Second Edition

SUSTAINABLE HEALTHCARE ARCHITECTURE

ROBIN GUENTHER, FAIA, LEED AP
GAIL VITTORI, LEED Fellow

WILEY

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"Our lives are touched by those who lived centuries ago, and we hope that our lives will mean something to those who will live centuries from now. It's a great 'chain of being,' someone once told me, and I think our job is to hope, to dream and to do the best we can to hold up our small segment of that chain."

Dorothy Day

For Perry Gunther and Pliny Fisk III

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FOREWORD

THE GREEN BUILDING MOVEMENT is guided by a simple, yet revolutionary, idea: that the buildings in which we live our lives can nurture instead of harm, can restore instead of consume, and can inspire instead of constrain. The business case for green building is highly compelling, and it is a large part of the reason that we have made such great strides in the last fifteen years. But it is important for us to remember that at its core, green building is about making the world a better place for people to live. In the second edition of *Sustainable Healthcare Architecture,* Robin Guenther and Gail Vittori present their essential guide to sustainable design and environmental stewardship for the healthcare industry. The second edition builds upon the groundbreaking first volume, detailing how resilient and regenerative design is transforming the sterile, imposing facilities of the past—replacing them with buildings that are filled with daylight, connected to nature, and, above all, designed to promote health and well-being and combat climate change.

The way we design, construct, and operate buildings has a profound impact on our health and the health of our environment. For too many years, the impact has been negative, from carbon dioxide emissions and construction waste to the wanton use of energy, water, and natural resources. Often, indoor air is more polluted than the air outside and has been linked to illnesses ranging from asthma to cancer.

That's the bad news. But the positive corollary is that changing the way we build offers unprecedented opportunities to have a positive impact on human and environmental health. Green buildings consume fewer resources, generate less waste, and dramatically curb emissions. The people who live, work, learn, and heal in green buildings are healthier, happier, and more productive. And the communities we build with green homes, offices, schools, and hospitals are the foundation of a healthy, prosperous future for generations to come.

The convergence of these opportunities in the healthcare sector has brought us to a watershed moment for both the green building movement and the healthcare industry. Healthcare has a huge influence on our nation's economy and politics, and in no other sector are the human health impacts of buildings more explicit or more important. With the healthcare industry's leadership, we can dramatically advance green building throughout the marketplace, while increasing our focus on critical public and human health issues.

Meeting patient needs is a hospital's top priority. Through what some experts are now terming "healing architecture,"[1] several studies have shown that elements of green building can positively influence patient health, leading to faster healing times and shorter hospital stays. One study found that more than 60 percent of patients in rooms with high levels of indoor daylight were hospitalized for a shorter period of time than those with less daylight exposure.[2]

Compared to other building types, healthcare facilities have an especially large impact on the environment. Operating those buildings to meet patient needs consumes tremendous energy and resources; hospitals use twice as much energy per square foot as office buildings and spend nearly $3 billion each year on electricity alone.[3]

Protecting the environment is a natural and necessary extension of this mission—as this book makes clear, you can't have healthy people on a sick planet. In the last decade, healthcare has made remarkable changes in its operations, such as creating safer, "no-burn" waste management practices and eliminating the use of mercury-based products. But the fact is that the healthcare sector can—and must—do more. Climate change is a ticking clock, a threat to the very systems on which we depend for life. Transforming the design, construction, and operations of our buildings is our best chance to stop time.

The U.S. Green Building Council (USGBC) was founded in 1993 with a mission that was at once wildly ambitious and terribly urgent: to transform the building industry to sustainable practices. The origins of this mission can

1 Aripin, S. Healing Architecture: Daylight in Hospital Design. Conference on Sustainable Building, South East Asia, November 5–7, 2007. Retrieved from http://mrt.academia.edu/RafidRifaadh/Papers/711511/HEALING_ARCHITECTURE_DAYLIGHT_IN_HOSPITAL_DESIGN.

2 Choi, Joonho and Liliana Beltran. Study of the Relationship between Patients' Recover and Indoor Daylight Environment of Patient Rooms in Healthcare Facilities. Proceedings of the 2004 ISES Asia-Pacific Conference. Retrieved from http://faculty.arch.tamu.edu/lbeltran/Pubs/Choi_Beltran_AsiaPacific_2004.pdf.

be traced to the energy crisis of the early 1970s, which prompted the architectural community to focus on energy efficiency in buildings. But recognizing that sustainability is about more than energy, architect Bob Berkebile asked a question that would fundamentally change the way we think about our built environment: "Are our designs improving quality of life, health, and well-being, and the quality of the neighborhood, community, and planet?"

USGBC was conceived as a coalition comprising every sector of the building industry, working together to transform the marketplace. Guided by the passion, vision, and commitment of early leaders like Berkebile, Bill Browning, and countless others (many of whose names you will find in this book's table of contents), we developed the LEED Green Building Rating System, a holistic framework for sustainable building design, construction, and operations.

Since its launch in 2000, LEED has been the catalyst for the explosive growth of the green building movement. Currently, nearly two billion square feet of building space has been built to LEED standards, with another 6.4 billion awaiting LEED certification. Organizations ranging from rural school districts to Fortune 100 companies have embraced LEED and green building as an immediate, measurable solution to the critical challenges ahead of us. More than 1,400 healthcare facilities have already embraced LEED.

To better support the healthcare sector's transformation to sustainability, USGBC developed LEED for Healthcare. Recognizing the unique challenges of hospital buildings, LEED for Healthcare affirms that a hospital's fundamental mission is to heal—placing emphasis on issues such as increased sensitivity to chemicals and pollutants; acoustical design; and access to daylight, nature, and the outdoors. Drawing upon the work of the environmental health advocates and healthcare industry leaders chronicled in these pages, LEED for Healthcare demonstrates that meeting patient and staff needs does not preclude meeting environmental needs. Instead, the goals are complementary, so interwoven as to be inseparable.

The current interest in green building results from the coincidence of our growing awareness about climate change with an ever-more-impressive business case. But there is another, equally important reason for building green: the direct impact building design has on human health and well-being. It doesn't make the *Wall Street Journal* as often as statistics about ROI and lease rates, but the way buildings make people feel is an essential part of the story. In the case of hospitals, we have ample evidence that design, construction, and operations are key determinants of patient health and staff well-being and productivity. Embracing green building is not just an opportunity to do what's right for the environment; it is also an opportunity for the healthcare industry to help us broaden and refine the definitions of green building to include human health and vitality.

In fact, the opportunities are endless. Sustainable design is bridging the traditional boundaries of building type, linking our homes and our schools and our hospitals with the common language of green building. By articulating green building in the context of health, the healthcare industry can help us to define the architecture of the twenty-first century. Together, the green building movement and the healthcare industry can enter a new era, one that is connected to the global imperatives of climate change, global toxification, freshwater shortages, and resource depletion—and one that recognizes how these imperatives are interconnected.

So how do we get there? In the end, green building comes down to people. Every green building, every LEED rating system, every new technology, happens because a passionate, committed person makes it happen. We see it in the projects and people described in this book, and we see it in the leadership of Robin Guenther and Gail Vittori. It has been my great privilege to know and work with both Robin and Gail for many years and to be part of a movement that has benefited so greatly from their vision. With this book, Robin and Gail show us how critical our green building mission is to the future of human health and secure a lasting legacy that will continue to challenge and focus the green building movement, the healthcare industry, and the world for years to come.

RICK FEDRIZZI
President, CEO, and Founding Chairman,
U.S. Green Building Council
Washington, D.C.

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3 Choi, Joonho and Liliana Beltran. Study of the Relationship between Patients' Recover and Indoor Daylight Environment of Patient Rooms in Healthcare Facilities. Proceedings of the 2004 ISES Asia-Pacific Conference. Retrieved from http://faculty.arch.tamu.edu/lbeltran/Pubs/Choi_Beltran_AsiaPacific_2004.pdf.

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SINCE BEGINNING THE FIRST EDITION of this book in early 2005, we have shared this journey with so many others. In 2010, Stephen Verderber published *Innovations in Healthcare Architecture*, citing our first edition as a major influence. This second edition of our book owes him a similar debt of gratitude—we are incredibly grateful for both his cogent thinking and intelligent framing of ecological design. Likewise, Thomas Fisher's writing on designing to avoid disaster is a critical and timely critique of building design. Ironically, it was Hurricane Katrina that catalyzed Stephen's idea set; the 2011 Fukushima nuclear power plant disaster that catalyzed Thomas Fisher's; we can describe the recent extreme drought in Texas and Hurricane Sandy as having a similar impact on us. We live in strange and interesting times, when weather events define both our psyche and our approach to scholarship.

This edition would not have come to completion without the amazing skills of our team—Patrick J. Roche, Himadri Sinha, Lindsay Franta, and Michelle DeForrest—who worked with the case study teams and tracked the images, and particularly Patrick, who designed the graphics and icons. Breeze Glazer, Perkins+Will, took the lead in organizing our updated research on the business case and researched a number of case studies. Special thanks to an impromptu focus group of our colleagues at Perkins+Will New York, who reviewed the drafts of the Global Survey projects and offered sage observations and advice. Blair McCarry, Perkins+Will, coached us through the metric conversions. Matt Kania and John Cotter assisted with organizing the maps. Marc Sansom, from the International Academy of Design and Health, introduced us to a number of the project teams. And thanks again to John Czarnecki, formerly with Wiley, who set us on this journey by posing the simple question about writing this book, and to Kathryn Bourgoine and Danielle Giordano, who picked up where he left off and gracefully and patiently stewarded us through this process. We also acknowledge the contributions of Maya Sheppard and Dylan Siegler on the first edition, whose work carries forward in this second edition.

We owe special thanks to the U.S. Green Building Council: Rick Fedrizzi, who generously offered once again to author our Foreword; Lonny Blumenthal, Mira Panek, and Chris Pyke, who assisted with accessing LEED data. Romilly Madew, from the Green Building Council of Australia, provided information on Greenstar for Health. Our essayists—many of them authors in their own right who have influenced our professional development—inspired us through their collective contributions (they are listed individually in the contributor list). We continue to marvel at our first edition essayists' wisdom and foresight: we hope the excerpts we have retained in this edition inspire many of our readers to seek out their work.

There are a few special individuals in our journey that deserve mention, including Jamie Harvie for his inspiring work on the Commons, Janet Brown for her enthusiasm for greening healthcare, and some of our other colleagues from the Green Guide for Health Care and LEED for Healthcare work, including Steve Guttmann, Jean Hansen, Adele Houghton, Tom Lent, Clark Reed, Kim Shinn, Jerry Smith, Scott Slotterback, and Walt Vernon—who are tireless in pushing the boundaries.

U.S. healthcare systems, collectively, are doing amazing work around sustainable design and operation. It was difficult to select a representative group! For their leadership and inspiration (as well as their thoughtful graphics and work products), we thank Sonia Roschnik (NHS); John Messervy and Hubert Murray (Partners HealthCare); Richard Beam and Geoffrey Glass (Providence Health & Services); Jeff Rich, Janelle Roghair, Tom Thompson, Corey Zarecki (Gundersen Health System) with Lin Hill (Practice Greenhealth); and John Kouletsis, Jeff Keyak, and Susan Saito (Kaiser Permanente).

The fifty-five case study teams, collectively, are actualizing extraordinary and innovative healthcare projects—breaking new ground every day in the service of a socially just and ecologically informed vision of healthcare. Over eighteen months, they tolerated our multiple requests for information, reviewed drafts of text, and assisted us while continuing to advance the industry. Teams include: Julian Weyer, CF Moller (Akershus); Sheri Besford, BDP (All Ukranian Health); Denis Bouvier, groupe-6 (Arras Hospital); Camila Morley, David Morley Architects (Bluestone Unit);

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And most importantly, thank you to Perry Gunther and Pliny Fisk III, who once again experienced what it means to have life partners buried in books (this time for even longer than before) with a shared aspiration that all of this is contributing to healthcare's transformation. Perry, thank you for your inspiring photos and good spirit through a whirlwind tour of European hospitals. Pliny, thank you for your relentless encouragement to learn from the edge. A special thanks to our parents, who instilled in us a sense of purpose and possibility; Robert Guenther, Eleanor Guenther Wells; Francis Charles Vittori and Doreen Dorothy Vittori. During our journey toward this edition, our first grandchild arrived to remind us of "the great chain of being"—Mela, the first of a new generation that will inherit the consequences of our collective actions. And finally, thank you all for your love, support, and encouragement through a seemingly endless process; and thank you to our children, Jyllian, Nicole, Ariel, Carson, Adam, and Noah, whom we know understand that this crazy life we lead is, after all, dedicated to their future. Imagine if we just tended the garden!

KEY SUSTAINABILITY INDICATORS

WHAT MAKES A BUILDING GREEN? Sustainable Healthcare Architecture defines thirty-one key sustainability indicators organized in six categories to measure performance: site planning; form + facade; water; energy; materials + construction practices; community. While not exhaustive, these indicators address a range of performance-based strategies that align with resilient, regenerative, and healthy buildings. Definitions of indicators are below, each with a unique icon. For some, specific benchmark performance thresholds establish a basis for recognition. For example, Low-EUI is highlighted if the project's modeled or actual energy use intensity is ≤120 kBtu/sf/yr (335 kWh/sm/yr). For others, multiple project-specific qualitative strategies aggregate to qualify for recognition. Each case study includes the collection of icons that characterize its sustainability profile; 21 of these indicators are compared on the infographic that follows.

Site Planning

Connection to nature

The building design prioritizes views of nature, incorporates biophilic design elements or therapeutic landscape, with the express intent of connecting building occupants to the natural world to promote healing

Habitat restoration

The landscape design contains specific elements that foster natural habitat restoration; restoration of native landscape species, natural hydrology, enhancement of wildlife corridors or specific restoration of degraded ecosystem services

Innovative stormwater management

Stormwater runoff is mitigated through absorptive site 'green infrastructure' elements such as swales, permeable surfaces and catchment systems

Brownfield site

A site whose use has been compromised by the presence of a hazardous substance or pollutant, and that, through remediation, can be safely redeveloped with appropriate cleanup of contaminants

Transit access

Provision of on- or near-site transit stop, extension of mass transit system or shuttle systems that connect building occupants to systems that offer alternative transportation options to single-occupancy vehicles

Innovative parking

Includes alternative to surface paved parking lots; permeable paving, significantly reduced parking quantity, structured/tuck-under parking are all examples of innovative parking solutions. Projects that have no additional parking qualify

Form and Facade

Climatic/bioregional design

Building form, orientation and construction designed to collect, store, and distribute solar energy and daylight; design that highlights the unique ecology of the bioregion, emphasizes local knowledge, customs, and solutions

Narrow floor plate

Planning that prioritizes access to light and air through either narrow building footprint (i.e., less than 78 feet (24 meters)) or larger floorplates that introduce interior courtyard(s) to provide an increased number of occupied spaces with daylight and views

Energy Responsive Facade

Envelope and fenestration strategies that modulate thermal performance through facade-specific exterior or building-integrated shading devices and high performance glazing, double-skin construction, or building-integrated photovoltaic facade systems

Green Roof

A vegetated roof using intensive or extensive planting methods to provide habitat, sound attenuation, thermal performance, roof longevity, and a visually stimulating roofscape

Water

Water Use Reduction

Reduction of potable water use resulting from the use of low flow indoor plumbing fixtures, water-conserving landscapes and irrigation equipment, and water-recirculating mechanical equipment

Rainwater Harvesting

The collection of rainwater from roofs, walls, and hardscapes in tanks or water bodies that reduces stormwater runoff and can be reused, with appropriate filtration, for potable and non-potable uses

Reclaimed Water Reuse

Collected condensate or other gray or black wastewater that is distributed for reuse after secondary or tertiary treatment, or utilization of large municipal-scale “purple pipe” systems; in this assessment, irrigation as a singular reuse strategy does not qualify.

Onsite Wastewater Treatment

The onsite treatment of gray- or blackwater using biological or chemical methods that results in water quality suitable for potable or nonpotable reuse, or to enable safe discharge into aquatic ecosystems

Energy

Low Energy Use Intensity (EUI)

Low EUI hospitals are defined as those with energy demand ≤120 kBtu/sf/yr (335 kWh/sm/yr); low EUI ambulatory facilities with energy demand ≤80 kBtu/sf/yr (252 kBtu/sf/yr), inclusive of plug load

Innovative Source Energy Systems

Innovative source energy systems include ground-coupled thermal energy systems, combined heat and power (CHP), tri-gen, fuel cell, or biomass- or landfill gas–fired condensing boilers and/or heat recovery chillers

Innovative Energy Distribution Systems

Innovative ventilation systems include displacement, underfloor air, low-velocity fan-wall technology, and mixed-mode systems; innovative conditioning systems include passive strategies such as thermal mass (i.e., night flush cooling systems) and thermal labyrinths; active strategies such as chilled beams and radiant/hydronic distribution systems

Natural Ventilation

Projects may incorporate mixed-mode ventilation systems or rely on natural ventilation in all or part of the program area. The presence of operable windows alone does not meet this intent; operable windows must be part of a natural ventilation strategy

Onsite Renewable Energy Systems

Inclusion of onsite renewable systems such as wind turbines, solar, thermal, or photovoltaics (PV) that directly meet energy needs or are grid-connected to offset fossil fuel use; biomass or landfill gas–fired boiler/turbine or fuel cell systems, if located onsite, are also included

Heat Recovery

Projects that incorporate heat recovery technologies to utilize waste heat from plant elements or building exhaust streams

Occupant Control

Thermal, lighting, and window blind controls that can be accessed and used by occupants of single- and multi-occupant spaces

Energy Display

Inclusion of public display for energy performance or integration of building performance with occupant behaviors

Materials + Construction Practices

Low Embodied Energy Materials

Encompasses local and natural materials that reduce extraction and transportation impacts, indigenous or minimally processed materials

Healthy Materials

Construction and interior finish materials and furnishings manufactured without added carcinogens, mutagens, teratogens, reproductive or other persistent bioaccumulative toxicants, and are protective of human health through the life cycle

Prefabrication/Modularity/Adaptability

Projects that include on- or offsite prefabrication of systems and building components, focus on modular components to decrease waste, and buildings that focus on long-term programmatic adaptability to completely different uses

Recycled Content Material

Materials and products manufactured with pre- or postconsumer recycled content

Acoustics

Sound attenuation strategies that locate and orient patient care and staff work areas to minimize externally and mechanically generated noise, and that employ products, materials, and design strategies that limit noise and diminish sound transmission

Safe Construction Practices

Adherence to protocols implemented on the construction site that are protective of worker health and safety, and of the broader public health, including use of low- and non-emitting construction equipment, noise reduction, and proper use of personal protection equipment

Community

Civic Function

Provide community benefit including free and reduced-fee patient services, space for community meetings, new community-based economic development and employment opportunities; program uses beyond healthcare services such as retail, transit stations, health clubs, daycare, schools, or libraries that foster community connectivity

Resilience

Incorporate explicit provisions for passive survivability and/or resilience in the face of health pandemics or extreme weather events; strategies include dedicated pandemic management facilities, "safe haven" provisions, locating critical infrastructure above floodplains, onsite renewable energy infrastructure for disaster management

Food Production

Onsite food production located on rooftops, in greenhouses, or on land used by the facility's food services department for patient, staff, and visitor meal preparation

INFOGRAPHIC '13

The Sustainable Healthcare Architecture (SHA) Infographic '13 aggregates twenty-one of the thirty-one key sustainability indicators for the fifty-five case studies in the book, color-coded by category. On the individual project scale, each "wedge" serves as an at-a-glance summary of its indicators, and the circle provides an opportunity to compare projects. The fifty-five case studies, which vary in scale, typology, and location, were each selected based upon a demonstrated level of innovation that sets them apart from the general field of sustainable healthcare.

On the aggregate scale, the intensity of implementation, as represented by the circular pattern of highlighted cells associated with a specific sustainability indicator, is a representation of cumulative achievement across the global sustainable healthcare marketplace—for the fifty-five case studies, what strategies, for example, are widely implemented (such as potable water reduction) and which are only sparsely implemented (such as on-site reclaimed water reuse). This "window" into the state of the marketplace is a powerful indicator of the effectiveness of public and institutional policy and practice. It also serves as a basis to gauge the maturity of market uptake along the innovation cycle, differentiating strategies employed by innovators and early adopters from those by early and late majorities.

The SHA Infographic '13 is an invaluable decision support tool to guide bases of design in sustainable healthcare projects around the world; over time, updates will provide a visual tracking of the evolution of key sustainability indicators and reveal market trends associated with each metric.

CASE STUDY KEY

Chapter 5

1 Dell Children's Medical Center of Central Texas
2 OHSU Center for Health and Healing
3 Peace Island Medical Center
4 Sherman Hospital
5 Kiowa County Memorial Hospital
6 Kohinoor Hospital
7 The Dyson Centre for Neonatal Care, Royal United Hospital,
8 St. Mary's Hospital Sechelt Addition
9 New Karolinska Solna University Hospital
10 UCSF Medical Center at Mission Bay
11 Lucile Packard Children's Hospital at Stanford

Chapter 7

12 Mittal Children's Medical Centre
13 The Bluestone Unit, Craigavon Area Hospital
14 New South West Acute Hospital
15 The Lunder Building, Massachusetts General Hospital
16 Spaulding Rehabilitation Hospital
17 Providence Newberg Medical Center
18 Providence St. Peter Hospital
19 Gundersen LaCrosse Hospital Addition
20 Kaiser Small Hospital Big Idea Competition

Chapter 8

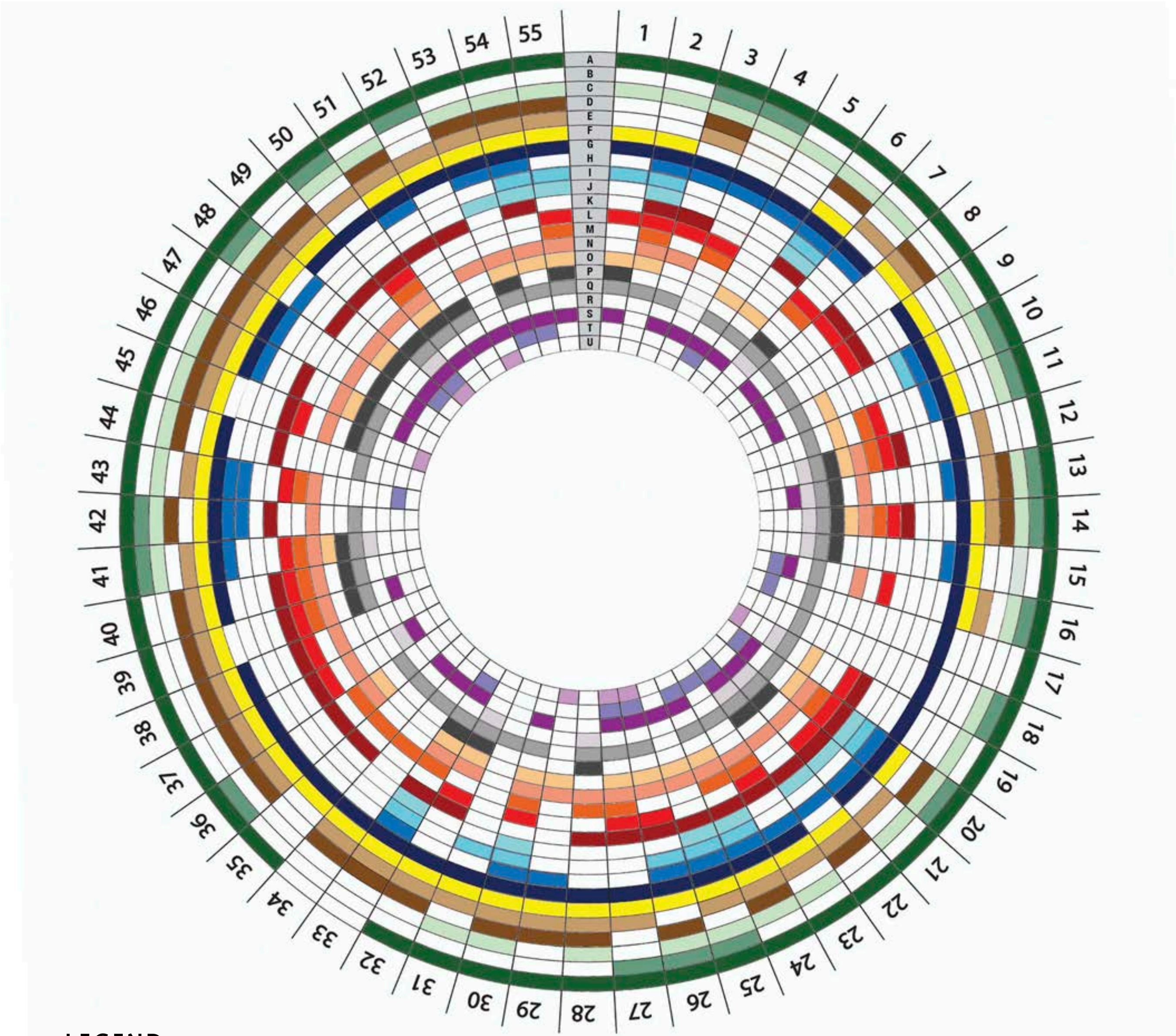
21 Akershus University Hospital
22 Butaro Hospital
23 Deventer Ziekenhuis
24 First People's Hospital
25 Hospital Universitario San Vincente de Paul
26 Khoo Teck Puat Hospital
27 Portadown Health and Care Centre
28 REHAB Centre for Spinal Cord and Brain Injuries
29 Reina Sofia Foundation Alzheimer Centre
30 The new Royal Children's Hospital
31 Rush University Medical Center
32 Salam Centre for Cardiac Surgery
33 Santa Lucia University General Hospital
34 St. Bartholomew's and The Royal London Hospitals
35 Swedish Medical Center
36 Ysbyty Aneurin Bevan (Aneurin Bevan Hospital)

Chapter 9

37 Martini Hospital
38 Arras Hospital Centre
39 Pediatric and Cardiac Center of the Innsbruck University Clinic
40 Helsingør Psychiatric Clinic
41 Rhine Ordinance Barracks Medical Center Replacement
42 Ng Teng Fong General Hospital and Jurong Community Hospital
43 Nanaimo Regional General Hospital Emergency Department
44 Seattle Children's Bellevue Clinic
45 Pictou Landing Mi'Kmaq Community Health Centre
46 Kenya Women's and Children's Wellness Centre
47 Tata Medical Centre Cancer Hospital
48 CBF [Centre pour le Bien-etre des Femmes] Women's Health Centre

Chapter 10

49 The Ubuntu Centre
50 Jubilee Gardens Health Centre and Library
51 Old Town Recovery Center
52 Waldron Health Centre
53 Mirebalais National Teaching Hospital
54 Embassy Medical Center
55 All Ukrainian Health Protection Centre for Mothers and Children



LEGEND

A – Connection to nature/biophilia
B – Habitat restoration
C – Innovative stormwater management

D – Climatic/bioregional design
E – Narrow floor plate
F – Energy-responsive facade

G – Water use reduction
H – Rainwater harvesting
I – Reclaimed water reuse
J – Onsite wastewater treatment

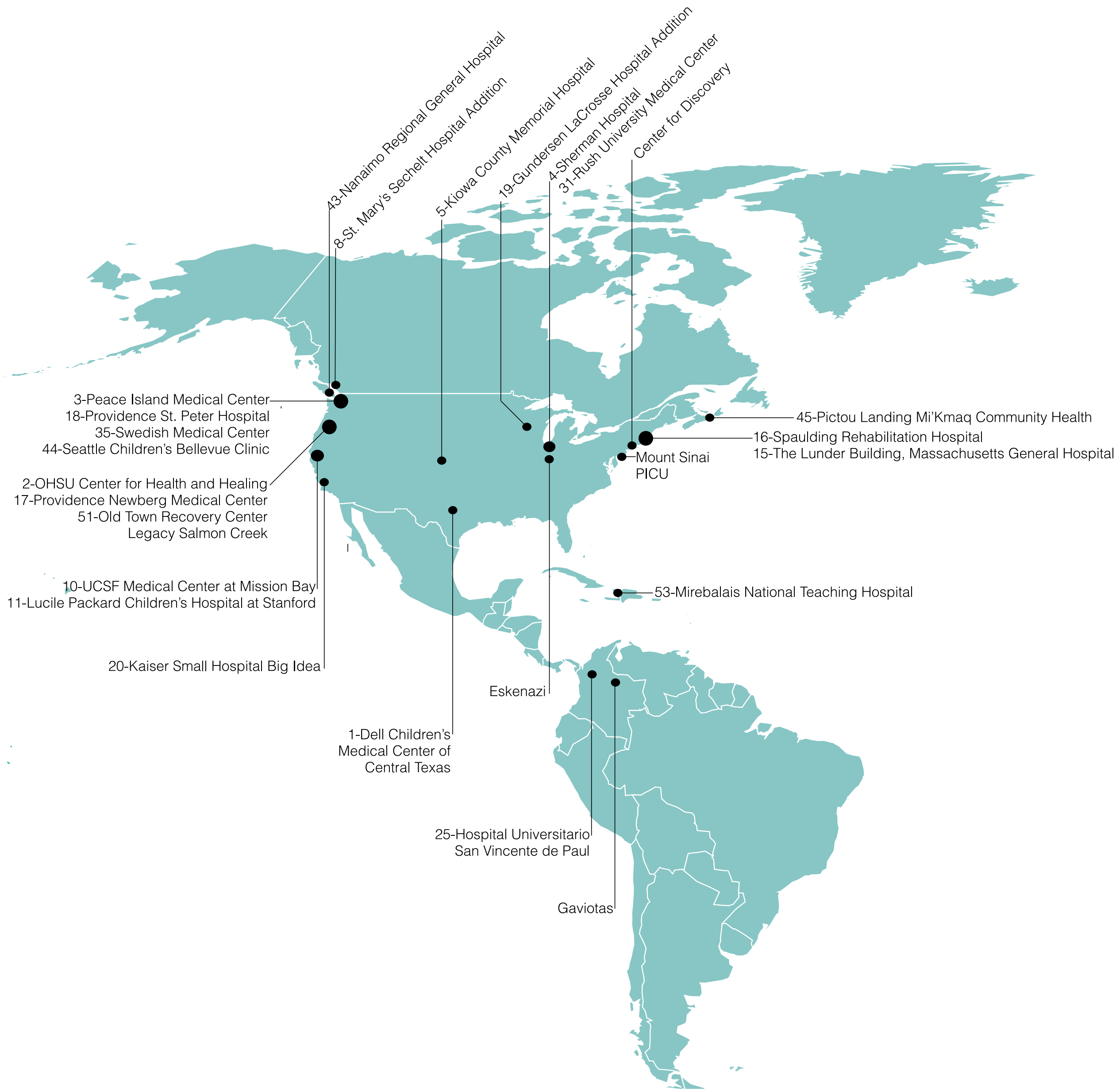
K – Low energy use index (EUI)
L – Innovative source energy
M – Innovative energy distribution
N – Natural ventilation
O – Onsite renewable energy

P – Low embodied energy materials
Q – Healthy materials
R – Prefabrication/modularity/adaptability

S – Civic function
T – Resilience
U – Food production

LOCATION MAPS

The 55 case studies in the book are located on a series of location, biome and climate zone maps.



LOCATION MAPS

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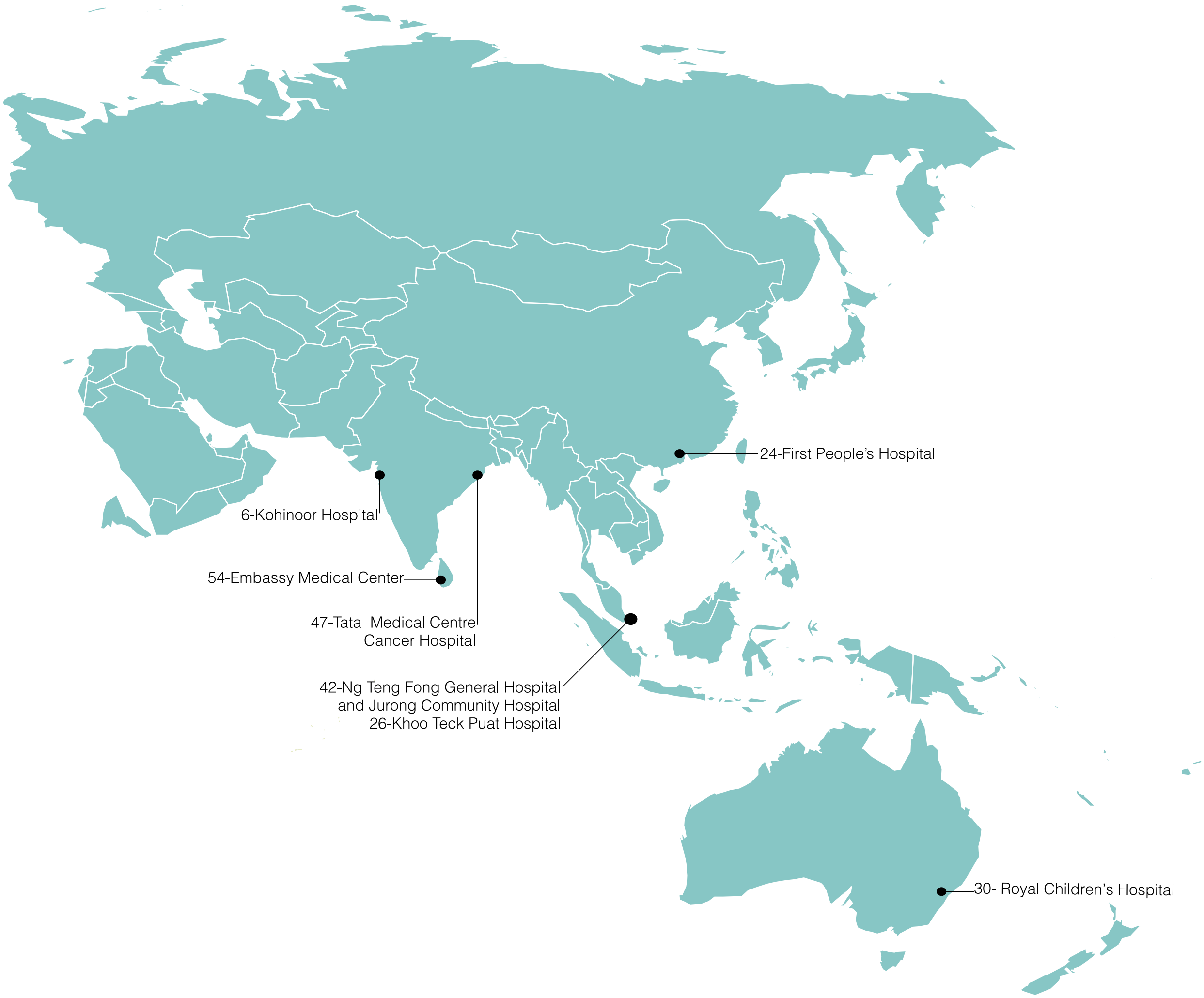
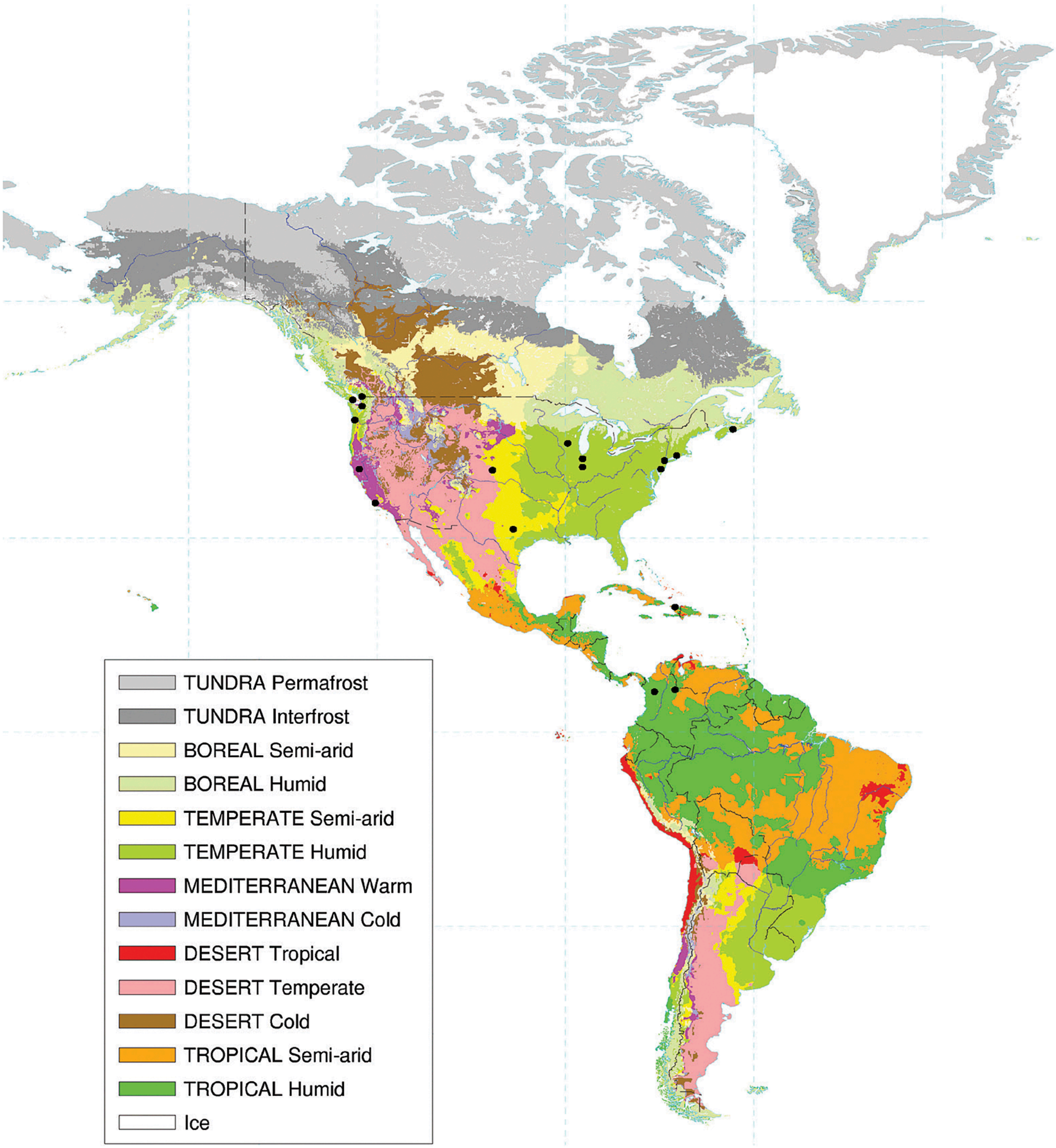
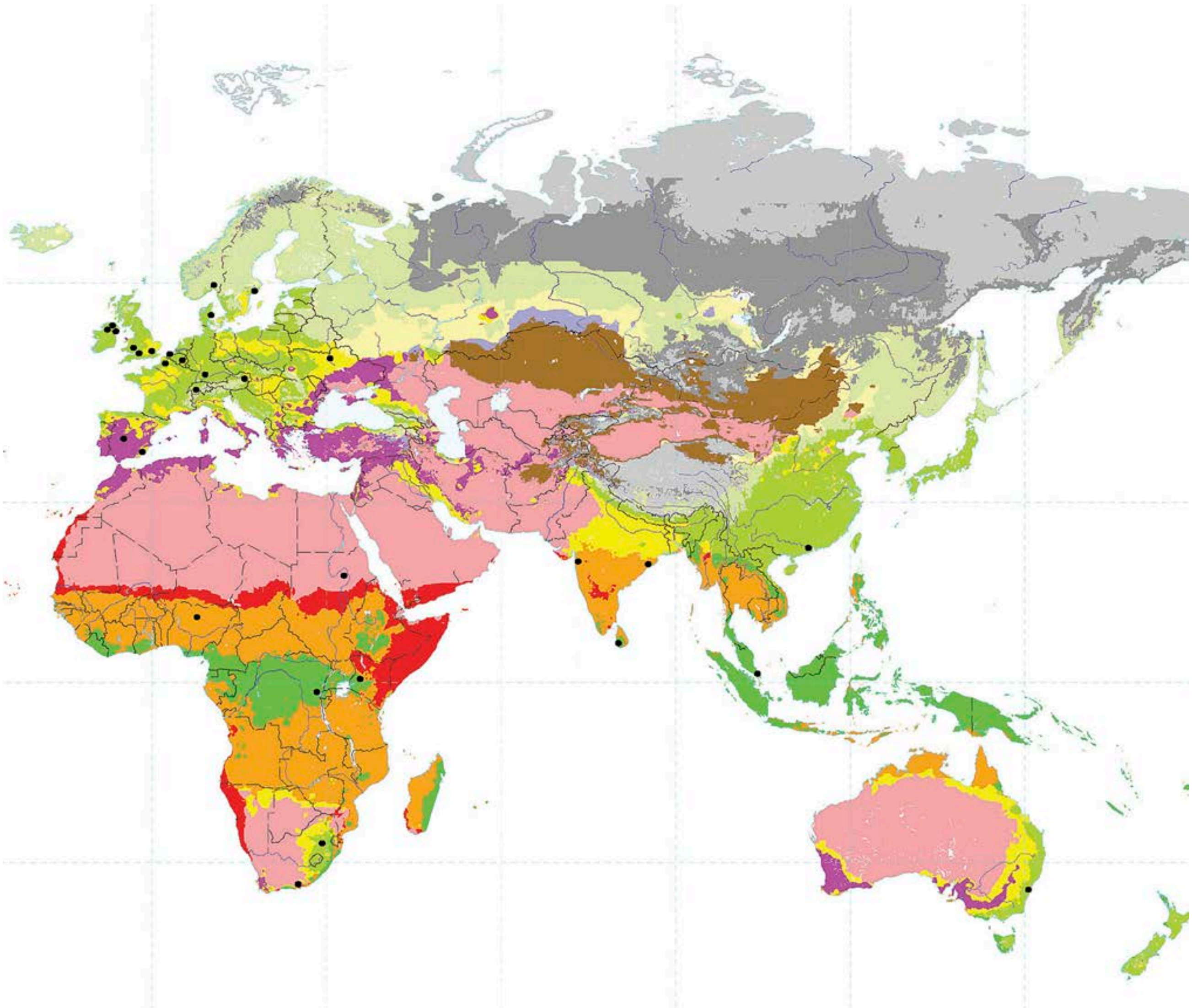


BIOME MAPS

Biomes are distinctive regions around the world that share similar patterns of flora and fauna; they also correlate with similar climate and soil types. Biomes provide a nature-based context to understand the relationship between building, site, and the stock of regional indigenous materials. Moreover, given their similar patterns, biomes provide a basis for robust global information sharing about appropriate approaches to climatic design strategies and material use.

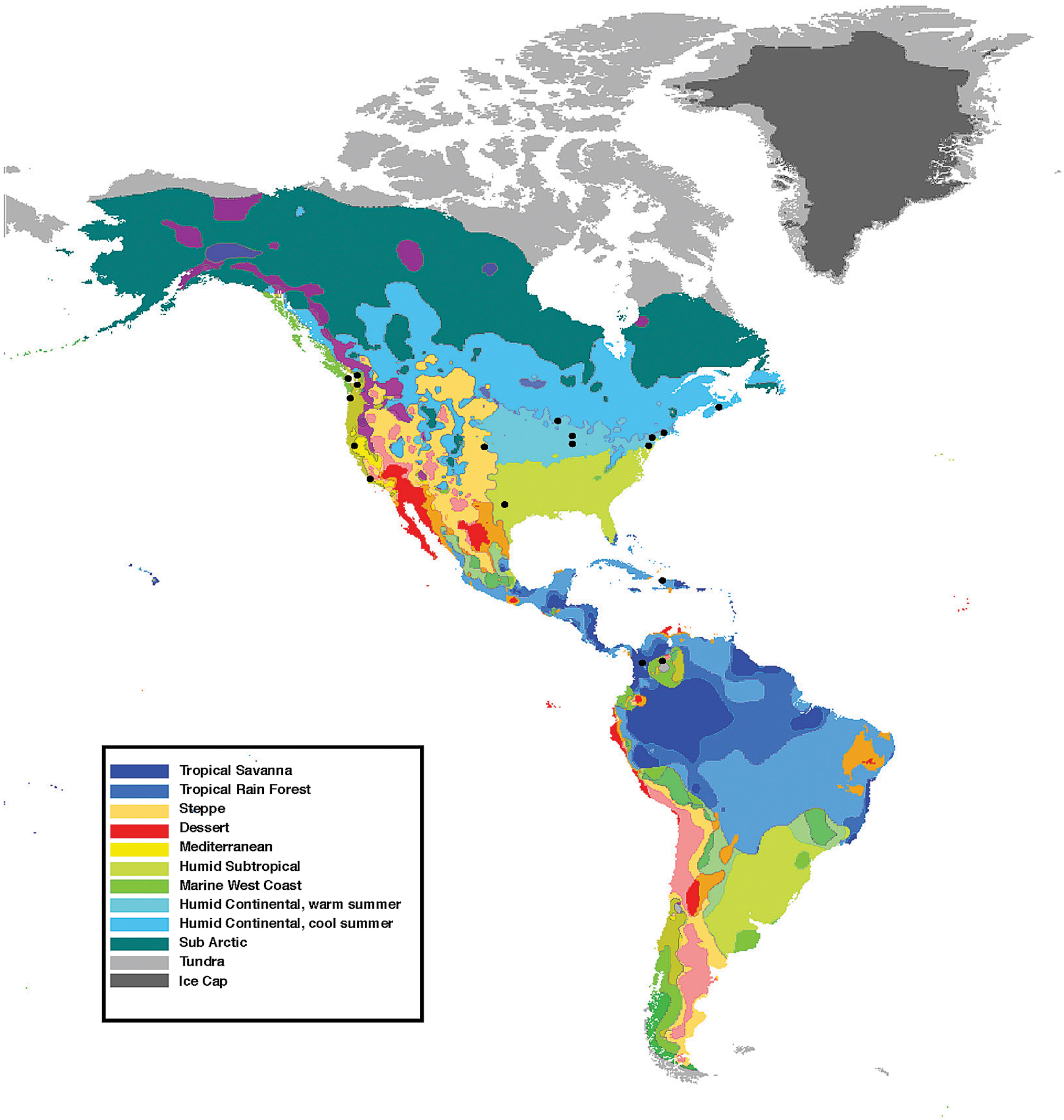


BIOME MAPS

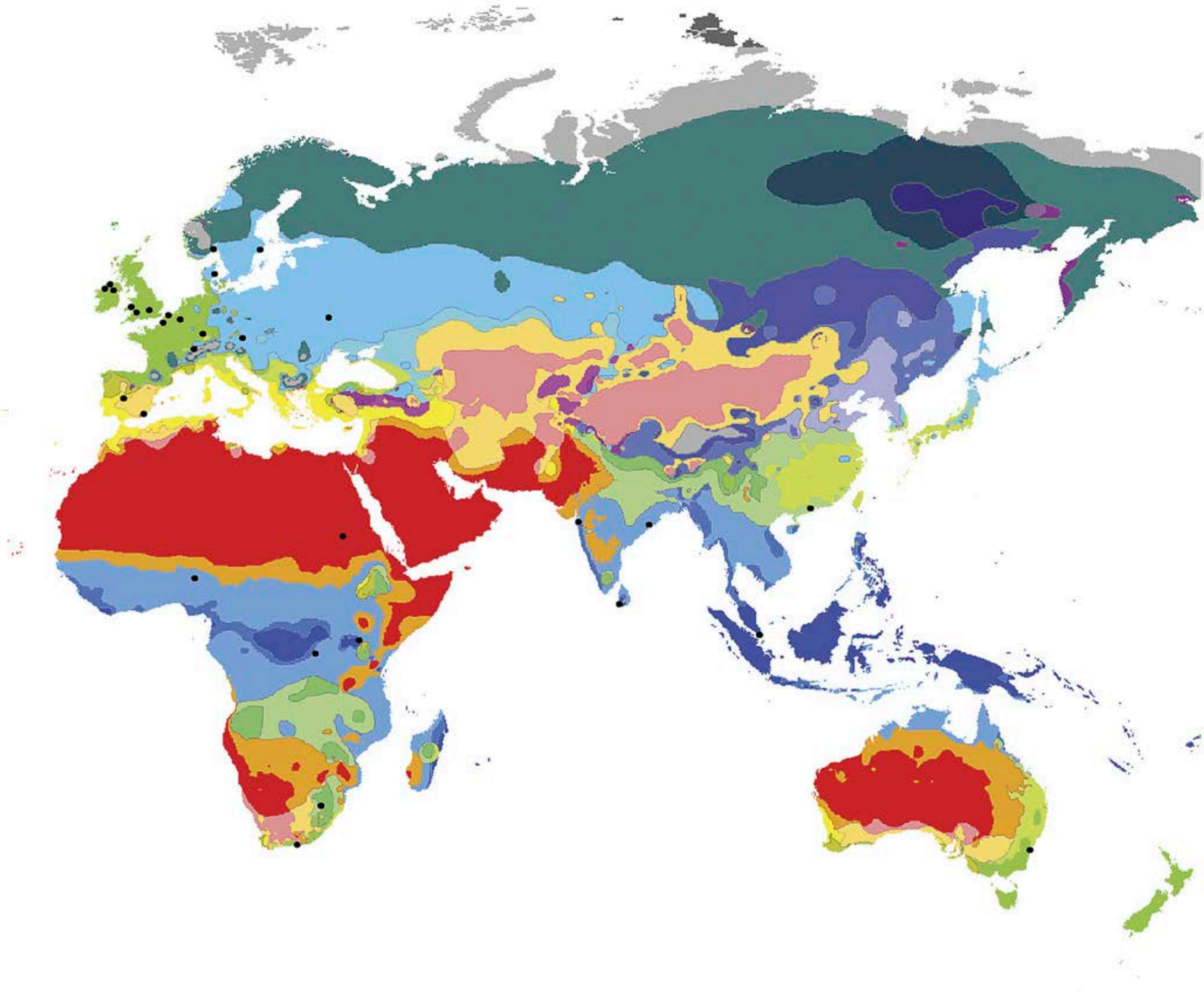


CLIMATE ZONE MAPS

Climate zones represent distinctive areas around the world, derived from the seminal climate classification work of the Russian German climatologist Wladimir Koppen initially released in 1884. Climate zones reflect native vegetation patterns, considered to be the best indicator of climate, along with annual and monthly temperatures and precipitation, and seasonal precipitation patterns. Recognizing the dynamic nature of these patterns, climatologists revise climate zone boundaries to reflect a changing climate.



CLIMATE ZONE MAPS



PART 1

CONTEXT

CHAPTER 1

DESIGN AND STEWARDSHIP

> 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 it 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.
>
> DAVID ORR

INTRODUCTION

What does stewardship mean, and what is the role of the design disciplines in furthering and developing this idea? The stewardship model of responsibility has its foundation in theological writings on the relationship between humans and the natural world—hence its prominent position in many of the mission statements of faith-based healthcare organizations. At many such organizations, stewardship of God-given natural resources has been reinterpreted in the modern era to include promotion of human health. Such an expanded view leaves the design industries a correspondingly broad role in terms of stewardship.

The concept of resource stewardship is pivotal in sustainable, or "green," design as it is currently defined and practiced throughout the design disciplines. The design of hospital buildings (as cultural artifacts) can be viewed as an important component of the larger practice of the design of habitats for humans—in this case, healing habitats. For the last half-century, however, the design of hospital buildings has been remarkably independent of the broader trends in architectural design. As a particular typology, healthcare architecture has evolved in a world apart, responding, for the most part, to industry trends in technology and ever-more complex life-safety regulations. Until recently, healthcare owners, architects, and engineers have been unaware of the impact that sustainable design concerns have had on the larger design industry.

Environmental stewardship is a defining principle of sustainable architecture, as the essayist and commentators in this chapter eloquently state. Architect Bill Valentine, FAIA, postulates below that "less is better" and challenges design professionals to reconsider scale and deliver better, healthier buildings using less. Designer and educator Pliny Fisk III presents an expanded definition of lifecycle design, one that postulates a "new ecology of mind," which joins together architecture and neuroscience. In his essay, designer Jason F. McLennan challenges design to redefine itself as no less than "living" for our buildings, our health, and the planet. Finally, architect Bob Berkebile, FAIA, challenges us to imagine a "restorative" and "regenerative" future, a concept further explored in the final chapter.

The sustainable design movement, through such leaders as Paul Hawken, Amory Lovins, and L. Hunter Lovins, has given us new lenses for viewing the economy: Natural Capitalism: Creating the Next Industrial Revolution (2000) and The Ecology of Commerce (1993). The parallel ideologies of "clean production" and William McDonough and Michael Braungart's "cradle to cradle" are having significant impacts on building materials science, from revolutions in the petrochemical components of our material economy to end-of-life ideas such as "waste equals food." Science writer Janine Benyus, in *Biomimicry: Innovation Inspired by Nature* (1997), points to a future when science will look to nature for inspiration and technology—and an impressive roster of corporations and designers who have adopted biomimicry principles in their research and applied them to products is testament to that future becoming reality (Biomimicry 3.8, 2012). Just outside the silo that defines the current practice of healthcare architecture, notions of planetary stewardship linked to health are fundamentally redefining the design and production of the built environment.

THE CASE FOR STEWARDSHIP

The scientific community is in general agreement that human activity now exceeds the global carrying capacity of the Earth's ecosystems, and that those ecosystems are rapidly degrading. The United Nations' Millennium Ecosystem Assessment, released in 2005, chronicles the continued degradation of the natural environment, amplifying the growing awareness that healthy people cannot live on a sick planet. The Ecological Footprint Atlas (Ewing et al. 2010) and the World Wildlife Fund's Living Planet Report (2010) estimate the world's economies are overshooting their capacity for natural resource regeneration by 50 percent (see Figure 1.1). While much of the discussion on finite global resources has focused on the depletion of nonrenewable resources, such as petroleum, it is increasingly evident that renewable resources, and the ecosystem services they provide, are also at great or even greater risk (Ewing et al. 2010).

Environmentalist and writer Bill McKibben (1989) contends that there are no longer any ecosystems on Earth uninfluenced by humans. "Anthropocene," a term introduced in 2000 by Nobel Prize laureate Paul Crutzen and ecologist Eugene Stoermer, describes our current geological epoch as fundamentally defined by the influence of human activities (Crutzen and Stoermer 2000). The Living Planet Report (2010) reports general decline in global biodiversity from 1970 to 2007 as follows:

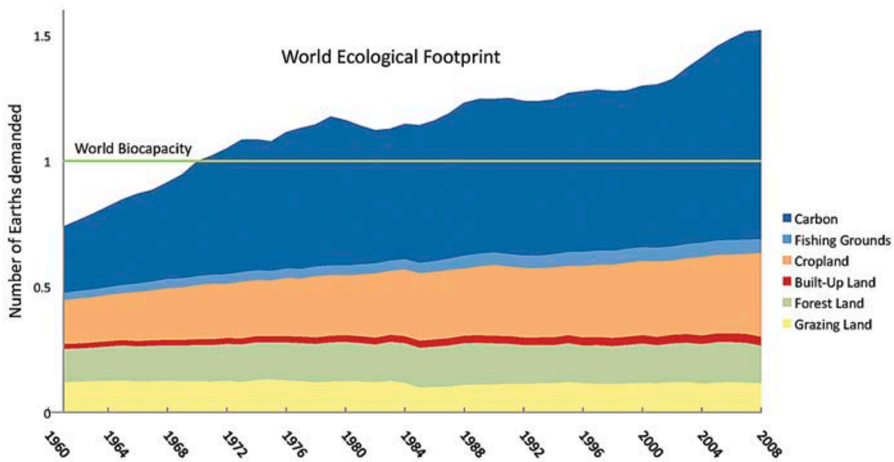


Figure 1.1 In 2007, humanity's total ecological footprint worldwide was 18.0 billion global hectares (gha); with world population at 6.7 billion people, the average person's footprint was 2.7 gha. But there were only 11.9 billion gha of biocapacity available that year, or 1.8 gha per person. This overshoot of approximately 50 percent means that in 2007 humanity used the equivalent of 1.5 Earths to support its consumption. *Source: Global Footprint Network and UNDP, 2010*

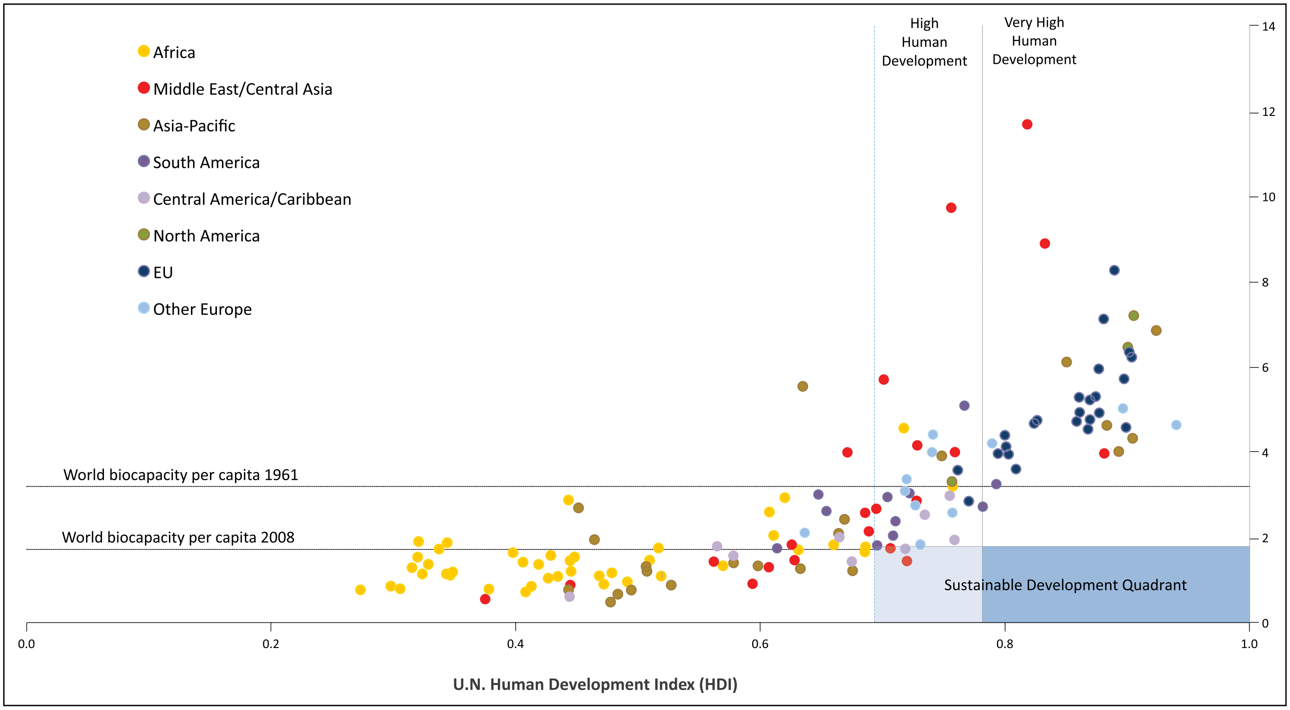


Figure 1.2 The Ecological Footprint of consumption for 2008 and Human Development Index by region. The HD values are linear interpolations between the 2005 and 2009 values from the Human Development Report 2011. Countries with an HDI score of 0.8 or higher and a footprint of 1.8 global hectares per person or lower meet two minimum criteria for global sustainable development. The graph indicates that countries consume vastly differing global resources to attain high human development. Countries living within planetary means also achieve radically different levels of human development. *Source: Global Footprint Network and UNDP, 2013*

- 37 percent decline in temperate and topical freshwater ecosystems
- 24 percent decline of marine life
- percent decline in terrestrial plant and animal species

From 10 to 15 percent of the Earth's land surface is dominated by agriculture and urban development. Close to 50 percent of the Earth's land mass has been transformed by humans. Humans consume more than 40 to 50 percent of all available freshwater (in the Middle East, consumption is estimated to be 120 percent); 25 percent of the Earth's land surface is cultivated. Furthermore, the globalization of nature—that is, the introduction of nonnative species in unfamiliar ecoregions—has disastrously weakened functioning ecosystems (Millenium Ecosystem Assessment 2005).

A key question is whether this increased resource consumption is required to meet basic human development needs. Given increasing global population, reliance on a growing level of consumption to attain sustainable well-being for all is unrealistic. The challenge of reaching a high level of human well-being while ensuring long-term resource availability is illustrated in Figure 1.2. High levels of human development, as measured by United Nations Development Programme (UNDP), are an HDI score of 0.8 or greater. The Global Footprint Network defines the average productive area available for each person on the planet as 1.8 global hectares.

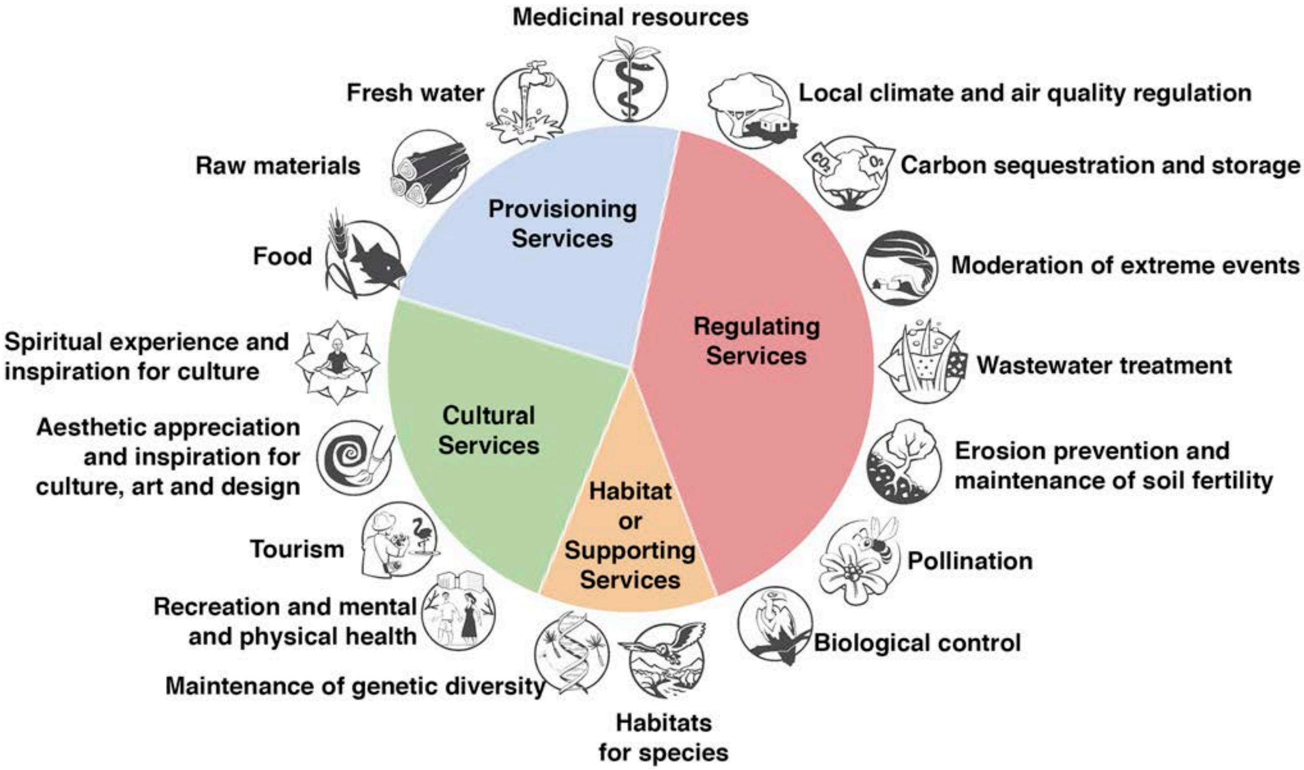


Figure 1.3 Ecosystem Services. These four types of ecosystem services are essential to support human life. *Source: TEEB, redrawn by the authors*

The concept of assigning monetary value to ecosystem services—i.e., the value of clean drinking water or pollinating insects—was first postulated by Vitousek and others (1997); at that time, they assigned a conservative value of approximately $33 trillion to these services. The Economics of Ecosystems and Biodiversity (TEEB 2010) is an ongoing project that reviews the science and economics of ecosystems and biodiversity and includes a valuation framework to improve policy decision-making. It defines four basic types of ecosystem services: provisioning services, regulating services, habitat services, and cultural services, as described in Figure 1.3.

In 1992, the Union of Concerned Scientists, on behalf of 1,600 scientists (including the majority of living Nobel laureates) issued the World Scientists' Warning to Humanity. It outlined the case for stewardship as essential to survival:

> We, the undersigned senior members of the world's scientific community, hereby warn humanity of what lies ahead. A great change in our *stewardship of the earth* [emphasis added] and the life of it is required, if vast human misery is to be avoided and our global home on this planet is not to be irretrievably mutilated (Union of Concerned Scientists 1992).

The principle of stewardship is intrinsic to the idea of sustainable development. This movement, global in scope while locally implemented, has broad implications for both medicine and the environments that support it.

> *The resilience of the community of life and the well-being of humanity depend upon preserving a healthy biosphere with all its ecological systems, a rich variety of plants and animals, fertile soils, pure waters, and clean air. The global environment with its finite resources is a common concern of all peoples. The protection of the Earth's vitality, diversity, and beauty is a sacred trust.*
>
> —Earth Charter (2000)

SUSTAINABLE DEVELOPMENT

Sustainable development was defined for the first time in the United Nations'1987 Brundtland Commission Report as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." It quickly gained stature in the public lexicon. This definition both inserted an explicit value proposition into the international development domain and gave "green building" a broad conceptual foundation on which to grow.

In 1992, the first United Nations' Conference on Environment and Development (commonly referred to as the Earth Summit), convened in Rio de Janeiro, and resulted in Agenda 21, a blueprint for achieving global sustainability, and the Rio Declaration on Environment and Development. The Earth Summit produced some of the earliest statements on climate change and biodiversity. Adopted by more than 178 participating governments (including the United States) (UN 2004), its visionary declarations and action plans recognized the interconnections among all living systems on Earth.

Two of these declarations would prove to be pivotal for sustainable building in healthcare. Principle 1 of the Rio Declaration states: "Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature." Principle 15 advances the principle of precaution, an important construct in medicine:

> In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

As global resources become less available, this precautionary approach becomes both more important but equally more challenging to actualize. At Rio+20, convened in 2012, Principle 15 was extensively debated. A diminishing resource base presents both unique opportunities and constraints in the development of design and stewardship. But one thing is clear: A diminishing resource base has profound consequences for the built environment and the profession of architecture.

THE PROFESSION OF ARCHITECTURE

Early environmental design initiatives were disparate, focusing primarily on the reduction of energy demands. In response to the energy crisis of the early 1970s, the American Institute of Architects (AIA) established the Committee on Energy to develop tools and policies to address mounting public concern about the building industry's reliance on fossil fuels. Parallel federal initiatives included the creation of the Solar Energy Research Institute (now the National Renewable Energy Laboratory) and the cabinet-level Department of Energy. Absent a larger framework for sustainable design, these departments focused on energy technologies and conservation.

In 1989, the AIA Committee on Energy transformed itself into the Committee on the Environment (AIA/COTE), reflecting a broader view of sustainability. In 1998, AIA/COTE announced the Top Ten Green Projects annual award program to recognize design excellence in sustainable architecture.

Inspired by the Earth Summit, the UIA/AIA World Congress of Architects (UIA stands for "International Union of Architects" in French) issued its Declaration of Interdependence for a Sustainable Future in 1993. Signed by more than three thousand participants, it states: "Buildings and the built environment play a major role in the human impact on the natural environment and on the quality of life"—a bold challenge to the profession at large to put a broader sustainability agenda into practice (UIA 1993).

In 2005, the AIA issued this position statement on the responsibility of design professionals (AIA 2005):

> The AIA recognizes a growing body of evidence that demonstrates current planning, design, construction and real estate practices contribute to patterns of resource consumption that seriously jeopardize the future of the Earth's population. Architects need to accept responsibility for their role in creating the built environment and, consequently, believe we must alter our profession's actions and join our clients and the entire design and construction industry to change the course of the planet's future.

The statement continues with a commitment to achieve a 50 percent reduction in fossil fuel consumption for new and renovated buildings by 2010 and target continuing reduction thereafter, a commitment to integrate sustainable design education into the curricula of architecture schools (and ultimately into the licensing process), and a commitment to promote research into lifecycle assessment methodologies.

In January 2006, architect Edward Mazria, FAIA, launched the 2030 Challenge: to achieve zero emissions and carbon neutrality for all building operations by 2030, beginning with an initial 60 percent reduction of fossil fuel consumption by 2010, and continuing with an additional 10 percent incremental reduction in every subsequent five-year period (Architecture 2030 2012) (see Figure 1.4). Many U.S. organizations have adopted this bold initiative, including the American Institute of Architects (AIA); American Society of Interior Designers (ASID); the U.S. Green Building Council (USGBC); the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE); and the U.S. Conference of Mayors.

In addition, major firms such as Perkins+Will, HOK, and HKS have also endorsed its principles. The Oregon State Hospital Replacement, Salem, Oregon, completed in 2011 by HOK and SRG, was designed to achieve an Energy Use Index of 114.5 kBtu/sf/yr to comply with the 2010 energy target of 60 percent below regional average baseline; in operation, it is tracking just below 100 kBtu/sf/yr (see Figure 1.5). For the new Oregon State psychiatric hospital in Junction City, HOK projects an EUI of just below 100 (see Figure 1.6).

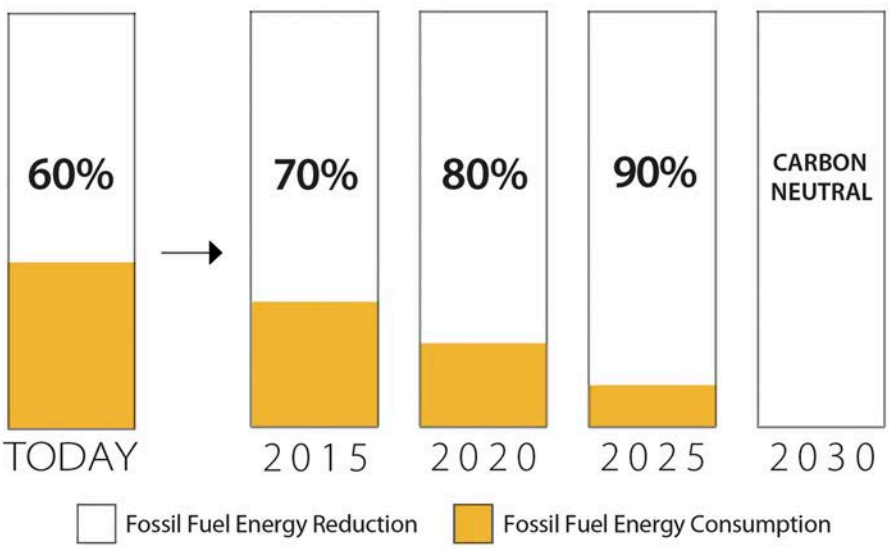


Figure 1.4 The 2030 Challenge goals. All new buildings, developments, and major renovations by 2015 shall be designed to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 70 percent below the regional (or country) average for that building type, increasing by 10 percent each five years. By 2030, all buildings will be designed to be carbon-neutral, operated with 100 percent renewable energy.

Figure 1.5 Oregon State Hospital at Salem, Oregon, is designed to meet the 2030 Challenge 2010 goal. *Source: HOK with SRG Architects*

Figure 1.6 Oregon State Hospital at Junction City is designed to meet the 2030 Challenge 2015 goal. *Source: HOK*

THE ETHICAL CHALLENGE FOR DESIGNERS

Ultimately, the built environment is the product of intentional design decisions, and waste signifies failure. *Metropolis* magazine editor Susan Szenasy (2004) sums up the challenge this way: "Designers today stand on the brink of being seen by society as essential contributors to its health, safety, and welfare. If you—together with the other design professions—decide to examine the materials and processes endemic to your work, as well as demand that these materials and processes become environmentally safe, you will be the heroes of the twenty-first century." Or, as David Orr (2004) sees it, "The larger challenge is to transform a wasteful society into one that meets human needs with elegant simplicity." As this change occurs, labels like "biomimicry" or "sustainable design" attempt to describe the efforts. The ethical challenge is, however, broad in scope. It is not simply about designing environmentally benign hospital buildings for an ever-expanding industrial-medical complex, but about formulating a system of healthcare that supports vital communities that nurture health and whole people "who do not confuse what they have with who they are" (Orr 2004). This broader vision of design can best be termed "ecological design."

ECOLOGICAL DESIGN

Ecological design, Orr continues, "requires a revolution in our thinking." He suggests changing the kinds of questions we ask about a design, from, "How can we do the same old things more efficiently?" to ones such as:

- Do we need it?
- Is it ethical?
- What impact does it have on the economy?
- 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?

> *Architects have wonderful opportunities to make things better by enthusiastically promoting "less" in the buildings we design. This doesn't mean stripping away the elements that make our buildings beautiful. But we can design structures in simpler, more thoughtful ways that work with, instead of against, nature. And by doing so we can prove to people that less can be better in many aspects of their lives. Though we can't legislate less in our culture, we're at a potential tipping point—that dramatic time popularized by Malcolm Gladwell's* Tipping Point *(2000) when something that had once been unique becomes common. Using less can become the norm.*
>
> *My message actually goes far beyond buildings and, I hope, straight to the heart of our culture. I'd like to trigger a move toward less in the building industry that also spreads across our society and catalyzes a profound cultural shift toward simplicity. Let's show people that all this stuff isn't required to live "the good life." Let's change our habits and reclaim our culture by making less a virtue. If we can make the idea of using less fashionable and chic in the U.S., our success could send ripples all over the world.*
>
> —Bill Valentine, Chairman, HOK (2008)

Orr conceives of ecological design not so much as an individual art practiced by individual designers but as an ongoing negotiation between a community and the ecology of particular places. Ecologically designed buildings "grow" from the long-term knowledge that derives from intimate experience of a place over time; they "live" within a biotic framework established by an understanding of natural principles and man-made policies standing together.

At the Patrick H. Dollard Discovery Health Center (see sidebar), the first LEED-certified ambulatory building, the decision to construct a sustainable building was informed by an ecological viewpoint—the belief that the health vulnerabilities of developmentally disabled children are influenced by the health of the ecosystems and built environments within which they live and learn. Completed in 2004, this building demonstrates the power of stewardship in healthcare settings. It is as relevant today as the day it opened.

CLEANER PRODUCTION

The concept of stewardship requires a reexamination of materials, the units of production from which the built environment is created. Materials extraction and production processes as they evolved during the Industrial Revolution have come to be categorized as "beat, heat, and treat" methodologies. Industry thrived in an era of inexpensive energy, using industrial processes to replace human labor in an ever-expanding era of raw material usage. Waste was seen as an inconvenience rather than a measure of inefficient production. In the early 1990s, in response to growing recognition of environmental degradation and resource depletion, the United Nations Environment Programme (UNEP 1989) defined "cleaner production":

> Cleaner Production is the continuous application of an integrated preventive environmental strategy to processes, products and services to increase overall efficiency, and reduce risks to humans and the environment...
>
> For production processes, Cleaner Production results from ... conserving raw materials, water and energy; eliminating toxic and dangerous raw materials; and reducing the quantity and toxicity of all emissions and wastes at source during the production process.
>
> For products, Cleaner Production aims to reduce environmental, health and safety impacts over their entire life cycles, from raw materials extraction, through manufacturing and use, to the "ultimate" disposal of the product.

Advocates of cleaner production have developed "tool kits" for reducing pollution by substituting safer, more benign materials for hazardous materials; by optimizing production technologies; and by closing loops in manufacturing processes to recycle and reuse what had been waste materials. Tools such as the Green Screen, Pharos, and the Health Product Declaration are being developed to assist designers and specifiers in accessing information and understanding the complex chemical components of building materials (see Chapter 5).

Pollution prevention programs, as defined by the healthcare industry, are examples of cleaner production initiatives in action. In some states, "toxic use reduction plans" are manifestations of cleaner production initiatives. Cleaner production demonstration programs have been launched all over the world and are now common not only in industrialized nations, but also in developing nations. Generally speaking, cleaner production "design" activities achieve both environmental benefits and economic returns—and demonstrate improved stewardship of both resources through the lifecycle.

The Patrick H. Dollard Discovery Health Center

Harris, New York

Architect: Guenther 5 Architects/Perkins+Will

This 28,000 sq. ft. (2,601 sq. m) project seeks to evolve a noninstitutional ambulatory medical facility nested within a rural, residential campus. It is the new front door for the Center for Discovery, a 350-acre residential facility that houses more than 250 developmentally disabled adults and children in a decentralized group home model.

The center emphasizes a nature-based program that includes community-supported agriculture manifested in its organic farm. Goats and horses pasture in the fields adjacent to the clinic building. The project site, a 9-acre (3.6-ha) former "industrial" egg farm, created significant pollution runoff to the adjacent organic farm. Although it might have been less expensive to develop on a greenfield parcel, the Center for Discovery realized that the ecological remediation of the project site would improve irrigation water quality on the farm and safeguard against future potential contamination. The plan prioritizes daylight and views, with a focus on visual connection to the adjacent farm (Figures 1.7–1.10).

Linking hydronic heating to ground-source heat pumps eliminated all onsite combustion, contributing to reduced airborne emissions (Figure 1.8). The center utilizes radiant heating systems in residential buildings because they provide superior thermal comfort, reduce maintenance, and improve resident safety, leaving no exposed heating equipment in the wheelchair zone. The project predates the 2030 Challenge but met the 2010 goal for 60% energy use reduction. It also captures and stores rainwater for irrigation, fire tank reserves, and ground source makeup. Excess rainwater is released to the farm irrigation system.

Source: Guenther 5/Perkins+Will

Figure 1.7 The Patrick H. Dollard Discovery Health Center. *Source: David Allee*

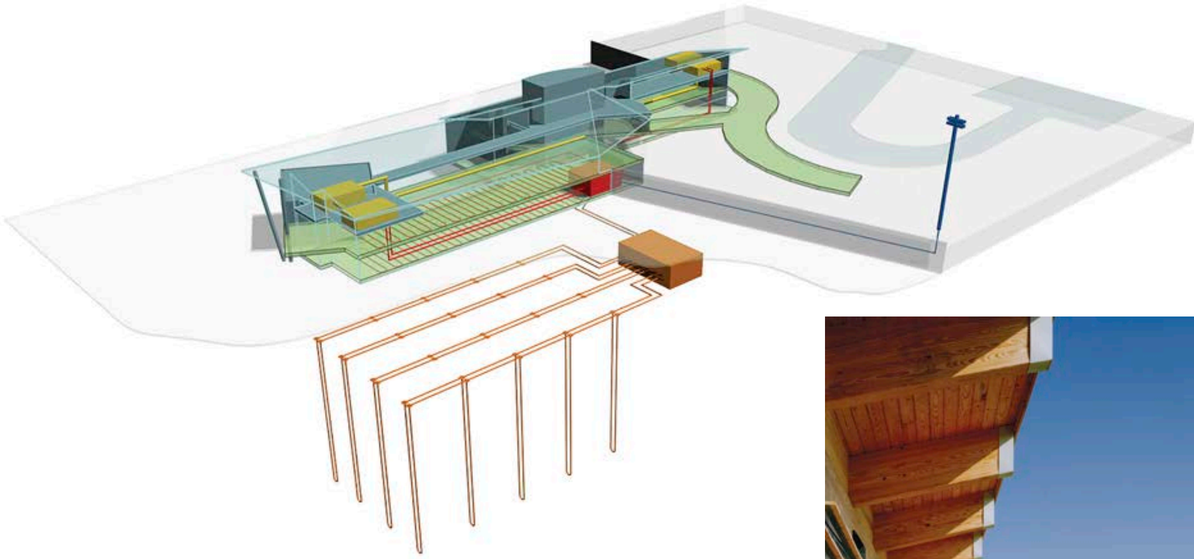
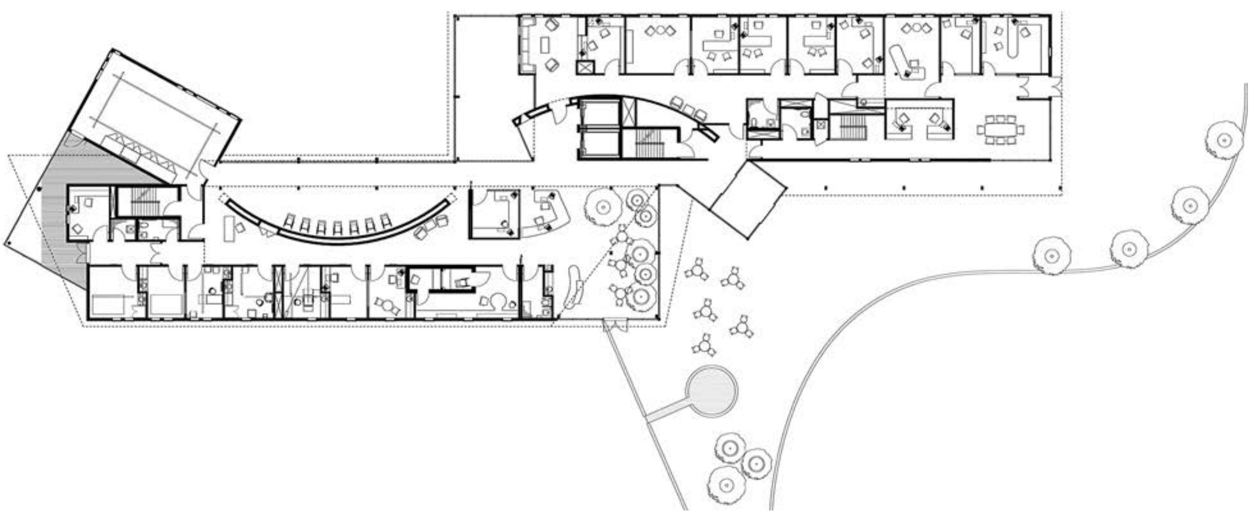


Figure 1.8 Ground source heat pump systems link to hydronic distribution. *Source: Guenther 5/Perkins+Will*

Figure 1.9 The deck overlooking the adjacent farm. *Source: David Allee*

Figure 1.10 The shallow floor plate ensures deep daylight penetration into waiting areas and exam spaces. *Source: Guenther 5/Perkins+Will*



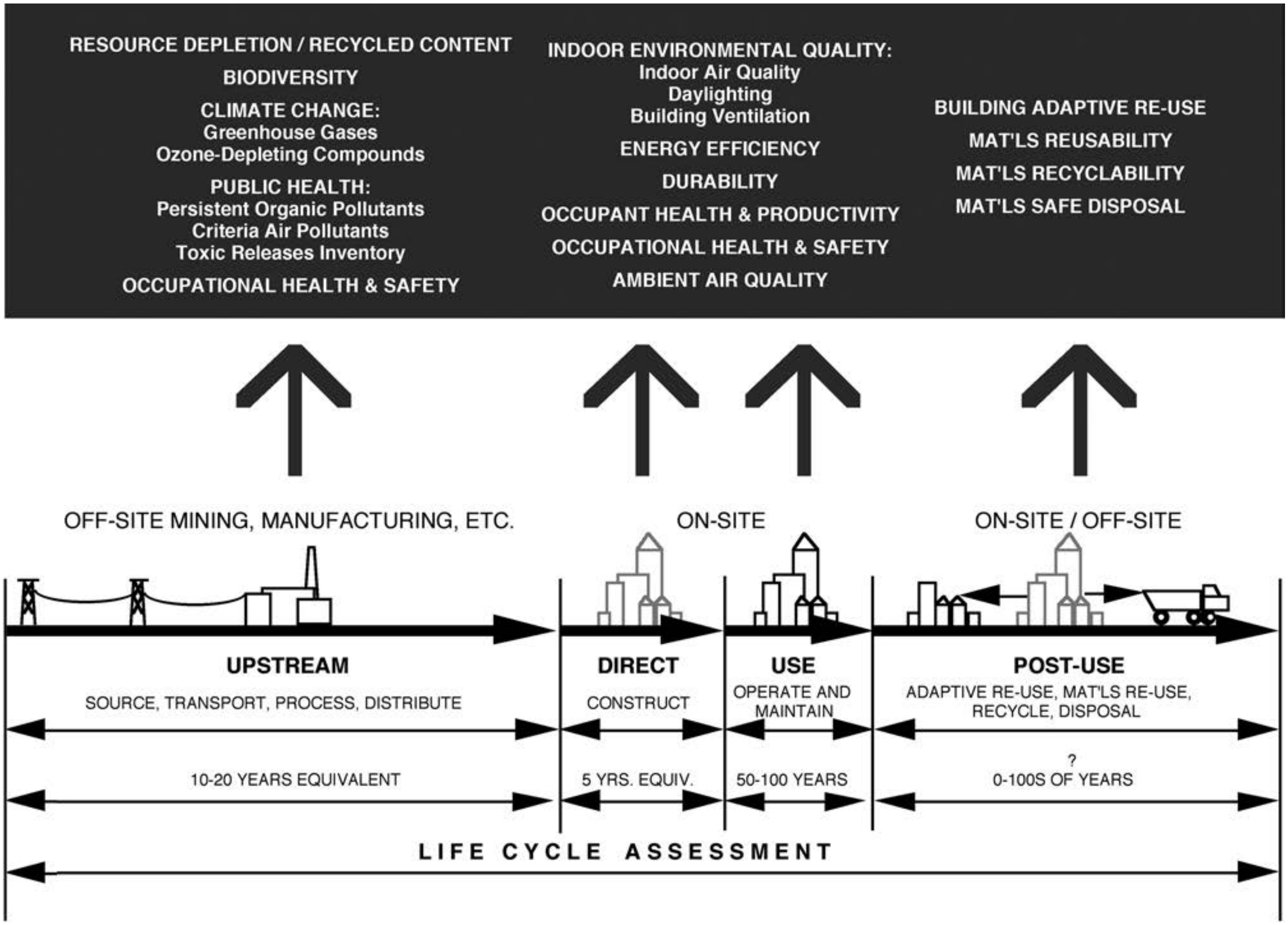


Figure 1.11 Life cycle diagram. Each building life cycle phase results in a range of environmental and health consequences—some of these are constants and some more variable based on building type, location, and programmatic focus. Using these indicators as evaluative criteria to compare material choices and design features leads to robust material specification and design decisions. *Source: Center for Maximum Potential Building Systems*

LIFE CYCLE THINKING

Healthcare building design and construction processes have usually been cradle to grave, with ever-shorter use life spans. While many late-nineteenth-century healthcare buildings remain in use, they have often been downgraded from acute care to ancillary facilities as the technology and the associated space requirements of acute-care buildings have escalated. After sixty years in service, the post–World War II Hill-Burton buildings throughout the United States are presently the target of replacement. At the same time, mid- to late-1970s facilities are being downgraded after barely thirty years in service. Because the vast resource base that supported the expansion of the built environment in the nineteenth and twentieth centuries is diminished, the processes associated with buildings at every stage of their life cycle are being fundamentally reconsidered (see Figure 1.11).

Broadly termed Life Cycle Design (LCD) thinking, the production cycle for building design and construction is expanded to include the extraction, production, and transportation consequences to ecosystems and human health that often, collectively, exceed the use-phase impacts of a building material. Within the discipline of sustainable design, the advantages of LCD have thus far been evaluated on a tangible level; for instance, reducing the distance a material must be transported to a building site creates quantifiable reductions in fuel, emissions, and economic cost. Incrementally more sophisticated effects of LCD might include the development of regionalized economic loops incorporating virgin and byproduct materials, local producers, and locally appropriate resources, or the advancement of a building vernacular based on such a regional network.

Architectural designer and educator Pliny Fisk III provides a brief introduction to both the principles that underlie current life cycle design concepts (see Life Cycle Design Principles) as well as a set of concepts that extend the reach of LCD into a behavioral realm (see Elements of an Ecology of Mind) and suggests that LCD has the potential to engage our perceptions and alter our behaviors related to the resources we use, reconnecting humans to nature and its processes.

> The hypothesis is based on an understanding of how humans engage with their environments through life cycle events—when we directly encounter the life cycles of water, energy, food, air, and materials often remote from our everyday experience. This reflects our lack of knowingly playing a role with life cycle "events," such as how oxygen is produced or carbon is absorbed by a certain quantity of vegetation and soil systems. The fact is that approximately 5000 sq. ft. (465 sq. m) of temperate forest is needed to support an individual's oxygen needed for breathing, and 7500 sq. ft. (697 sq. m) is needed for carbon sequestering—these essential life-giving threads have not been part of our "event" vocabulary, but should be. In the model outlined here, buildings are designed to mimic and illuminate the life cycle events around us, causing humans to experience resource flows and cycles, understand resource dependencies, and adapt their behavior accordingly (Fisk 2008).

Life Cycle Design Principles

- Recognize the resource flows on which a building depends, and identify them and their multiple boundaries, from the building scale through to neighborhood, city, regional, and global scales.
- Evaluate and apply the source, transport, process, use, and re-source life cycle sequence in all resource-flow areas when considering the scales above, including energy, materials, water, and air. (In healthcare projects, food and medical waste are examples of operational resource flows that might be considered as well.)
- Increase resource-flow efficiency by basing decisions first on the scale of the building and site, progressing upward to tap into larger life cycle scales only as necessary.
- Support regionalized economic loops by respecting tight-knit regional integration. Each stage of the building life cycle supply chain should become a part of a regional economy.
- Plan for the extended use of a building through the separation of utilities, structure, and shell. Designing for flexibility extends the use phase of the building's life cycle.
- Create regionally relevant benchmarks throughout the world through comparisons with similar industrial bases, climates, and material conditions, as well as similar flora and fauna, using patterns supplied by the internationally accepted biome system.
- Reduce the size and complexity of the life cycle to enable it to relate more directly to people, involving the user with the resources associated with their everyday activities.
- If possible, incorporate both an input-output life cycle assessment and a process life cycle assessment, one supplying the perspective using national data, the other homing in on the low-hanging fruit identified.

Source: Pliny Fisk III (2008)

Elements of an Ecology of Mind

- Consider life cycle events in a building—direct interactions with the natural life cycles of water, air, energy, and materials—as microcosms of the life cycle events around us, and treat them with the same awe and respect as natural life cycle events, eliciting engagement with and response to these cycles through design.
- Identify the full range of ecosystem life cycles and life cycle events in and around our buildings, and consciously cover all environmental life cycle phases (or in behavioral terms, "events") from source (e.g., rain) to re-source (e.g., drinking water).
- Conceive of the life cycle as successions of resource events that can be balanced and the user part of the balancing act, so that people understand both the parts (i.e., the individual events) and the whole.
- When designing, differentiate between building elements that stimulate human brain activity at the circadian and interval scales, so that life cycle involvement can occur at both levels.
- Go beyond circadian brain rhythms by engaging the interval time function of the brain's neocortex through the miniaturization of the life cycle.
- Synchronize the scale of everyday life cycle events with the interval time of the neocortex through two- and three-dimensional means and miniaturization.
- Project from past to future and from locus to region the effects of our actions, not just at the individual scale but also at the community, regional, and global scales. Consider simulation and gaming environments so the neocortex is enticed to participate with the life cycles that support us.

Source: Pliny Fisk III (2008)

According to Fisk, this represents a new LCD framework not driven solely by the physical and engineering manipulation of resources and analyses of building phases, but instead by the idea that our relationship with life cycle events might be related to behaviors based on the evolution of the brain itself. In this new conception of LCD, miniaturizing the life cycle—for example, bringing the cycle of water (from capture to use to waste treatment) within the site boundary so that the processes are no longer removed and abstracted—is recognized to trigger brain functions that may better connect us to these significant environmental sequences. Buildings, then, extend our perceptions and connect us to the resources we use on a deeper level than previously imagined.

CRADLE TO CRADLE DESIGN

Informed by ecological design approaches, industrial designers are beginning to use an alternative framework for reengineering both products and processes as a response to the limits of "cradle to grave" ideology. Architect William McDonough and chemist Michael Braungart (2002) developed the cradle to cradle (C2C) design paradigm based on three key principles (see sidebar).

CRADLE TO CRADLE PRINCIPLES

- ***Waste equals food.*** In nature, one organism's waste is food for another.
- ***Use current solar income.*** Plants use sunlight to manufacture food. In fact, fossil fuels are "ancient sunlight"—past solar income. Both energy and material inputs are renewable rather than depleting.
- ***Celebrate diversity.*** Nature's diversity provides many models to imitate in the design of systems and processes: biomimicry.

Source: McDonough and Braungart, Cradle to Cradle 2002