scale,"[18] such as solar, wind, or tidal energy; renewable resources, resources that can be replenished through natural processes in a relatively short time, such as trees and water; or nonrenewable resources, resources that require millions or billions of years to be replenished through geological, physical, and chemical processes, such as aluminum, coal, and oil.

The law of conservation of matter states that matter can be neither created nor destroyed. What we have inherited—perpetual (exclusive of the solar input), renewable, or nonrenewable—is, ultimately, all we've got. We can take some from here and move it there, reshape it, burn it, bury it—but it's all we are going to get. What existed at the beginning of time is what we have now.

A significant ecological aspect of the law of conservation of matter is that matter goes through cyclical transformations. Matter cycles from physical reservoirs into biological reservoirs and back again. Water, for example, regularly travels through rivers, lakes, oceans, and the atmosphere, making detours through plants and animals (e.g., humans). Through transpiration, plants transfer water from the soil to vapor in the air. The rising vapor condenses to form clouds; rain falls, trees grow. Water vapor also condenses over the ocean. Algae in seawater produce dimethyl sulfide, which provides cloud-condensing nuclei, the particles that water condenses around to form clouds. The cloud cover lowers the temperature, causing differentials in temperature and air movement. The cloud collides with a land mass—rain.

There are some interesting environmental corollaries to the law of conservation of matter. If matter cannot be created, we never really get anything new, and we never really throw anything away. We just move it around and combine it with different materials. Therefore, we are drinking the same water that has traveled through the cycle over and over and over since day one. And, if we deposit chemicals into a stream, they are likely to travel with the water to the next location in the cycle, and the next. Ultimately, everything is in your own backyard. The time a water molecule stays at any one point in the cycle is as follows:[19]

Location	*Residence Time*
Atmosphere	9 days
Rivers	2 weeks
Soil moisture	2 weeks to 1 year
Large lakes	10 years
Underground water at slight depth	10s to 100s of years
Ocean mixed layer to a depth of 55 yards	120 years
Seas and oceans	3,000 years
Underground water at depth	up to 10,000 years
Antarctic ice cap	10,000 years

The question of how well we use our perpetual, renewable, and nonrenewable resources must be answered in terms of our effect on the quality of the resource and our impact on the cycle of the resource (rate of flow, diversion, etc). According to the EPA, "In 2000, states, tribes, territories, and interstate commissions report that about 40% of streams, 45% of lakes, and 50% of estuaries that were assessed were not clean enough to support uses such as fishing and swimming."[20] That survey included only 19 percent of the nation's 3.7 million miles of rivers and streams, and only 43 percent of the nation's 40.6 million acres of lakes, reservoirs, and ponds. According to the Index of Watershed Indicators for 2002, only 15 percent of the nation's watersheds had relatively good water quality.[21] Hose down your driveway and you have diverted a portion of the daily one-third of flowing water in the country and added to it an assortment of petroleum products, pesticides, herbicides, and debris that will flow down the street into the stormwater system. Thermoelectric power generation is responsible for nearly half of the annual water withdrawals in the United States, amounting to approximately 195 billion gallons per day in 1990.[22] A significant pollutant that power plants add to the water is waste heat.

The options for greener use of a resource are often complicated by political and economic factors. Water quite visibly travels across borders and is subjected to a variety of social, economic, and political values along the way. Of the 200 largest river systems in the world, 120 flow through two or more countries. Access to shared resources has triggered numerous conflicts over the centuries. Witness the tension in the Middle East. The 1967 Arab-Israeli war was fought, in part, over water rights to the Jordan River. The conflicting demands of agricultural, industrial, and urban uses are felt not only between countries but also between and within states. The Los Angeles aqueduct project infuriates Northern California. The mighty Colorado River has so many users that it is virtually dry at its end.

While sustainable approaches could benefit from political advances and new technologies, many simple and innovative options are currently available. Many not only improve the manner in which we use our resources but also have financial benefits. For example, a water recirculation system reduced the amount of water the Gillette Company used to make razor blades from 730 million gallons to *156 gallons* per year. Companywide, Gillette now saves approximately $1.5 million a year in water and sewage bills.[23]

Harrah's Hotel and Casino in Las Vegas asked its customers whether they wanted their sheets changed every day. Most said no. Harrah's reduced "its energy and water costs for cleaning sheets by $70,000 per year."[24] By utilizing a landscaping technique called *xeriscaping*, which relies on native plants instead of water-intensive imported plants, Valley Bank in Tucson, Arizona, realized a $20,000 per year savings.[25]

The Earth has evolved thousands of intricate, delicately balanced cycles, each of which is woven into increasingly more complex systems to create the overall single system that is our world. The prospect of living sustainably in the midst of such complexity can be overwhelming. Some respond with a deus ex machina confidence that technology will "solve" the problems, whatever they are, or that nature will adjust as necessary. Others, overwhelmed by the enormity of the challenge, reassure themselves by asserting that the impact one individual can make is negligible. Technology may solve *some* problems, but only if we focus our attention on those problems and seriously endeavor to understand them. Nature *will* undoubtedly adjust; the question is whether or not that adjustment will involve the eradication of our species. And individual impact *does* add up, regardless of whether or not you choose to see the aggregate. Furthermore, history books are full of individuals who had tremendous cultural, economic, political, and environmental impact. As the anthropologist Margaret Mead pointed out, "Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it is the only thing that ever has." Solving all the problems simultaneously is as unrealistic as avoiding them. A more constructive approach is to do what you can and continue improving. Maintain the deep dark green goal, but don't let the fact that you are a few shades lighter stop you from achieving even that much.

Can you, as a designer or building owner, envision a building that neither imports nor exports material or energy during construction? during operation? If not, can you envision a trade for the imported or exported material that will balance in a larger picture? To determine how closely you come to this goal, ask these questions: What am I using? How well am I using it?

With a basic appreciation of the law of conservation of matter, the answer to the first question will have implications for the impact of your choice on our natural resources and on the relative healthfulness of our environment. These two topics—resource management and toxicity—are valuable tools for evaluating materials. The answer to the second question will have implications for the performance of the material. Performance issues include durability, energy efficiency, amount of waste generated, and potential for reuse or recycling. Performance is also a valuable tool for evaluating the greenness of a material.

Life Cycle Assessment (LCA) is the formal methodology for answering these questions. LCA is a process that investigates the impact of a product at every stage in its life, from preliminary development through obsolescence. At each stage, you look at the materials and energy consumed and the pollution and waste produced. Life stages include extraction of raw materials, processing and fabrication, transportation, installation, use and maintenance, and reuse/recycling/disposal. To date, there is no single accepted LCA methodology. Experts are still trying to define precisely what is meant by *life cycle assessment*. Groups as diverse as the EPA, ASTM International, the Society of Environmental Toxicology and Chemistry (SETAC), the National Institute of Standards and Technology (NIST), and the International Organization of Standardization (ISO) each have worked on creating an outline of the process. Nevertheless, there is general consensus regarding the concept of LCA and its usefulness in quantifying sustainability.

Selection of materials is only one part (albeit an important one) of making a green building. The LCA methodology helps us visualize the link between the big picture and the details while bringing us that much closer to the goal of living sustainably. This point is emphasized by inclusion of the LCA approach specified in ISO 14000 standards in the BEES software. A future version of the LEED Green Building Rating System is scheduled to include LCA methodology as well.

Every human endeavor has as its basis a condition or state of being we wish to attain. Call it an ideal of perfection for which we strive. In order to make our struggle more manageable, we break our efforts into smaller pieces called *goals*. Goals are the steps we can take on the path toward our ideal. Within the context of the subject of this book, our ideal can be described as a world of buildings that are located, constructed, and designed in a sustainable manner and that allow their occupants to live, work, and play in a sustainable manner.

An inherent quality of an ideal, of perfection, is that it is unattainable. This should not discourage us from making changes in the status quo. With a limited investment of time, money, and research, it is relatively easy to make measurable improvements. That is the crucial point: If you shift your paradigm from simple black-and-white answers to shades of gray (or should we say green), then the possibilities for environmental successes are unlimited.

The subject of green buildings has been widely discussed and often written about. This book does not attempt to be an exhaustive text on the pros and cons of going green. It also does not try to engage in a detailed discussion of green buildings. Many fine books are available on both subjects.

The goal of this book is to help designers and other members of the building construction team better understand the green building material selection and specifying process. By attaining this goal, we hope to take one more step toward reaching our ideal.

Notes

1. In the words of the landmark World Commission on Environment and Development (the Brundtland Commission), we should "meet the needs of the present without compromising the ability of future generations to meet their own needs." Cited in Joel Darmstadter, *Global Development and the Environment: Perspectives on Sustainability,* Resources for the Future, Washington, D.C., 1992.
2. U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy High Performance Buildings, http://www.eere.energy.gov/buildings/highperformance.
3. Valerie Harms. *The National Audubon Society Almanac of the Environment: The Ecology of Everyday Life* (New York: G.P. Putnam's Sons, 1994), 93.
4. *The Denver Post 1991 Colorado Recycling Guide.*
5. EPA Municipal Solid Waste Programs Division.
6. EPA Document EPA530-N-02-003, "WasteWise Update: Building for the Future," 2002, http://www.epa.gov/wastewise/pubs/wwupda16.pdf.
7. USGS Fact Sheet FS-068-98, "Materials Flow and Sustainability," 1998, http://pubs.usgs.gov/fs/fs-0068-98/fs-0068-98.pdf.

8. Department of Energy, "North American Energy Measurement and Verification Protocol," March 1996, DOE / EE-0081, p. 1.
9. David Malin Roodman and Nicholas Lenssen, Worldwatch Paper 124, "A Building Revolution: How Ecology and Health Concerns Are Transforming Construction" (Washington, D.C.: Worldwatch Institute, March 1995), 23.
10. National Science and Technology Council, *Technology for a Sustainable Future: A Framework for Action* (Washington, D.C.: Government Printing Office, 1994), 32.
11. Ibid.
12. James Lovelock first put forth the Gaia Hypothesis in 1969, and published the theory in his book *Gaia: A New Look at Life on Earth* in 1979. With the Gaia Hypothesis, Lovelock proposed that our planet is not just a space occupied by a variety of living things, but is a collection of living things that act together as a single living organism.
13. James Lovelock, *Healing Gaia: Practical Medicine for the Planet* (New York: Harmony, 1991), 157.
14. Roodman and Lenssen, "A Building Revolution," 22.
15. Ibid.
16. G. Tyler Miller, *Living in the Environment: An Introduction to Environmental Sciences*, 7th ed. (Belmont, Calif.: Wadsworth, 1992), 334.
17. United Nations Population Fund, "State of World Population," 2004.
18. Miller, *Living in the Environment*, 10.
19. World Resources Institute, *1994 Information Please Environmental Almanac* (New York: Houghton Mifflin, 1994).
20. EPA Document EPA-841-R-02-001, National Water Quality Inventory, 2000 Report, www.epa.gov/305b.
21. EPA Office of Wetlands, Oceans, and Watersheds, "Index of Watershed Indicators: An Overview," 2002, www.epa.gov/iwi/.
22. Stephen A. Thompson, *Water Use, Management, and Planning in the United States* San Diego, Calif.: Academic Press, 1999), 125, 127.
23. Joel Makower. *the e factor: the bottom-line approach to environmentally responsible business*, (New York: Tilden Press, 1993), 217.
24. Joseph J. Romm, *Lean and Clean Management: How to Boost Profits and Productivity by Reducing Pollution* (New York: Kodansha, 1994), 4.
25. Makower, *the e factor*: the bottom-line approach to environmentally responsible business, New York, NY; The Tilden Press, 1993, p. 217.