

BUILDING ECOLOGY  
FIRST PRINCIPLES FOR A SUSTAINABLE BUILT ENVIRONMENT



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## FIRST PRINCIPLES FOR A SUSTAINABLE BUILT ENVIRONMENT

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**Blackwell**  
Science

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Editorial offices:

Blackwell Science Ltd, 9600 Garsington Road, Oxford OX4 2DQ, UK

Tel: +44 (0) 1865 776868

Blackwell Publishing Inc., 350 Main Street, Malden, MA 02148-5020, USA

Tel: +1 781 388 8250

Blackwell Science Asia Pty Ltd, 550 Swanston Street, Carlton, Victoria 3053, Australia

Tel: +61 (0)3 8359 1011

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Line drawings by Anita Lincolne-Lomax,  
Lincolne-Lomax Design, Melbourne, Australia

First published 2003 by Blackwell Science Ltd  
Reprinted 2005

Library of Congress Cataloging-in-Publication Data is available

ISBN-10: 0-632-06413-7

ISBN-13: 978-0632-06413-7

A catalogue record for this title is available from the British Library

Set in 10.5/12.5pt Palatino  
by Sparks, Oxford – [www.sparks.co.uk](http://www.sparks.co.uk)  
Printed and bound in Great Britain  
by TJ International Ltd, Padstow, Cornwall

The publisher's policy is to use permanent paper from mills that operate a sustainable forestry policy, and which has been manufactured from pulp processed using acid-free and elementary chlorine-free practices. Furthermore, the publisher ensures that the text paper and cover board used have met acceptable environmental accreditation standards.

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*Dedicated to my Nan*

*Phyllis Moulton*



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## ACKNOWLEDGEMENTS

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This book has not come from me, but through me. I have been facilitator of the ideas presented here, more developer than creator, and as such have many to thank for this final outcome. I would not have been able to complete this without the love and support of my parents – Dr Kay Moulton and Dr John Graham and my sister Sarah. Having a family as eminent and willing to read and comment on the many drafts is a wonderful thing. I must especially thank my mother for letting me stay in the spare room and for feeding me wonderfully during the last two weeks of writing. For her passion for life, her love and inspiration I would like to thank Carly Davenport, whose confidence in my capacity to write a book has kept me going. In my darker moments you reminded me of our love for life, and the urgency of our campaign to make the world a better place for all children. You are beautiful.

Bill Lawson, from the University of New South Wales – thank you for your excellent comments on my draft manuscript. Without your body of work, this book would have been very hard to complete. Thank you for asking me whether I use ‘nature’ in the big ‘N’ sense, as designed by some ‘transcendental force’, ‘first cause’ or ‘God’. You will notice that I have opted for the small ‘n’ as in ‘evolving systems’.

As a surfer I certainly feel big ‘N’ nature and this fuels my passion for life. In writing this book the little ‘n’ comes out because I don’t want to condition people’s understanding with my perspective alone. I am sure that everyone has some perception of the presence or otherwise of a divine energy. The imperative is for us all to agree on what forms of development will keep us alive so we can enjoy our exploration of what nature means to us. The current state of the world exemplifies what happens when people’s attachment to ideas are given priority over developing understandings about what we all share.

Building with nature means understanding how to work with the physical laws that govern life. Any surfer will tell you what it is like. Surfers learn the art of going with the flow – not aimlessly following

## *Acknowledgements*

a whim, but directing their action to find the location and the moment in which all of the energies present in the wave work together. I would like to thank my friends in Urban Ecology and the Surfrider Foundation for all of our work together, our conversation and inspiration. Bill and Heather Pemberton deserve a special mention for reading, then staying up very late debating thermodynamics with me. Thanks also to all of the people that contributed ideas and case studies.

A big thank you also to Mary Tomsic for her exceptional research assistance and compilation of many of the tables. *Building Ecology* would not have been completed within deadline had it not been for your calm, 'can do' attitude.

My students at RMIT in Australia and SIM in Singapore used the text and tried out the activities. Their feedback provided insights into approaches to teaching and learning that have helped shape this book. I must also thank my colleagues at the Department of Building and Construction Economics at RMIT for their support.

This book is a consequence of the relationships created between people. It is a manifestation of an emerging system emblematic of our time – an empowered network. A saying common in the twentieth century was 'it is not what you know – but who you know'. The empowered network is more than just knowing people. It is about helping people. A saying for the twenty-first century that might define an empowered network is 'it is not just who you know – but how you help each other'. I would not have been able to write *Building Ecology* without my empowered network. Thank you.

Peter Graham  
February 2002

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## ABOUT THIS BOOK

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This book is intended for students and building practitioners who are new to the field of ecologically sustainable building. It is designed to provide grounding in the general issues and in the fundamental laws and principles of ecological sustainability. It is written for all people involved in shaping our built environment, not for any one particular vocation.

I have written this book because I want to provide a way of helping people understand their intimate interdependency with nature, and be able to make decisions that sustain and can be sustained by nature. I have not set out to tell people what to do, or what to think about building or the environment. I am interested in engaging how we think about building and the environment and the models we think with.

I have set out to provide a more holistic, systems-based way of thinking about ecologically sustainable building that can help people develop an understanding of the relationships between natural systems and built environments and between decisions and intended outcomes. The emphasis therefore is not on providing comprehensive descriptions of environmental impacts of building materials, nor extensive building design critiques.

*Building Ecology* is intended to help people develop an initial level of ecological literacy and environmental awareness, an approach to thinking about building that can become a platform for life-long learning in this field.

The book is structured in three sections. The first part deals with how our buildings and our minds are connected with natural systems. Its purpose is to increase understanding of how and why building affects nature. It introduces the concepts of life-cycle thinking and urban metabolism as ways of understanding relationships between building and nature. The impacts of our current practice on biogeochemical cycles and ecosystems are then described. We discover that

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our building activity is causing changes in natural systems that are having a negative impact on us. We need to change...but how?

Part II deals with that question of change. It describes the fundamental principles of ecological sustainability derived from thermodynamic laws, and contains observations of the way we are changing nature, and in turn the pressures nature places on us to change. At the end of section two we understand what the properties of ecologically sustainable building are.

The purpose of Part III is to take a look again at the big picture, but this time from an ecologically sustainable perspective. This section distils a set of laws and principles for ecologically sustainable building. These principles are presented in a framework that makes sense of their individual and collective purpose. We then look at how a built environment might progress if these principles were applied. A detailed case study of a school in Sweden is also provided in this section to show the sort of building that results from a holistic approach to thinking about ecological sustainability.

As general rather than detailed knowledge is presented, suggestions for supplementary and complementary reading and information resources are provided at the end of each section, organised into topic areas. Reflective learning activities are also provided at the end of Parts I and II as tools for assisting deeper thinking on issues raised.

Many terms used require definition or a level of explanation for which space in the text does not allow. A glossary of terms is provided for this purpose.

I hope you enjoy *Building Ecology*.

---

# 1 INTRODUCTION

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People and buildings are as intrinsically infused with nature as bees and their hives are with honey. Unfortunately the effects of our building industry are far less sweet. Unlike bees, whose produce is nourishing, the process of constructing and operating buildings often creates environmental outcomes that are not. Due to the non-ecological structure of the building industry and the historical lack of environmental awareness of many building professionals, the way buildings, built environments and the process of building have been created, has played a major role in the decline in Earth's ecological health.

Ecosystems are life-supporting systems and building that can be sustained by ecosystems rather than damage them is urgently required. The intent of this book therefore, is to provide a way of extending the understanding of building from mere regard for the structure and material to include all of the natural systems with which all building is interdependent. It also extends the concept of the building professional from one who helps make a structure, to one who builds a system of relationships between ecosystems and human systems. In essence this book is designed as an introduction to a systems approach to thinking about building for people new to the field of ecologically sustainable building.

Modern science is providing a far more detailed perspective of the way ecosystems function. This new knowledge is now beginning to be used by building professionals and the building industry in order to protect the life-supporting goods and services of ecosystems, and provide the basis for sustained life opportunity on Earth. *Building Ecology* presents approaches to gaining knowledge about the environmental influences of building in a holistic framework that helps students of building professions and practising professionals to:

- understand the interdependencies of buildings and nature;
- understand how building affects nature;

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- understand what is and is not sustainable;
- understand how building can work with nature.

### **A hive of understanding**

Imagine all of the existing knowledge on ecologically sustainable building as cells of honeycomb in a beehive, and all knowledge of economics and all other fields of human enquiry and understanding as being brought together in a honeycomb structure. The knowledge within each of these cells is like the pollen that busy bees go out to collect, while the processed and applied knowledge becomes understanding – and that is the honey.

Experts of many disciplines are busy at work in and around their cells collecting and processing knowledge in order to create understanding which, like honey, nourishes us. In building we must bring together many types of knowledge, apply many types of understanding. As well as thinking within a cell of specialised knowledge, we have to think *outside* the cell in order to solve the complex problems posed by creating a built environment in a world of decreasing ecological health and increasing human demands.

How do we learn to select, and then fit together, cells containing the knowledge we need, in a way that allows us to appreciate the whole system that we will affect when we build? We need a model that can allow us to bring together the knowledge contained in discrete disciplinary cells, and which allows the honey of combined understanding to flow freely.

A honeycomb in a beehive has a unifying hexagonal pattern, which is common to all cells. Too often environmental courses at universities are offered as separate subjects to those dealing with the perceived ‘world’ of financial and economic ‘reality’. Cells of knowledge concerning such issues as the environmental impact of materials, energy efficiency, sustainable construction, environmental design and management, cost estimating and quantity surveying, to name a few, although essential for holistic understanding of ecologically sustainable building, are sometimes as fragmented in curricula as a beehive might be after a bear’s breakfast.

The media too, frequently sets issues of environmental health in opposition to economic and social welfare, reinforcing the perception of a chasm between such things as ‘jobs and forests’ or the ‘cost of energy-efficient building and greenhouse gas reduction’. ‘Building bridges’ of compromise is then required where the outcomes are not optimal for anyone.

## *Introduction*

All of us are affected by the fragmented or adversarial way issues are presented to us. Many have accepted, perhaps unconsciously, what Gregory Bateson<sup>1</sup> refers to as the 'obsolete' Cartesian dualism of mind and matter. Another 'obsolete' idea that regularly enters the classroom is that economics simply refers to the management of financial transaction and that it is an opposing idea to that of ecological sustainability, further fragmenting our worldviews. So in learning ecologically sustainable building we end up being required to integrate discrete cells of knowledge using our own fragmented mental models of the way we think the world works. Unfortunately, when it comes to sustaining the life-supporting processes of our planet there is no room for compromise.

If we are going to be successful in creating ecologically sustainable building then we need to deal with the issue of how we have been constructed to see the world. We need to be given thinking tools that we can use to first develop a holistic rather than dualistic worldview and then use to reintegrate existing knowledge. As honeycomb has its hexagon, our knowledge and understanding of ecologically sustainable building needs a unifying pattern also.

In nature there exists a common thread of influences that, considered together, provide a model for synthesising existing knowledge so that we can understand it in the context of the broader ecological systems. This common thread allows us to understand our effects on the natural systems within which our economies sit, not as separate to economic concerns, but as integral to them.

This book offers a way of thinking about building that can become a mental map upon which the co-ordinates of any knowledge or information relating to ecologically sustainable building could be included. The model is reflected in the structure of this book and is based on fundamental aspects of life on Earth. The model is intended as a way of understanding the knowledge available, not as an attempt to displace it. The elements of this model, the structure of this book, our pattern that connects, the very beeswax of building ecology are the issues of interdependency, thermodynamics and change.

This approach is based on new advances in the life sciences, particularly systems ecology. Chemistry, ecology and principles of thermodynamics are coupled with systems ecology, providing a broad context of general knowledge of building-related environmental science. We can use this expanding area of scientific knowledge as a basic field of inquiry as our aptitude in ecologically sustainable building develops during our lives. The key to understanding ecology is the knowledge that all elements of the system, whether living or non-living, are interdependent. Understanding interdependency shifts

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the emphasis for learning from the components of the system to the relationships between the components, from the parts to the whole.

These shifts in perception, based on an understanding of interdependency, also provide the basis for extending the concept of self-interest from our body and the building to include our greater 'self' of community, ecosystem and planet. Extending the notion of self-interest implies that we also know how to take care of our greater self – the ecosystems and life cycles of nature, and the communities of humans that, as building professionals, our actions affect.

Because of self-interest we have learnt which food is good for us and which is bad, what to do when we get too hot or too cold, and who to consult when we get sick. We know how to stay healthy. When we go to a pharmacy to buy a cure for a headache there are many remedies to choose from. If we choose the wrong one it might have no effect or only treat the symptom – the pain – rather than address the problem that is causing the pain. Being able to choose a remedy that will cure us depends on how well we understand the cause of our problem.

The building industry has over the years had a profoundly negative influence on the Earth's ecological health, largely because the economic system within which it now operates has ignored its interdependency with nature.<sup>2</sup> Many principles and strategies for building 'green', designing 'ecologically' and constructing 'sustainably' have been developed. Like choosing medicine at a pharmacy, understanding what building decisions cause ecological ill-health is an essential prerequisite for being able to either choose the best 'off the shelf' building remedy or for developing even better ones. By understanding the current scientific view of how nature works and how buildings link with and affect nature, we can gain a foundation of knowledge for understanding how to take action as building professionals to keep our greater self – the Earth, healthy too.

This knowledge, together with the technical ability and confidence to use ecologically sustainable building approaches, is the basis of ecological literacy. There are many building professionals all over the world who are applying this quality of ecological literacy to create ecologically sustainable building projects. In this book these people are called *building professionals* who are *ecologically literate* and *environmentally aware* (BEEs). They are the vanguard of innovation in the building industry because they are not only pioneering new building technologies and designs, they are also profoundly changing the economics of the industry so that it enhances rather than damages ecosystems. These BEEs produce the honey!

## *Introduction*

Presented in this book is the basic knowledge required to become a BEE and the laws and principles of ecologically sustainable building that guide their decisions.

### **What do BEEs know?**

Our ecological literacy is a function of our understanding of required knowledge, coupled with our technical ability and willingness to use what we know. An ecologically literate building professional not only knows how to design, construct or manage buildings that contribute to ecologically sustainable development, they are also confident enough to *act* on the basis of their knowledge. Knowledge, technical ability and confidence are personal attributes that are gained over time. The information, case studies and activities presented in this book are intended to help facilitate gaining an initial level of ecological literacy, and introduce conceptual tools that can help us continue to develop our ecological literacy throughout our lives.

An important aspect of ecological literacy is understanding the environmental implications and effects of the different decisions made throughout the life cycle of a building development. Building-related environmental damage does not happen by itself. Environmental damage occurs due to the outcomes of decisions made by people responsible for different aspects of a project. Because environmentally literate people understand the likely environmental consequences of their decisions, they are empowered to make decisions that are environmentally beneficial.

Today's building industry leaders are individuals who not only participate in creating projects that have low environmental impact in terms of materials, processes and operational energy consumption. They conceive, nurture, promote and facilitate the kind of changes in building practice that are necessary to contribute to sustaining our life-supporting environments. BEEs have five essential types of knowledge that facilitate their ability to do this.

### ***Knowledge of interdependency***

BEEs know that buildings, built environments and the process of building depend on nature for all of their resources and that nature provides services like waste disposal and remediation that keep living systems healthy. They also know that what they build establishes

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flows of material and energy that affect present and future environments and people. This is the knowledge of interdependence.

### ***Knowledge of conservation and efficiency***

BEEs know that what goes around comes around – that matter is neither created nor destroyed but is continually circulating through all living and non-living systems. The first law of thermodynamics teaches us that energy can't be created or destroyed. This law focuses attention on how efficiently we use our materials and energy. As we cannot ultimately make any more of many of the resources we require for building, BEEs ensure that materials and energy are not being wasted, that as little material and energy is being used to solve as many problems as possible, and that we are doing more with less. This is the knowledge of conservation and efficiency or the first law of thermodynamics.

### ***Knowledge of surviving designs***

BEEs know that everything they build creates a system that continually needs the input of energy to keep it from breaking down. With this knowledge they can create systems that rely on renewable energy, and which use *energy-quality* in the most efficient and effective ways. They ensure that energy is used in a large number of small steps rather than in a small number of large steps. They create systems that use the outputs of consumption as resources for production, turning waste into food. This is the knowledge of surviving designs based on the second and fourth laws of thermodynamics.

### ***Knowledge of natural systems***

BEEs know that life is sustained by the constant cycling of materials from the Earth, through plants and animals, to the atmosphere and back through the Earth. They know that these grand cycles are what drive ecosystems and sustain a life-supporting biosphere. With this knowledge they ensure that their decisions address the imbalances in biogeochemical flows caused by human activity, and that their buildings help support the diversity of, and biodiversity within, ecosystems. This is the knowledge of natural systems.