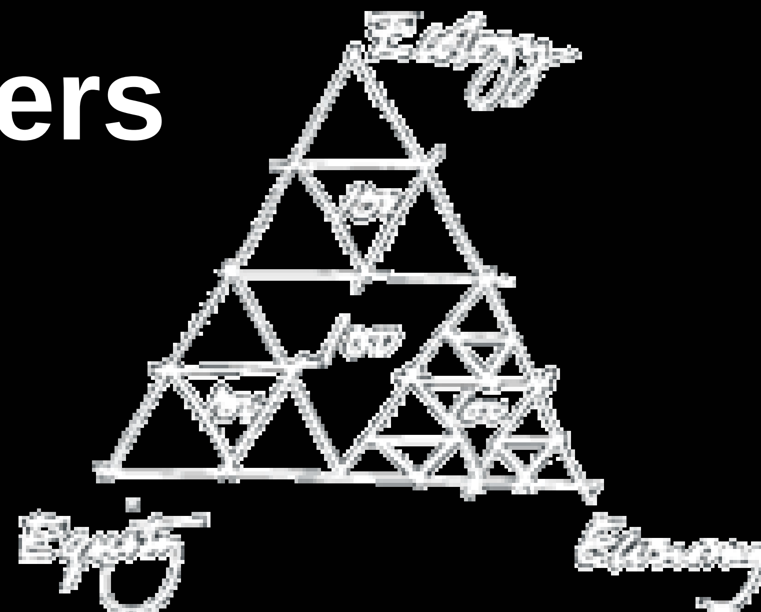
Green Buildings and the Need for Ecological Engineers

Rodney C. McDonald

28 September 2004



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The Council is the nation's foremost coalition of leaders from across the building industry working to promote buildings that are environmentally responsible, profitable and healthy places to live and work.

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LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN

Green Building Rating System

For New Construction & Major Renovations

(LEED-NC)

Version 2.1

LEED
LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN

Five LEED Categories

1. Sustainable Sites
2. Water Efficiency
3. Energy and Atmosphere
4. Materials and Resources
5. Indoor Environmental Quality

The Phillip Merrill Environmental Center
(Chesapeake Bay Foundation Headquarters)
Annapolis, Maryland

Owner:	Chesapeake Bay Foundation	
Project Team:	Architect:	*SmithGroup, Inc.*
	Engineer:	*SmithGroup, Inc.*
	P.Manager:	*Synthesis, Inc.*
	Contractor:	*Clark Construction Group*
	Consultant:	*Janet Harrison, Architect*

Building Statistics:

Completion Date:	*November, 2000*
Cost:	*$6.36 Million*
Size:	*30,600 gross square feet*
Footprint:	*12,000 square feet*
Construction Type:	*3B, Two Stories over Open Parking*
Use Group:	*Business(B), Assembly(A-3), Storage(S-2)*
Lot Size:	*33 acres*
Annual Energy Use:	*23 kBtu/sf/year*
Occupancy:	*90 Staff*

LEED Version 1.0 **PLATINUM**

Notes from the Project Team: *LEED was instrumental in conveying the importance of the sustainable elements of the design to CBF's Board of Trustees.*

Sustainable Sites
- **Site Selection:** *Erected in Smart Growth Funding Area on footprint of existing structure; 26.6 acres remain undisturbed in Land Trust.*
- **Educational Model:** *Interpretive trails and demonstrations for public visitors*
- **Storm/Waste Water:** *Composting toilets and bioretention/wetland*
- **Resource Protection:** *Woodland, wetland, and tidal water restoration*

Water Efficiency
- **Water:** *Rainwater catchment and reuse for hand washing and irrigation*

Energy and Atmosphere
- **Domestic Hot Water:** *Thermomax-solar technology*
- **Energy:** *Exceeds ASHRAE/IES Standard 90.1-1989 by 50%*
- **Envelope:** *Structural Insulated Panels (SIP) R-20 walls; R-30 roof*
- **HVAC:** *Natural ventilation and desiccant dehumidification and heat recovery; heat pump system with geo-thermal heat exchanger*
- **Controls/Monitoring:** *"Green Light" building energy management system notifies staff to open windows when outside conditions comply*
- **Renewable Energy:** *10.7% of energy needs met by photovoltaic panels; solar hot water heating*
- **Lighting:** *Daylight harvesting; time clock lighting controls*

Materials and Resources
- **Rapidly Renewable:** *Paralam post, beam, and truss system; bamboo, cork and linoleum floorings*
- **Recycled Content:** *Metal roofing and siding, acoustic ceiling, ceramic tile, and MDF cabinetry*
- **Framing:** *Structural Insulated Panels (SIP) decrease wood use*

Indoor Environmental Quality
- **Indoor Environmental Quality:** *CO_2 and VOC monitors*
- **Furniture:** *Small, open offices allow for communal space; systems furniture allows flexible layout to accommodate "churn"*

Canada **Green Building** Council

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WELCOME

The Canada Green Building Council (CaGBC) exists to accelerate the design and construction of Green Buildings across Canada. The Council is a broad-based inclusive coalition of representatives from different segments of the design and building industry.

Our Vision

a transformed built environment, leading to a sustainable future

Hot Topics:

LEED Canada-NC 1.0 English Documents

Documents LEED Canada-NC 1.0 en français

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the NATURAL STEP

INSPIRE. INNOVATE. LEAD.

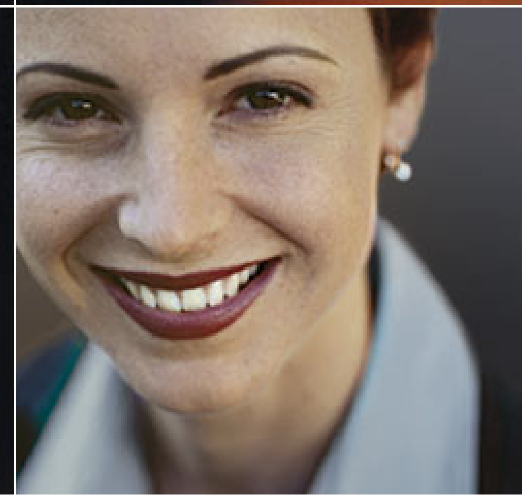
It's what we do.

The Natural Step provides a visionary blueprint for a sustainable world. Our upstream approach means we address problems at the source and turn them into opportunities for innovation. As an international advisory and research organization, we work with some of the largest resource users on the planet to create solutions, models and tools designed to accelerate global sustainability.

Learn more: **SERVICES | RESEARCH | EDUCATION**

What you can do.

Choose your area of interest.



WHAT IS SUSTAINABILITY?

Creating a sustainable world means creating new ways for people to live and thrive -- while keeping the planet balanced and healthy. Our principles of sustainability drive path-breaking models and tools that pass these three tests: Is it good for business, good for society and good for the environment?

more on sustainability

SPOTLIGHT

The Natural Step collaborates with **Starbucks** to develop sustainability metrics with which to measure the company's progress and improve its performance with respect to social and environmental responsibility.

more on Starbucks

HIGHLIGHTS

New Book: The Natural Step for Communities

Catherine Gray Receives Award

Masters Program Grounded in The Natural Step Offered

TNS System Conditions

In a sustainable society, nature is not subject to systematically increasing:

1. concentrations of substances extracted from the earth's crust;
2. concentrations of substances produced by society;
3. degradation by physical means and, in that society. . .
4. human needs are met worldwide.

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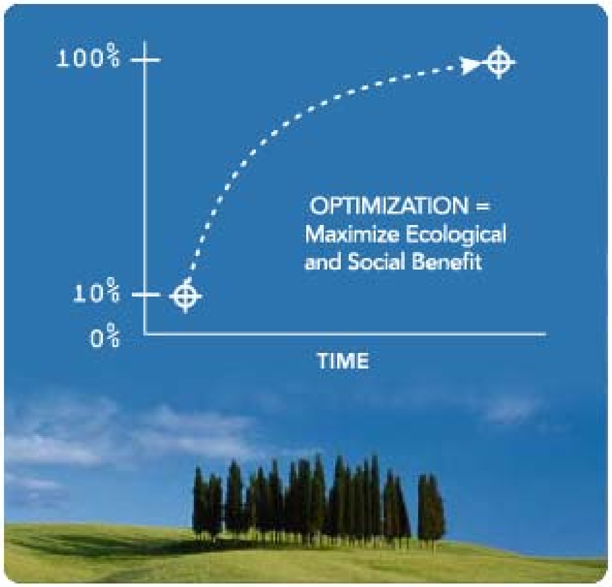
ABOUT US | CRADLE TO CRADLE | ACTIVITIES | GET INVOLVED | CONTACT

The Cradle to Grave Legacy
Cradle to Cradle Material Flows



A NEW VISION:
CRADLE TO CRADLE DESIGN

CRADLE TO CRADLE DESIGN REJECTS THE ASSUMPTION THAT HUMAN INDUSTRY INEVITABLY DESTROYS THE NATURAL WORLD. INSTEAD, CRADLE TO CRADLE DESIGN EMBRACES ABUNDANCE, HUMAN INGENUITY, AND POSITIVE ASPIRATIONS.

Imagine an industrial system that:

- Purifies air, water, and soil
- Retains valuable materials for perpetual, productive reuse
- Requires no regulation
- Celebrates an abundance of cultural and biological diversity
- Enhances nature's capacity to thrive
- Grows health, wealth, and useful resources
- Generates value and opportunity for all.

Such a system, modeled on the natural world's abundance, can solve rather than just manage the problems industry currently creates, allowing both business and nature to thrive and grow.

Eco-Effectiveness: Following Nature's Design Principles
By pursuing a vision of industry that does not damage ecosystems or social systems, Cradle to Cradle Design moves beyond the "less bad" aims of eco-efficiency. It proposes, instead, a new strategy called eco-effectiveness. By learning from nature's 'design principles,' eco-effective design conceives industrial systems that emulate the healthy abundance of nature.

Waste equals food.
The processes of each organism engaged in a living system contribute to the health of the whole. One creature's "waste" is nourishment for another.

Use current solar income.
Simply put, plants use sunlight to manufacture food-an elegant, effective system that uses the earth's one perpetual source of energy income.

Celebrate diversity.
Natural systems thrive on diversity and complexity. Life burgeons with rich variety in response to evolving niches.

GreenBlue

A New Vision | Putting C2C Design to Practice

CRADLE TO CRADLE MATERIAL FLOWS

THE KEY PRINCIPLES GOVERNING MATERIAL FLOWS IN CRADLE TO CRADLE DESIGN WERE FIRST SYSTEMATICALLY OUTLINED IN 1993 THE "INTELLIGENT PRODUCT SYSTEM" (IPS), DEVELOPED AND ARTICULATED BY MICHAEL BRAUNGART AND HIS COLLEAGUES AT EPEA. THE DEVELOPMENT OF THIS MODEL DRAWS ON ADVANCES IN MANY RELATED FIELDS OF SCIENCE, INCLUDING INDUSTRIAL ECOLOGY, TOXICOLOGY, CHEMISTRY, MATERIALS SCIENCE, AND ENVIRONMENTAL SCIENCE.

Just as in natural systems one organism's 'waste' becomes nutrients for another, the cradle-to-cradle model utilizes effective nutrient cycles in the realm of human industry. The cradle-to-cradle model recognizes two metabolisms within which materials flow as healthy nutrients.

Biological Metabolism
Materials that flow optimally through the biological metabolism are called biological nutrients (e.g. the nitrogen cycle). As defined for cradle-to-cradle products, biological nutrients are biodegradable (or otherwise naturally degradable) materials posing no immediate or eventual hazard to living systems that can be used for human purposes and be safely returned to the environment to feed ecological processes.

Products conceived as biological nutrients are called products of consumption. They are designed for safe and complete return to the environment to become nutrients for healthy living systems.

Example: Upholstery Fabric
Upholstery fabrics, which wear out with use, can be comprised of biological nutrients that can be returned to ecosystems after use. Climatex® Lifecycle™ fabric is an example of this type of product. The fabric is a blend of pesticide-residue-free wool and organically grown ramie, dyed and processed entirely with non-toxic chemicals. All of its product and process inputs were defined and selected for their human and ecological safety within the context of a biological metabolism. Currently, the fabric trimmings (process "waste") is made into felt and used by garden clubs as

BIOMIMICRY – *Innovation Inspired by Nature*

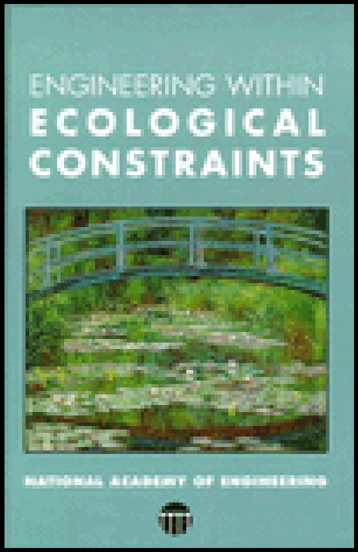
Nature as Model

Nature as Mentor

BIOMIMICRY – Nature as mentor

How does nature manufacture materials?

What is Ecological Engineering?



"The design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both."[1]

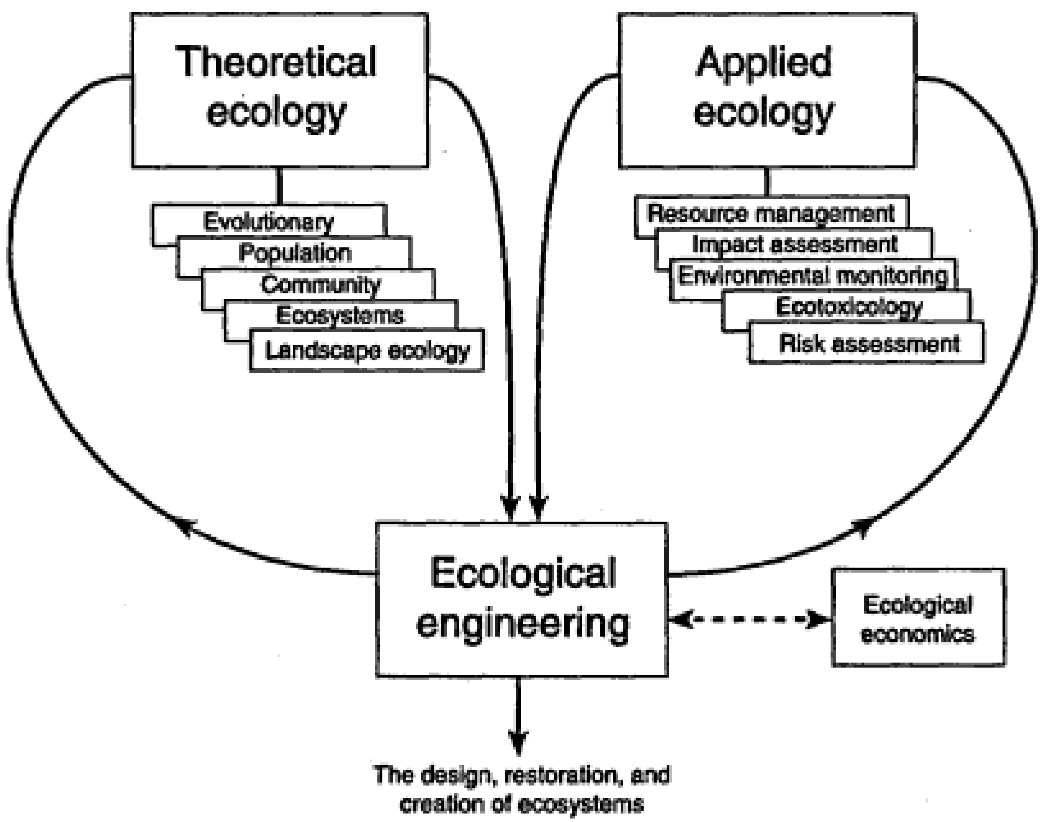
[1]Mitsch, M.J. (1996). Ecological Engineering: A New Paradigm for Engineers and Ecologists, in *Engineering within Ecological Constraints.* National Academy of Engineering. Retrieved from: http://books.nap.edu/books/0309051983/html/index.html

What is Ecological Engineering?

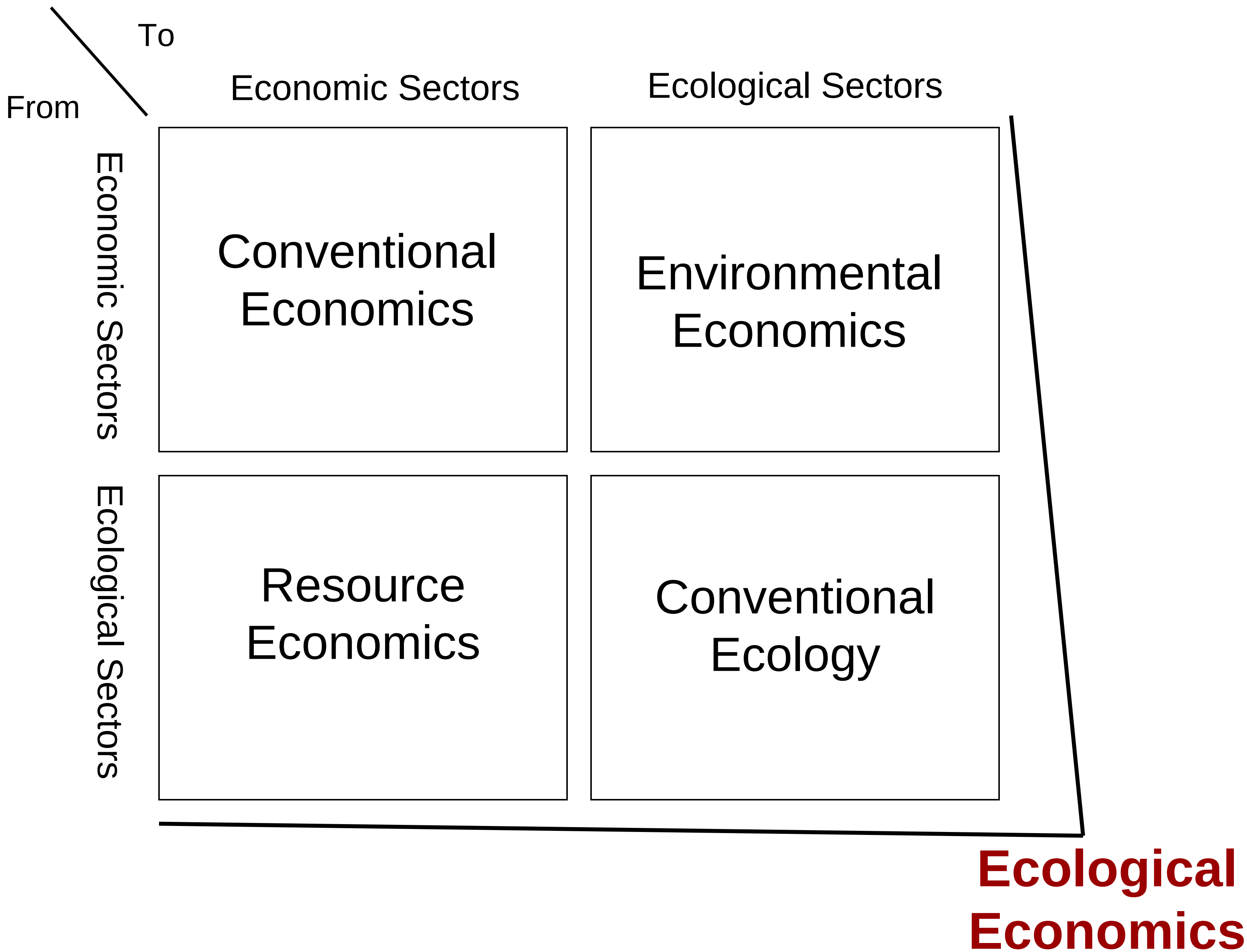
"The design of sustainable systems, consistent with ecological principles, which integrate human society with its natural environment for the benefit of both."[1]

[1]Bergen, S.D., Bolton, S.M. & Fridley, J.L. (2001). Design principles for ecological engineering. *Ecological Engineering* (18), 201-210.

Relationships among ecology, applied ecology, and ecological engineering



From Mitsch, 1993, copyright American Chemical Society


To
From
Economic Sectors
Ecological Sectors
Economic Sectors
Ecological Sectors
Conventional Economics
Environmental Economics
Resource Economics
Conventional Ecology
Ecological Economics

Ecosystem Services (in-kind)

- **Climate regulation**
- **Water regulation**
- **Water supply**
- **Soil formation**
- **Waste treatment**
- **Pollination**
- **Food production**
- **Raw materials**

The value of the world's ecosystem services and natural capital

Robert Costanza*†, Ralph d'Arge‡, Rudolf de Groot§, Stephen Farber‖, Monica Grasso†, Bruce Hannon¶, Karin Limburg#☆, Shahid Naeem, Robert V. O'Neill††, Jose Paruelo‡‡, Robert G. Raskin§§, Paul Sutton‖‖ & Marjan van den Belt¶¶**

The services of ecological systems and the natural capital stocks that produce them are critical to the functioning of the Earth's life-support system. They contribute to human welfare, both directly and indirectly, and therefore represent part of the total economic value of the planet. We have estimated the current economic value of 17 ecosystem services for 16 biomes, based on published studies and a few original calculations. For the entire biosphere, the value (most of which is outside the market) is estimated to be in the range of US$16–54 trillion ($10^{12}$) per year, with an average of US$33 trillion per year. Because of the nature of the uncertainties, this must be considered a minimum estimate. Global gross national product total is around US$18 trillion per year.

NATURE | VOL 387 | 15 MAY 1997

Where Does it Fit?

"Ecological engineering should have its roots in the science of ecology, just as chemical engineering is close to chemistry and biochemical engineering is close to biochemistry. It logically should be considered a branch of ecology as well as a new field of engineering."

- W. J. Mitsch

ELSEVIER

Ecological Engineering 18 (2001) 201–210

ECOLOGICAL ENGINEERING

www.elsevier.com/locate/ecoleng

Design principles for ecological engineering

Scott D. Bergen [a,1], Susan M. Bolton [b,*], James L. Fridley [a]

[a] *Forest Management and Engineering Division, College of Forest Resources, Box 352100, University of Washington, Seattle, WA 98195-2100, USA*

[b] *Center for Streamside Studies, Box 352100, University of Washington, Seattle, WA 98195-2100, USA*

Received 22 August 2000; received in revised form 18 December 2000; accepted 16 February 2001

Five Principles

1. Design consistent with ecological principles
   - Mimic natural structures and processes.
   - Treat nature as a partner in design.
   - Allow for diversity – more resilient.

[1]Bergen, S.D., Bolton, S.M. & Fridley, J.L. (2001). Design principles for ecological engineering. *Ecological Engineering* (18), 201-210.

Five Principles

2. Design for site-specific context

   - What is here?
   - What will nature allow us to do here?
   - What will nature help us do here?

[1]Bergen, S.D., Bolton, S.M. & Fridley, J.L. (2001). Design principles for ecological engineering. *Ecological Engineering* (18), 201-210.

Five Principles

3. Maintain the independence of design functional requirements

   - Best designs are those that have independent (not coupled) FRs and one and only one DP to satisfy each FR.

[1]Bergen, S.D., Bolton, S.M. & Fridley, J.L. (2001). Design principles for ecological engineering. *Ecological Engineering* (18), 201-210.

Five Principles

4. Design for efficiency in energy and information

    - Make maximum use of the free flow of energy into the system from natural sources, primarily the Sun.

[1]Bergen, S.D., Bolton, S.M. & Fridley, J.L. (2001). Design principles for ecological engineering. *Ecological Engineering* (18), 201-210.

Five Principles

5. Acknowledge the values and purposes that motivate design

    - Most engineering codes of ethics state at least that engineers have a responsibility to serve and protect society.
    - Responsibility broadened to include the natural systems that support life.

[1]Bergen, S.D., Bolton, S.M. & Fridley, J.L. (2001). Design principles for ecological engineering. *Ecological Engineering* (18), 201-210.

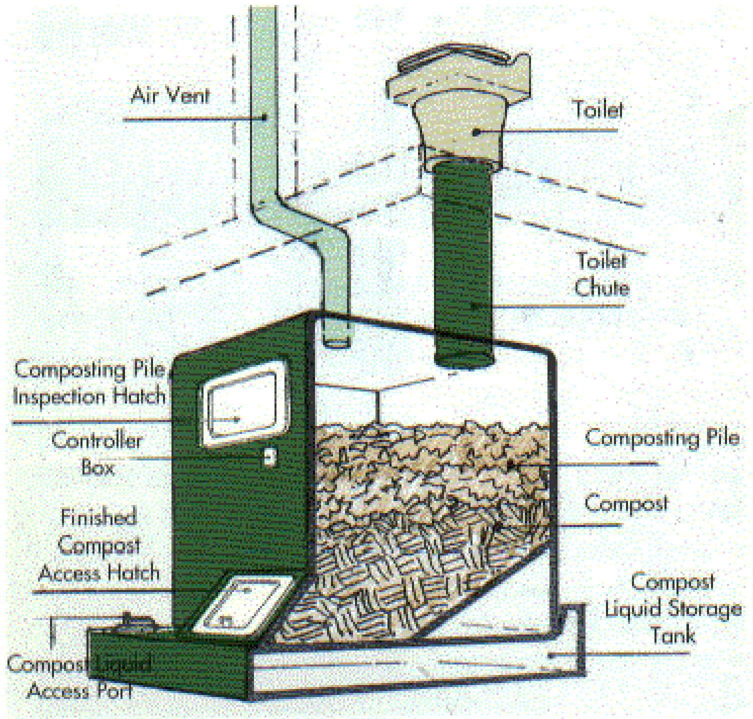
Scope of Application

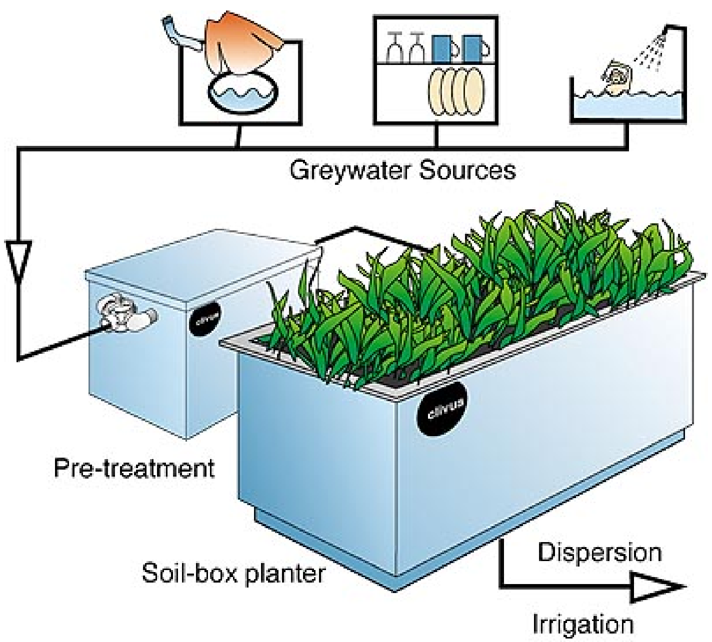
1. The design of ecological systems (ecotechnology) as an alternative to to man-made/energy-intensive systems to meet various human need (e.g., constructed wetlands for wastewater treatment)
2. The restoration of damaged ecosystems and the mitigation of development activities.
3. The management, utilization, and conservation of natural resources.
4. The integration of society and ecosystems in built environments (e.g., in landscape architecture, urban planning and urban horticulture applications.

[1]Bergen, S.D., Bolton, S.M. & Fridley, J.L. (2001). Design principles for ecological engineering. *Ecological Engineering* (18), 201-210.

On-site Wastewater Management

- Composting Toilets & Greywater Systems





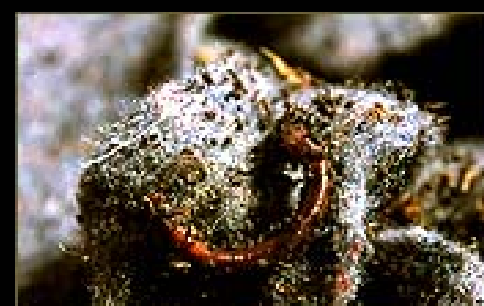
Adam Joseph Lewis Centre at Oberlin College (Ohio)

On-site Wastewater Management

- Living Machines

Climatex® Lifecycle™ - Cradle to Cradle Product

- **Free-range wool and ramine**
- **Only 38 chemical dyes met criteria**
- **Fabric trimmings used as mulch**

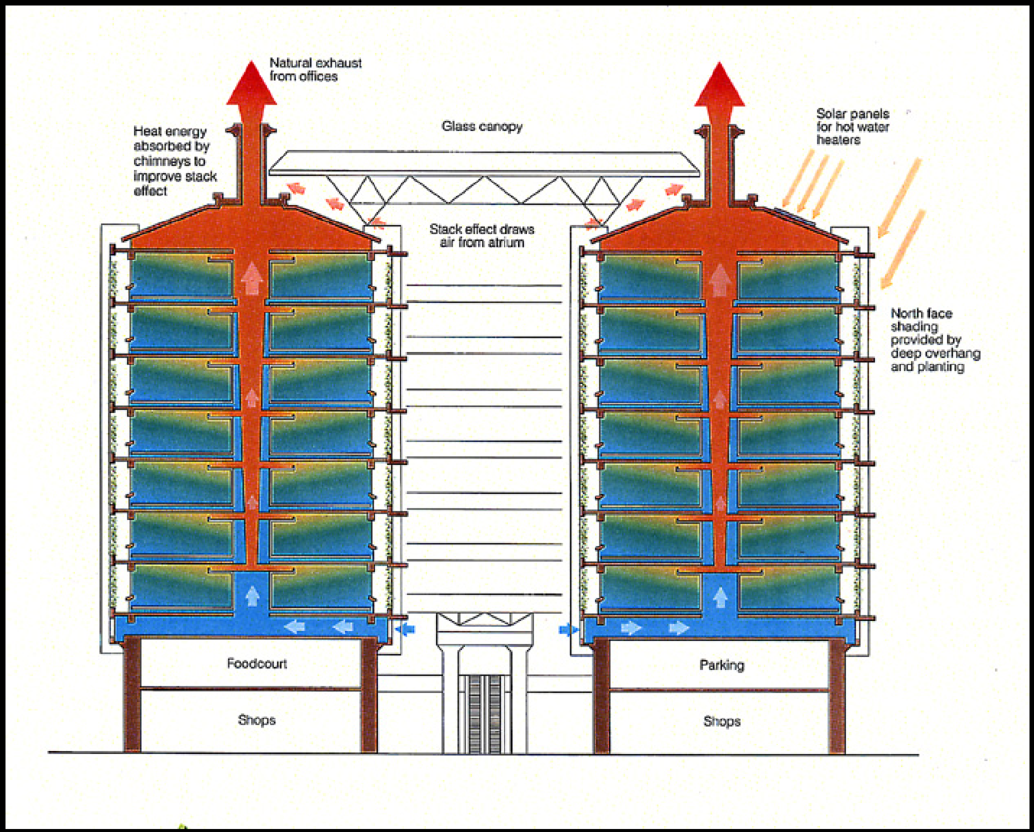


“Waste equals Food” upholstery fabric.

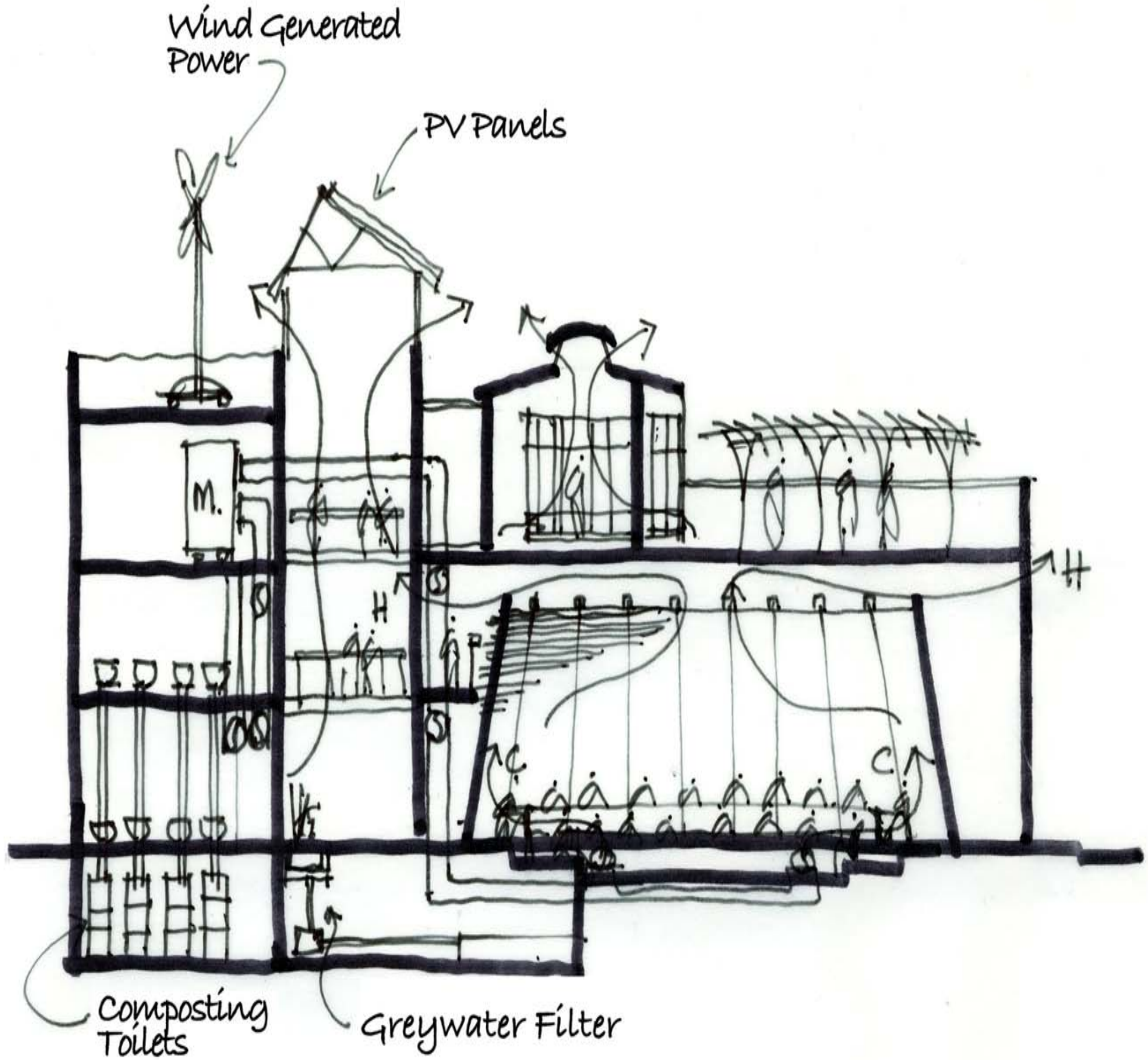
Source: www.climatex.com

BIOMIMICRY – Nature as model

How does nature cool structures?



Eastgate Building, Harare, Zimbabwe



Wind Generated Power
PV Panels
M.
H
H
C
C
Composting Toilets
Greywater Filter

Resources

Green Building

Canada Green Building Council
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U.S. Green Building Council
www.usgbc.org

Ecological Engineering

American Ecological Engineering Society
http://aeesociety.org

International Ecological Engineering Society
http://www.iees.ch