



THE SUSTAINABLE SITES INITIATIVE

the Sustainable Sites Handbook

A Complete Guide to the Principles, Strategies, and
Best Practices for Sustainable Landscapes

Foreword by MICHAEL VAN VALKENBURGH

Meg Calkins

THE SUSTAINABLE SITES

H A N D B O O K

A Complete Guide to the Principles, Strategies,
and Practices for Sustainable Landscapes

Meg Calkins



John Wiley & Sons, Inc.



100% Total Recycled Paper
100% Postconsumer Paper

This book is printed on acid-free paper.

Copyright © 2012 by John Wiley & Sons, Inc. All rights reserved

Published by John Wiley & Sons, Inc., Hoboken, New Jersey

Published simultaneously in Canada

No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, scanning, or otherwise, except as permitted under Section 107 or 108 of the 1976 United States Copyright Act, without either the prior written permission of the Publisher, or authorization through payment of the appropriate per-copy fee to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, (978) 750-8400, fax (978) 646-8600, or on the web at www.copyright.com. Requests to the Publisher for permission should be addressed to the Permissions Department, John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, (201) 748-6011, fax (201) 748-6008, or online at www.wiley.com/go/permissions.

Limit of Liability/Disclaimer of Warranty: While the publisher and the author have used their best efforts in preparing this book, they make no representations or warranties with respect to the accuracy or completeness of the contents of this book and specifically disclaim any implied warranties of merchantability or fitness for a particular purpose. No warranty may be created or extended by sales representatives or written sales materials. The advice and strategies contained herein may not be suitable for your situation. You should consult with a professional where appropriate. Neither the publisher nor the author shall be liable for any loss of profit or any other commercial damages, including but not limited to special, incidental, consequential, or other damages.

For general information about our other products and services, please contact our Customer Care Department within the United States at (800) 762-2974, outside the United States at (317) 572-3993 or fax (317) 572-4002.

Wiley publishes in a variety of print and electronic formats and by print-on-demand. Some material included with standard print versions of this book may not be included in e-books or in print-on-demand. If this book refers to media such as a CD or DVD that is not included in the version you purchased, you may download this material at <http://booksupport.wiley.com>. For more information about Wiley products, visit www.wiley.com.

Library of Congress Cataloging-in-Publication Data:

Calkins, Meg, 1965-

The sustainable sites handbook: A complete guide to the principles, strategies, and best practices for sustainable landscapes / Meg Calkins.

p. cm. — (Wiley desktop editions)

Includes index.

ISBN 978-0-470-64355-6 (hardback); 978-1-118-10003-5 (ebk.); 978-1-118-10004-2 (ebk.); 978-1-118-10608-2 (ebk.); 978-1-118-10609-9 (ebk.); 978-1-118-10611-2 (ebk.)

1. Landscape ecology—Handbooks, manuals, etc. 2. Sustainable development—Evaluation—Handbooks, manuals, etc. 3. Environmental management—Evaluation—Handbooks, manuals, etc. 4. Sustainable Sites Initiative. I. Title.

QH541.15.L35C35 2011

577.5'5—dc22

2011013754

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

THE SUSTAINABLE SITES

H A N D B O O K

FOREWORD

THE EMERGENCE OF THE SUSTAINABLE SITES Initiative Program (SITES) and what it says about the ecological awakening that has taken place over the last twenty-five years are quite encouraging. SITES addresses the urgent need for a coordinated response among landscape design professionals to take on the environmental imperatives of the twenty-first century. The information, methods, and approaches contained in *The Sustainable Sites Handbook*, an essential companion to realizing the goals of SITES, offer guidance for beginning and established practitioners alike. It has the potential to have a profound effect on how the built landscapes of our time are designed, constructed, and managed, and how they perform within their larger environmental and ecological context.

Ecology and landscape architecture are inseparable, as is demonstrated by the broad range of specialists consulted in the development of SITES and the *Handbook*. In fact, these were precisely the types of concerned and far-sighted professionals who laid the philosophical groundwork for sustainable site design in the last century. In the 1930s, for instance, naturalist Aldo Leopold stirred the Western world's consciousness of nature's complex and interrelated systems. Two decades later, Rachel Carson, an ecologist and scientist, warned us about the dangers of destabilizing natural systems, pointing to both environmental havoc and the potential for associated human tragedy. By the late 1960s, thanks in large part to both Ian McHarg and Carl Steinitz, landscape architects were awakened to a methodology for regional and local planning that firmly placed ecology at its center.

The urgency of environmental stewardship is not in question, and the fact that landscape architects can and will play a leadership role in the drive to create a more sustainable exchange between humans and our environment is clear. Our profession knows that nature will not simply reestablish or mend itself in many of the critically disturbed systems on which we all now work. Up until now, the question of how landscape architects might intelligently and effectively transform our practice to meet current challenges has been loosely defined on an individual basis. The *Handbook* has the potential to help a great deal: It consolidates a body of knowledge about environmentally positive design approaches and frames it as a response to the challenges of contemporary practice, where ideals and on-the-ground performance must be reconciled.

With the SITES standards, landscape architects—and indeed all site designers—have a framework for sustainable site design defined by acknowledged experts in their respective specialties and a means of bringing recognition to clients who dedicate themselves to building sustainably. *The Sustainable Sites Handbook* is an important first step in trying to define what sustainability means with respect to the multitude of social, environmental, economic,

and experiential concerns that impact everything we design and build. The future is very much about taking on the promise these guidelines offer and raising them to a higher and more defensible level, in terms of both the science and the economics of how these endeavors improve public health. I look forward to future editions of this book that demonstrate that our field is growing based on new research, postoccupancy monitoring, and further innovation.

MICHAEL VAN VALKENBURGH

LETTER FROM SITES™ PARTNERS

WHILE THE GREENING OF THE BUILT ENVIRONMENT has been widely embraced, a key element has largely been missing: robust standards to guide the creation of sustainable landscapes, with and without buildings. Traditionally, designed landscapes have been major consumers of scarce resources, but—unlike buildings—when done correctly, can improve and regenerate natural systems. Yet until now, no “green” design and construction standards existed for large campuses, public parks, conservation areas, private resorts, recreation areas, or transportation and utility corridors.

This significant challenge spurred the formation of the Sustainable Sites Initiative™ (SITES™), an interdisciplinary partnership of the American Society of Landscape Architects, the Lady Bird Johnson Wildflower Center at the University of Texas at Austin, and the United States Botanic Garden, which has developed voluntary guidelines and a rating system for landscape sustainability. In developing the guidelines, SITES tapped the expertise of a diverse group of stakeholder organizations and more than 70 nationally respected authorities on soil, hydrology, materials, vegetation, and the impact of the environment on human health and well-being. Their collective expertise guided a rigorous science- and research-based process to produce the *Sustainable Sites Initiative: Guidelines and Performance Benchmarks 2009*.

In the *Sustainable Sites Handbook*, editor Meg Calkins, ASLA, and John Wiley & Sons, Inc., have created a comprehensive resource for all those who seek to create sustainable landscapes and especially those who hope to attain certification under the SITES Rating System™. Incorporating the work of many of the SITES experts, *The Sustainable Sites Handbook* is a valuable companion document to the SITES Guidelines and Performance Benchmarks and has been carefully reviewed for technical accuracy and adherence to SITES prerequisites and credits.

Use of these design approaches will provide tangible benefits to our cities and communities, including cleaner air and water, climate regulation, conservation of energy and other natural resources, and protection of biodiversity. We hope SITES and the *Sustainable Sites Handbook* will encourage all those who teach and practice landscape design, construction, and maintenance to adopt sustainable best practices and create sustainable landscapes.

NANCY C. SOMERVILLE, HON. ASLA, EXECUTIVE VICE PRESIDENT/CEO
AMERICAN SOCIETY OF LANDSCAPE ARCHITECTS

SUSAN RIEFF, EXECUTIVE DIRECTOR
LADY BIRD JOHNSON WILDFLOWER CENTER AT THE UNIVERSITY OF TEXAS AT AUSTIN

HOLLY SHIMIZU, EXECUTIVE DIRECTOR
UNITED STATES BOTANIC GARDEN

ACKNOWLEDGMENTS

JUST LIKE A SUSTAINABLE PROJECT requires collaboration among many disciplines to create complex, living systems, the richness of this book results from the efforts of many dedicated professionals who each bring an important perspective to the work.

Chapter Authors, most of whom were technical advisors to development of the SITES Guidelines and Performance Benchmarks, generously shared their expertise by creating rich content for each chapter. Each chapter was thoughtfully reviewed by the experts listed below who gave freely of their time and expertise with many insightful comments. Heather Venhaus, in particular, offered invaluable input over the many phases of book development.

Perhaps the largest group I must acknowledge are the varied professionals listed below who originally developed the SITES Guidelines and Performance Benchmarks. They contributed immeasurably to this book by identifying the broad reach of design and management considerations for sustainable sites and by creating the SITES Guidelines—an extremely important tool for twenty-first century site development.

I would also like to thank the SITES partners: The Ladybird Johnson Wildflower Center, The American Society of Landscape Architects and the US Botanic Garden for their support of this book. Thank you to Margaret Cummins, Senior Editor at Wiley for supporting this project from the initial idea to its completion.

Many professional design firms generously contributed images of their work to this book. I thank them for this and more importantly, for the wonderful work they are doing to design, build and manage sustainable sites that will serve as fine examples and offer many lessons for sustainable site projects to come. Many of the projects depicted in the photos are SITES case studies or pilot projects.

Jody Rosenblatt Naderi, John Motloch, and Martha Hunt, my colleagues at Ball State University, offered me support and guidance during the process of developing and editing this book. I would also like to thank graduate student Ryan Smith for his research assistance (and persistence) with obtaining images and permissions, and the many students in my Sustainable Site Design seminar who contributed insight and in a few cases, research to the book.

Lastly, I owe a huge thank you to my family and friends for their support over the duration of this book's development. My husband, George Elvin, was immeasurably helpful with encouragement and feedback on book ideas AND he also willingly took up the parenting slack over and over during the many long deadlines. My parents, sister, and friends provided a supportive structure for my children as well, allowing me time and space to devote to the creation of this book.

Chapter reviewers:

Heather Venhaus
Nina Bassuk
Steve Benz
Larry Costello
George Elvin
Martha Hunt
Alison Kinn Bennett
John Motloch
Jerry Smith
Laura Solano
Alfred Vick
Ken Willis
David Yocca

SITES Technical Experts:

José Almiñana
Michael Barrett
Nina Bassuk
Amy Belaire
Jacob Blue
Meg Calkins

Michael Clar
Kimberly Cochran
Scott Cloutier
Fred Cowett
Susan D. Day
Richard J. Dolesh
Deon Glaser
Nora Goldstein
Robert Goo
Deb Guenther
Liz Guthrie
Len Hopper
William Hunt
Karen C. Kabbes
Alison Kinn Bennett
Nick Kuhn
Frances (Ming) Kuo
Tom Liptan
Ed MacMullan
Chris Martin
David McDonald
Ray Mims
Karen R. Nikolai

James Patchett
Danielle Pieranunzi
Kristin Raab
Robert Ryan
Jean Schwab
Melanie Sifton
Mark Simmons
Jerry Smith
Laura Solano
Fritz Steiner
Eric Strecker
John C. Swallow
Rodney Swink
Janice E. Thies
John Peter Thompson
Megan Turnock
Valerie Vartanian
Heather Venhaus
Lynne M. Westphal
Julie Wilbert
Steve Windhager
Kathleen L. Wolf
David J. Yocca

CONTENTS AT A GLANCE

Foreword ➤ **ix**

Letter from SITES™ Partners ➤ **xi**

Chapter 1 ➤ Introduction **1**

Chapter 2 ➤ Predesign: Site Selection, Assessment, and Planning **33**

Chapter 3 ➤ Site Design: Water **65**

Chapter 4 ➤ Site Design: Vegetation **197**

Chapter 5 ➤ Site Design: Soils **247**

Chapter 6 ➤ Site Design: Materials and Resources **323**

Chapter 7 ➤ Human Health and Well-Being for Sustainable Sites **429**

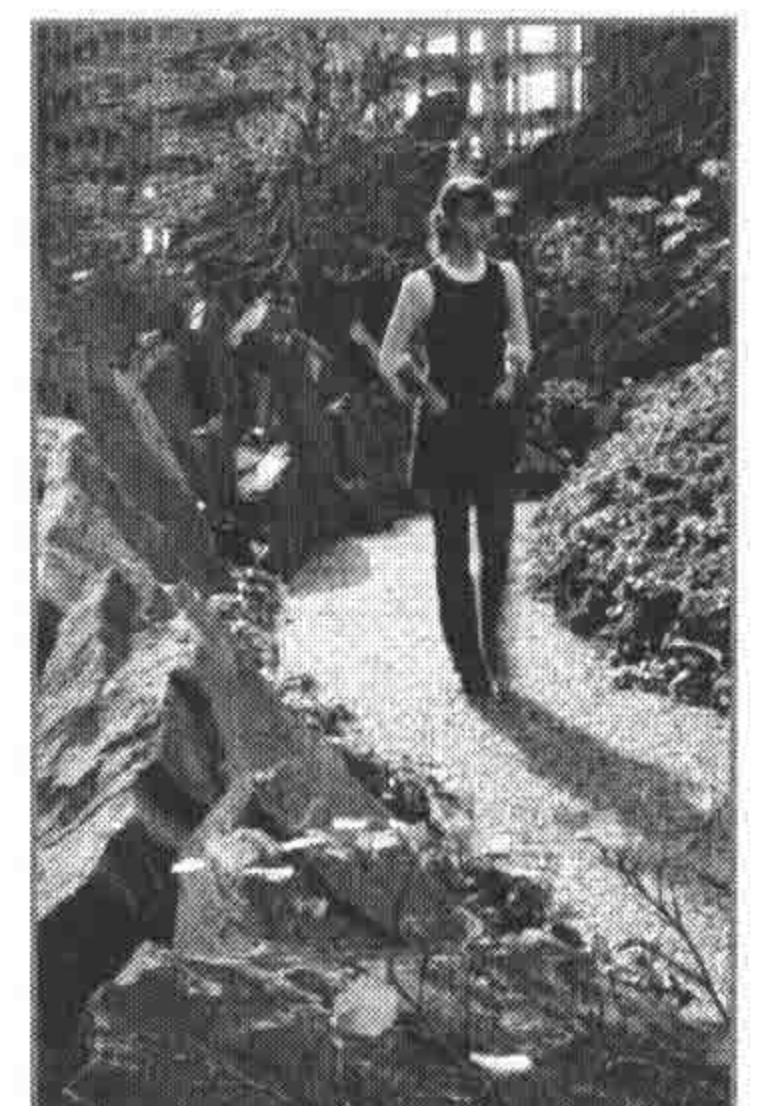
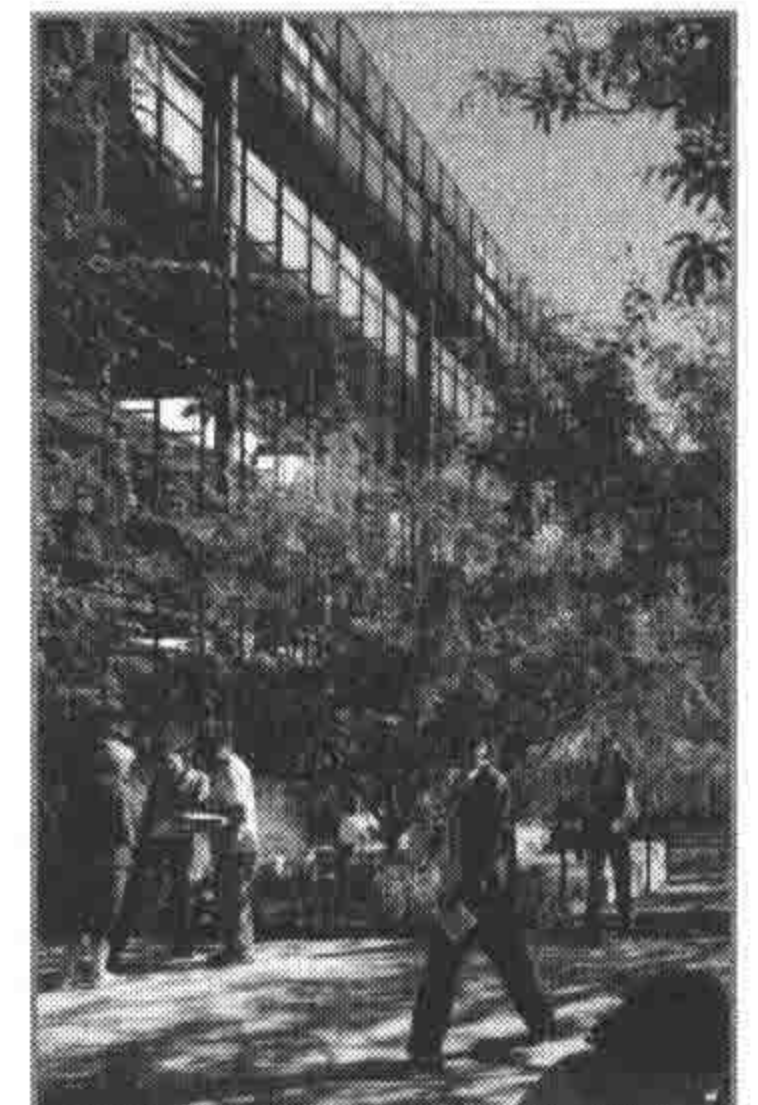
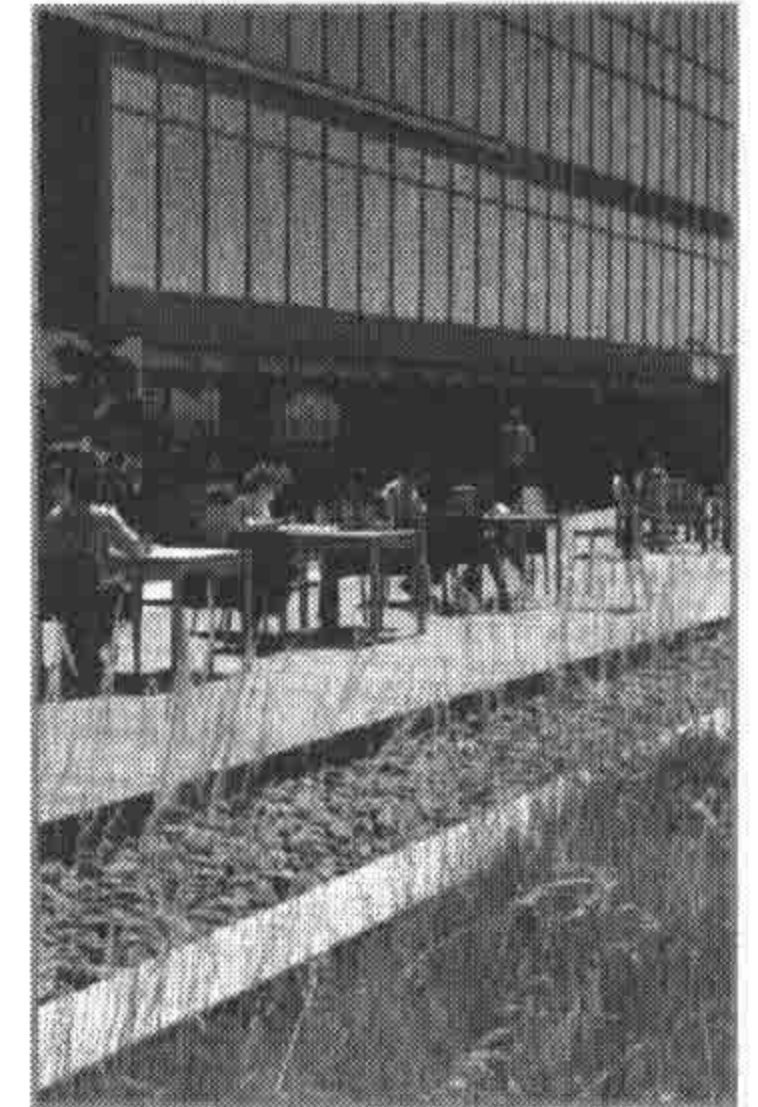
Chapter 8 ➤ Operations, Maintenance, Monitoring, and Stewardship **479**

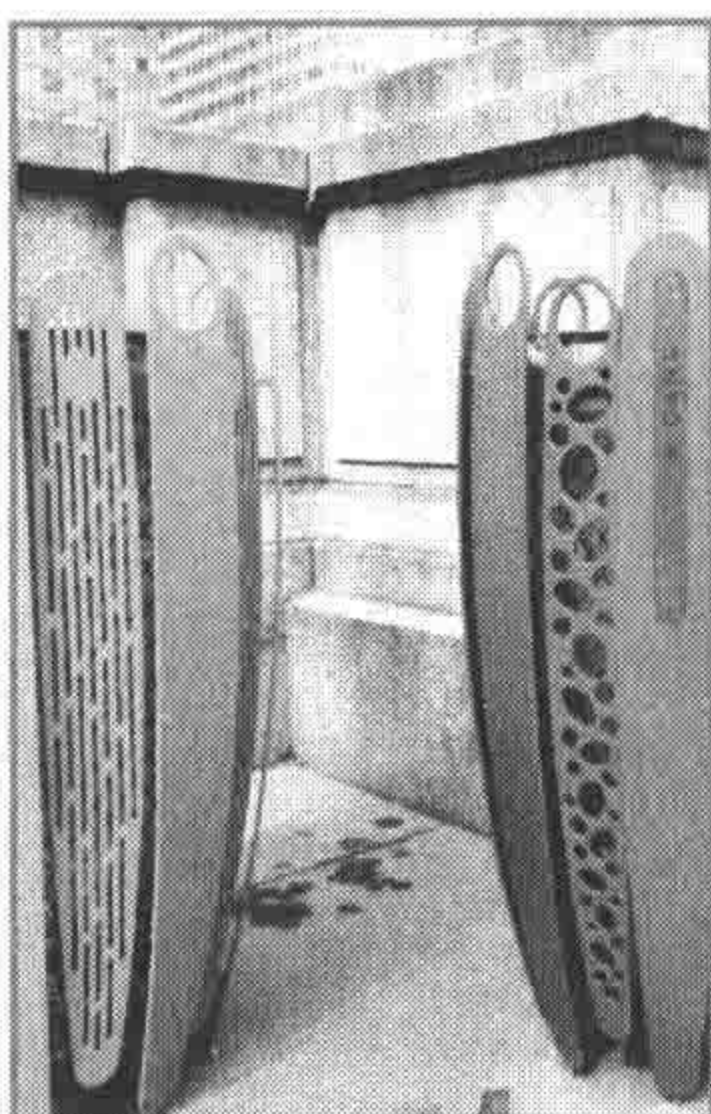
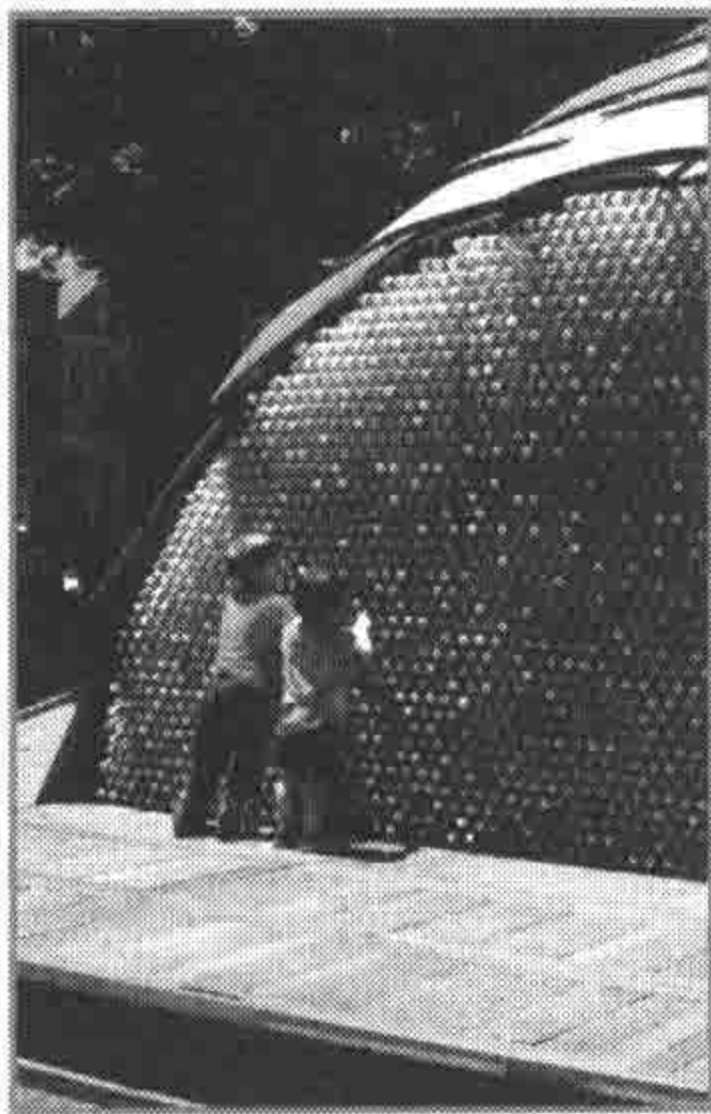
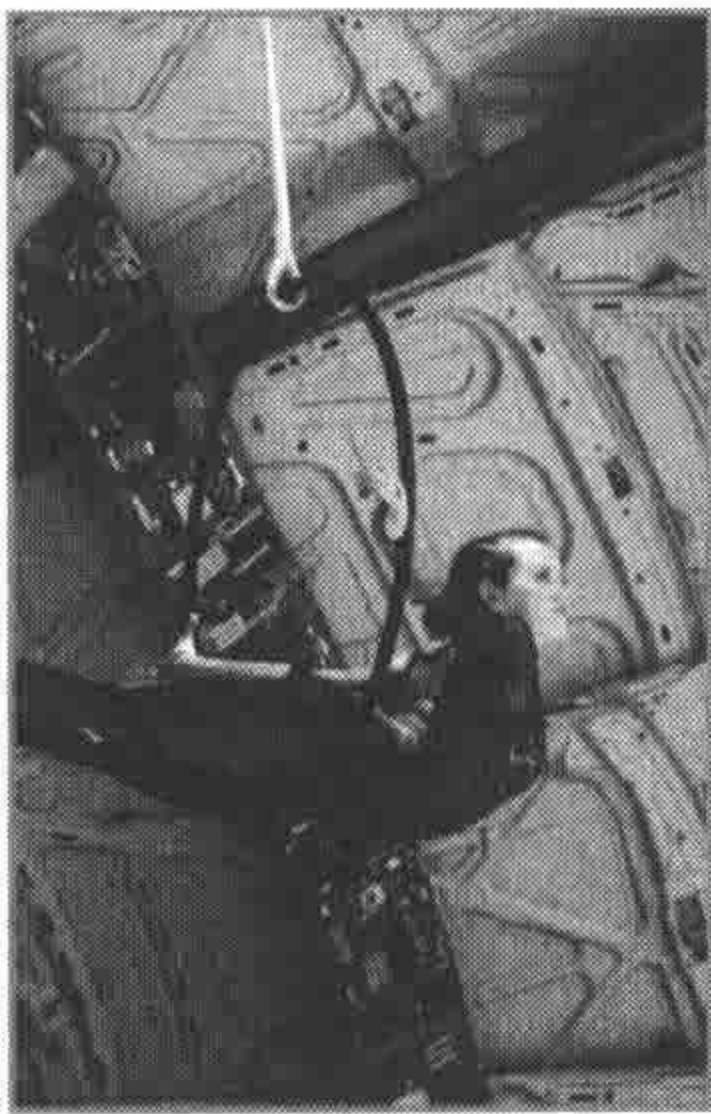
Resources ➤ **521**

Index ➤ **535**

CONTENTS

	Foreword	ix
	MICHAEL VAN VALKENBURGH	
	Letter from SITES™ Partners	xi
Chapter 1 ▶	Introduction	1
	MEG CALKINS	
	Sustainable Site Design Defined	2
	The Contents and Structure of This Book	27
Chapter 2 ▶	Predesign: Site Selection, Assessment, and Planning	33
	HEATHER VENHAUS	
	Site Selection	33
	Understanding the Site	41
	Team Development and Planning Strategies	54
	Developing Project Direction: Principles, Goals, and Performance Targets	58
Chapter 3 ▶	Site Design: Water	65
	ALFRED VICK, JOHN CALABRIA, STUART ECHOLS, MICHAEL OGDEN, and DAVID YOCCA	
	Sustainable Stormwater Management	72
	Stormwater Design Approaches	104
	Water Conservation	148
	Onsite Wastewater Treatment, Disposal, and Reuse	166
Chapter 4 ▶	Site Design: Vegetation	197
	STEVE WINDHAGER, MARK SIMMONS, and JACOB BLUE	
	Vegetation and Ecosystem Services	202
	Vegetation Protection Techniques	213
	Sustainable Planting Design and Management	216
Chapter 5 ▶	Site Design: Soils	247
	NINA BASSUK and SUSAN DAY	
	Integrating Soil into the Design Process	249
	Soils in the Site Assessment	251
	Soil Characteristics and Associated Tests	265
	Managing Soils for a Sustainable Site	295
	Soil Replacement and Specialized Soils	310
	The Soil Management Plan	316





Chapter 6 ▶	Site Design: Materials and Resources	323
	MEG CALKINS	
	The Lifecycle of Construction Materials and Products.	327
	Environmental Impacts of Materials and Products.	331
	Human Health Impacts of Materials.	344
	Evaluating Environmental and Human Health	
	Impacts of Materials.	348
	Inventory and Analysis for Materials.	358
	Resource Efficiency.	360
	Low-VOC Materials and Products.	390
	Materials to Minimize Heat Island Impacts.	390
	Concrete.	396
	Aggregates and Stone.	398
	Asphalt.	401
	Brick Masonry.	403
	Earthen Materials.	404
	Plastics.	407
	Metals.	409
	Bio-Based Materials.	413
	Wood.	416
	Site Lighting.	421
Chapter 7 ▶	Human Health and Well-Being for Sustainable Sites	429
	ROBERT RYAN	
	Assessing the Site's Social Setting.	432
	Sustainability Awareness and Education.	436
	Social Equality in Site Development, Construction, and Use.	440
	Site Accessibility.	445
	Site Wayfinding.	449
	Site Safety.	454
	Design for Physical Activity.	458
	Restorative Settings.	462
	Design for Social Interaction and Community Building.	466
	Preserving Historic and Cultural Features.	470
Chapter 8 ▶	Operations, Maintenance, Monitoring, and Stewardship	479
	AMY BELAIRE and DAVID YOCCA	
	Environmental and Human Health Impacts of Sustainable Site Operations, Maintenance, and Monitoring.	480
	Incorporating Operations, Maintenance, and Monitoring Considerations into Site Design.	482
	Monitoring to Inform Active and Adaptive Stewardship.	519
	Resources.	521
	Index.	535

INTRODUCTION

► Meg Calkins

THE NATURAL ENVIRONMENT IS COMPRISED OF COMPLEX, interrelated systems of water, soil, air, atmosphere, flora, and fauna that are constantly evolving, balancing, changing, and rebalancing. These ecosystems offer services such as air and water cleansing, water supply and regulation, and productive soil that sustain and enhance human systems—services that are critical to survival of all species. Designed sites can protect, sustain, and even provide these critical ecosystem services. Offering potential to serve multiple functions, sites can be productive, provide ecosystem services, *and* offer rich aesthetic experiences to the site occupants.

This idea of ecosystem services as a basis for design is a profound shift in the way that we think about the role of designed sites. If we are to design and manage sites that support and engage natural processes, we need to shift our focus from creating and maintaining static, isolated landscapes to that of designing and managing complex, interrelated living systems of the built environment. And as a model for designing site systems that can ensure sustainable development, we need look no further than the principles inherent in our planet's ecosystems, principles that include zero waste, adaptation, and resiliency.

If we are to protect the world's ecosystems for future generations, the human-made environment must foster the health of both ecological and human systems. Design of the built environment, including site design, plays a critical role in this. In 2000, the United Nations commissioned the Millennium Ecosystem Assessment, a global study by 1,360 scientists from an international consortium of governments, universities, nonprofits, and businesses. The 2005 concluding report stated that "human activity is having a significant and escalating impact on the biodiversity of world ecosystems, reducing both their resilience and bio-capacity" (MEA 2005). The report, referring to natural systems as humanity's "life support system," established that "ecosystems are critical to human well-being—to our health, our prosperity, our security, and to our social and cultural identity" and unless we change the way that we develop land, use resources, and produce food, these services will be seriously compromised for future generations. The report warns: "At the heart of this assessment is a

stark warning. Human activity is putting such a strain on the natural functions of Earth that the ability of the planet's ecosystems to sustain future generations can no longer be taken for granted" (MEA 2005).

In response to this imperative, the Sustainable Sites Initiative™ (SITES™), a partnership of the American Society of Landscape Architects, the Lady Bird Johnson Wildflower Center at the University of Texas at Austin, and the United States Botanic Garden, have released *Guidelines and Performance Benchmarks* to guide development of sustainable sites through a voluntary credit rating system. These guidelines and benchmarks encourage the protection, restoration, and provision of ecosystem services as a basis for sustainable site design. They address the design and management of systems of vegetation, soils, water, materials, energy, and culture.

This book has been created to offer comprehensive and detailed information on strategies, technologies, tools, and best practices for sustainable site design. This book, like the *SITES Guidelines and Performance Benchmarks*, is based on the premise that any site in any location can be designed and managed to foster healthy ecosystems, and promote ecosystem services and sustainable human systems. It is intended to assist practitioners with successful implementation of the SITES rating tool, and it will also stand as a resource guide for the design and management of sustainable sites. This publication, developed with the cooperation of the Sustainable Sites Initiative, will complement the *Guidelines and Performance Benchmarks*, the prerequisites and credits, and future SITES publications. It will be a companion resource that practitioners can turn to for deeper guidance on the topics of hydrology, vegetation, soils, materials, human health and well-being, and site selection.

SUSTAINABLE SITE DESIGN DEFINED

Sustainable design as defined by SITES is "design, construction, operations and maintenance practices that meet the needs of the present without compromising the ability of future generations to meet their own needs" (SITES 2009a). This is based on the definition of sustainable development from the United Nations World Commission on Environment and Development's Bruntland Report, *Our Common Future* (UNWCED, 1987). For site design, this translates to fostering both human and natural ecosystem health, closing material and resource loops, and designing with respect for nutrient and water cycles. Sustainable site design emphasizes design of whole, complex functioning systems; a widened scale of analysis and design consideration; highly site-specific (as opposed to universal) design responses; and continued monitoring, management, and adaption to ensure healthy, functioning systems for the life of the landscape.

Design of sustainable sites involves a fundamental shift in the way that we think about the Earth and its resources. We must shift from the extractive mind-set of viewing the Earth's resources as abundantly available for human consumption to the understanding that Earth's resources and ecosystems are the sustainers of life on this planet and must be protected. New development must work toward fostering the health of ecosystems and the services they provide through their protection and restoration. We must forge a new and respectful relationship with natural systems, acknowledging their critical role in our health and the health of the planet.

Triple Bottom Line

Sustainability encompasses not only environmental conservation, but also the ideals of social equity and economic feasibility. This “triple bottom line” is the key to truly sustainable development (Figure 1-1). While this book primarily focuses on environmental sustainability, it addresses areas of social and economic sustainability as they relate to environmental issues and sustainable site design. Design of the built environment also has a direct impact on human and cultural systems. Therefore, a chapter is devoted to human health and well-being considerations of site development.

Ecosystem Services

Ecosystem services are defined in the Millennium Ecosystem Assessment as “the benefits humans obtain from ecosystems” (MEA 2007). Living elements of ecosystems, such as vegetation and soil organisms, interact with the nonliving elements such as water, air, and bedrock in ecosystem processes to produce goods and services that offer direct or indirect benefits to humans. The MEA groups ecosystem services into four broad categories (MEA 2005):

- ▶ *Provisioning*, such as the production of water, clean air, food, and medicines;
- ▶ *Supporting*, such as pollination, waste decomposition, and nutrient cycling;
- ▶ *Regulating*, such as global and local climate regulation, erosion control, disease control; and
- ▶ *Cultural*, such as health, spiritual, recreation, and relaxation benefits.

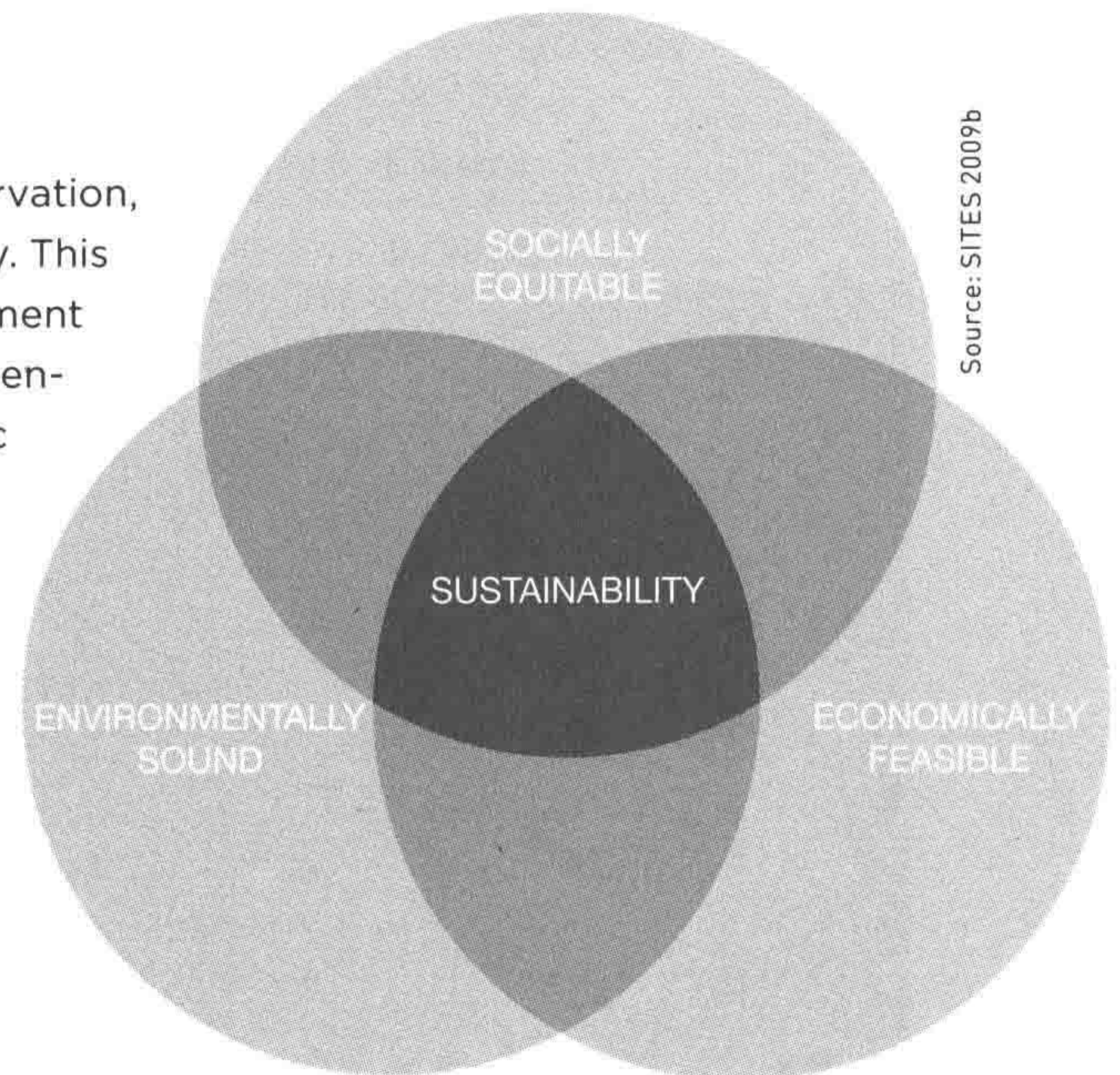


FIGURE 1-1: Sustainable design addresses overlapping aspects of environmentally sound, socially equitable, and economically feasible development.

There are many ecosystem services that can be provided by sites (Figure 1-2) (Table 1-1). Some examples are:

- ▶ Trees regulate local climate through evapotranspiration, shade, and wind control.
- ▶ Vegetation mitigates local air quality.
- ▶ Soils and vegetation infiltrate and purify stormwater protecting adjacent waterways and the water table.
- ▶ Vegetation and construction materials mitigate heat island impacts in urban areas.
- ▶ Vegetation, water, and materials are combined to make parks, gardens, and open spaces for human health and well-being and cultural benefits.
- ▶ Water and soil organisms break down waste and cycle nutrients.

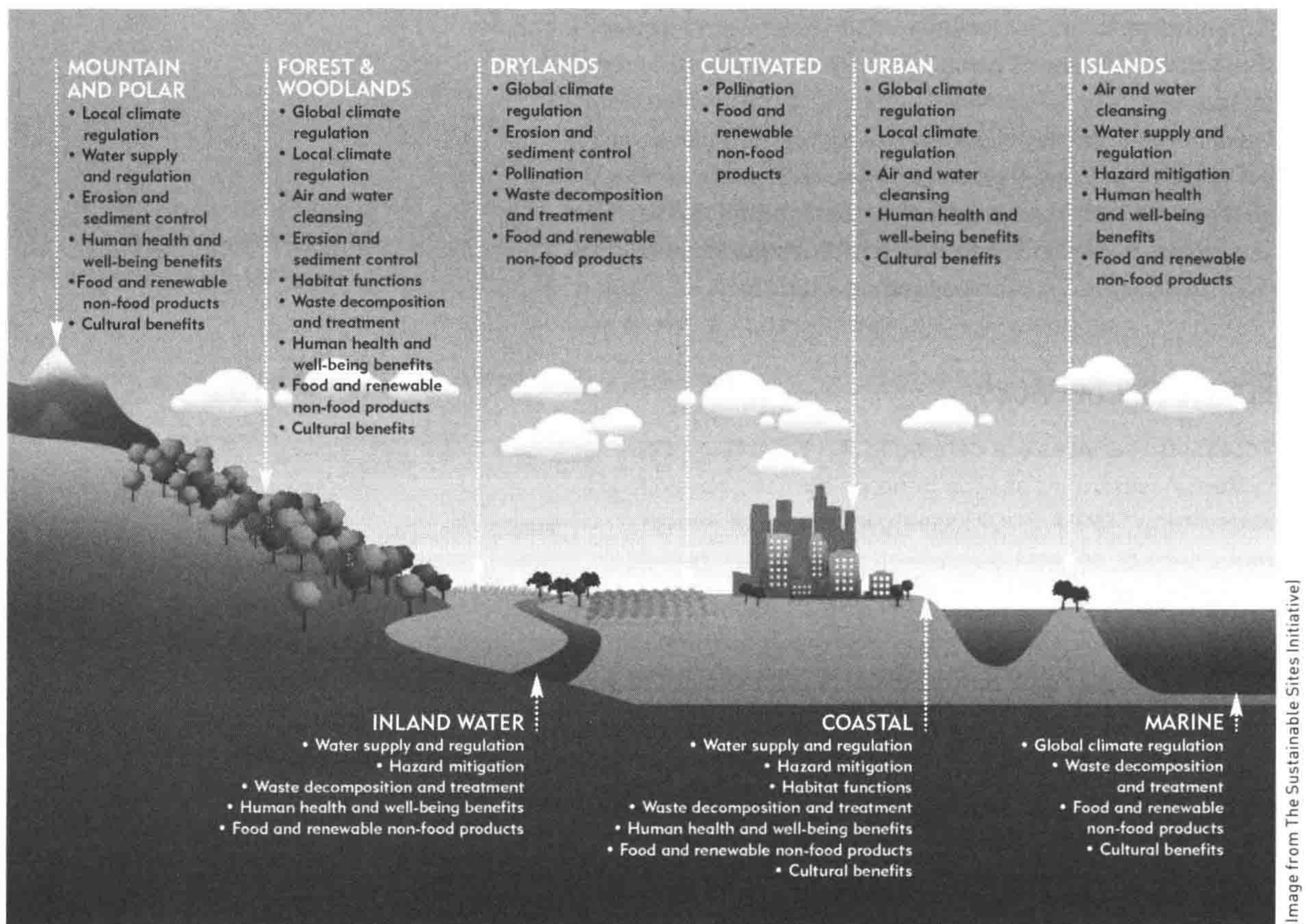


FIGURE 1-2: Ecosystem services by landscape type.

It is important to note that site development decisions can impact ecosystem services far away from a site as well—and these impacts are not often easily seen or understood. Decisions about stormwater management and vegetation inputs (e.g., fertilizers and herbicides) can impact waterways hundreds of miles downstream. Resource extraction and material manufacturing can impact ecosystems halfway around the world. And air currents can carry airborne pollutants far away from the manufacturing plant that released them.

TABLE 1-1: Ecosystem Services

ECOSYSTEM SERVICE	FUNCTION
Global climate regulation	Maintaining balance of atmospheric gases at historic levels, creating breathable air, and sequestering greenhouse gases
Local climate regulation	Regulating local temperature, precipitation, and humidity through shading, evapotranspiration, and windbreaks
Air and water cleansing	Removing and reducing pollutants in air and water
Water supply and regulation	Storing and providing water within watersheds and aquifers
Erosion and sediment control	Retaining soil within an ecosystem, preventing damage from erosion and siltation
Hazard mitigation	Reducing vulnerability to damage from flooding, storm surge, wildfire, and drought
Pollination	Providing pollinator species for reproduction of crops or other plants
Habitat functions	Providing refuge and reproduction habitat to plants and animals, thereby contributing to conservation of biological and genetic diversity and evolutionary processes
Waste decomposition and treatment	Breaking down waste and cycling nutrients
Human health and well-being benefits	Enhancing physical, mental, and social well-being as a result of interaction with nature
Food and renewable nonfood products	Producing food, fuel, energy, medicine, or other products for human use
Cultural benefits	Enhancing cultural, educational, aesthetic, and spiritual experiences as a result of interaction with nature

Source: SITES 2009a