

**Sustainable Architecture Module:**

# **Recycling and Reuse of Building Materials**

*Written by*

**Kurt Rathmann**

**Graduate Research Assistant**

**Department of Architecture**

**The University of Idaho**

*Published by*

**National Pollution Prevention Center for Higher Education,**

**430 E. University Ave., Ann Arbor, MI 48109-1115**

**734.764.1412 • fax: 734.647.5841 • [nppc@umich.edu](mailto:nppc@umich.edu)**

**website: [www.umich.edu/~nppcpub/](http://www.umich.edu/~nppcpub/)**

*This compendium was made possible in part by a grant from the 3M Corporation. These materials may be freely copied for educational purposes.*



# Contents

---

## Introduction

List of Figures .....	6
Abstract .....	13
Background .....	14
Problem Statement .....	17
Methodology .....	18
How to Use the Educational Resource Module .....	19
Endnotes .....	20

---

## Learning Units

### A. Waste Prevention ..... 21

A.1.1 Discussion: Resource Efficiency .....	21
A.1.2 Case Study: ReCraft 90 (Missoula) and Model Conservation Home (Seattle) .....	24
A.1.3 Exercise: Resource-Efficient Building Materials .....	26
A.2.1 Discussion: Materials Recovery .....	27
A.2.2 Case Study: Serial Materials Recovery (Berkeley) ...	29
A.2.3 Exercise: Mapping Materials Recovery .....	31
A.3.1 Discussion: Industrial Ecology .....	32
A.3.2 Case Study: Industrial Symbiosis (Kalundborg) .....	35
A.3.3 Exercise: Regional Material Streams .....	38
A.4.1 Endnotes for Waste Prevention .....	39

### B. Construction and Demolition Recycling ..... 41

B.1.1 Discussion: C&D Materials Recovery .....	42
B.1.2 Case Study: Clean It Up Mark!, Portland, Oregon .....	45
B.1.3 Exercise: C&D Debris Analysis .....	47
B.2.1 Discussion: Recycling Economics .....	48
B.2.2 Case Study: Metro Headquarters (Portland) .....	52
B.2.3 Exercise: Job-site Recycling Economics .....	54
B.3.1 Endnotes for C&D Recycling .....	55

<b>C. Architectural Reuse .....</b>	<b>57</b>
C.1.1 Discussion: Adaptive Reuse .....	58
C.1.2 Case Study: Pickering Barns (Issaquah, Washington) .....	61
C.1.3 Exercise: Design for Reuse .....	63
C.2.1 Discussion: Conservative Disassembly .....	64
C.2.2 Case Study: The Sauna Experience (Moscow, Idaho) .....	67
C.2.3 Exercise: Building Deconstruction .....	68
C.3.1 Discussion: Reusing Salvaged Materials .....	69
C.3.2 Case Study: Urban Ore, Inc., (Berkeley, California) .	72
C.3.3 Exercise: Reuse Operations .....	74
C.4.1 Endnotes for Architectural Reuse .....	75
<b>D. Design for Materials Recovery .....</b>	<b>75</b>
D.1.1 Discussion: Life Cycle Analysis .....	76
D.1.2 Case Study: Advanced Green Builder Project (Austin, Texas) .....	82
D.1.3 Exercise: Life Cycle Design .....	84
D.2.1 Discussion: Building With Waste .....	85
D.2.2 Case Study: Stookey's Plant Nursery (Moscow, Idaho) .....	89
D.2.3 Exercise: Design/Build Project .....	95
D.3.1 Endnotes for Design for Materials Recovery .....	96

---

**Appendices**

Appendix I Recycling Markets .....	97
Appendix II Straw Building Materials .....	101
Appendix III Product Directories and Sourcebooks .....	103
Appendix IV C&D Debris Analysis Worksheet .....	104
Appendix V Recycling Economics Worksheet A .....	105
Appendix VI Recycling Economics Worksheet B .....	106

---

**Bibliography ..... 107**

---

**Annotated Bibliography ..... 111**

## List of Figures

Figure 1.	Photo of the ReCraft 90 House, Missoula, Montana (CRBT)	24
Figure 2.	Illustration of a section through the ReCraft 90 House, Missoula, Montana (CRBT)	24
Figure 3.	Photo of the Model Conservation Home, Seattle, Washington (Jonathan Reich)	25
Figure 4.	Illustration of the ground floor plan of the Model Conservation Home, Seattle, Washington	25
Figure 5.	List of the Clean Dozen master recycling categories developed by Urban Ore, Inc., Berkeley, California	28
Figure 6.	Table summarizing the Berkeley Serial Material Recovery Network (Urban Ore, Inc.)	29
Figure 7.	Illustration of the Berkeley Serial Materials Recovery Facility (Mark Gorrell, Architect)	30
Figure 8.	Diagram showing the circular flow versus the linear flow of materials	32
Figure 9.	Illustration summarizing the life cycle analysis framework	33
Figure 10.	Diagram of the industrial ecosystem, Kalundborg, Denmark (Hardin Tibbs, Novo Nordisk)	35
Figure 11.	List of the Clean Dozen master recycling categories developed by Urban Ore, Inc., Berkeley, California	42
Figure 12.	Table of hazardous materials typically found in construction and demolition debris (C.T. Donovan Associates, Inc.)	42
Figure 13.	Photo of concrete debris	43

Figure 14.	Photo of source separation recycling	43
Figure 15.	Photo of homogeneous job-site construction debris	44
Figure 16.	Photo of commingled construction and demolition debris at the inert landfill, Latah County, Idaho	44
Figure 17.	Pie chart of typical residential construction debris (Toronto Homebuilders Association)	45
Figure 18.	Photo of job-site commingled construction debris found in Dumpster	47
Figure 19.	Sample bid specification language for job-site recycling (The Kasian Kennedy Design Partnership)	47
Figure 20.	Table of construction and demolition debris weight and volume conversion figures (Metro Portland Solid Waste Department)	47
Figure 21.	Photo representing quality of life and biodiversity	49
Figure 22.	Photo of industrial scale clear-cutting of forests	49
Figure 23.	Photo of Metro Portland Headquarters (Erik Barr)	52
Figure 24.	Photo showing gutted concrete frame Sears building awaiting reuse as Metro Portland Headquarters (Metro Portland Solid Waste Department)	52
Figure 25.	Photo of decorative reused cast medallions (Erik Barr)	53
Figure 26.	Photo of salvaged hardwood flooring (Metro Portland Solid Waste Department)	53
Figure 27.	Photo of wood waste at the University of Idaho chipper facility	54

Figure 28.	Photo of wood waste chipped at the job-site at Pickering Barns ECO Center, Issaquah, Washington (KPG, Inc.)	54
Figure 29.	Photo of adaptive reuse at Stookey's Feed and Garden, Moscow, Idaho	57
Figure 30.	Photo of Pickering Barns ECO Center, Issaquah, Washington	58
Figure 31.	Photo of Gas Works Park, Seattle, Washington	58
Figure 32.	Photo of the old Southern California Gas Company headquarters in Downey (Southern California Gas Company)	59
Figure 33.	Photo of the Energy Resource Center during "open-heart surgery," Downey (Southern California Gas Company)	59
Figure 34.	Illustration of building types organized with regards to their cellular structure	60
Figure 35.	Photo of the Pickering Barns prior to their historic restoration and adaptive reuse as the ECO Center, Issaquah, Washington (KPG, Inc.)	61
Figure 36.	Photo showing the stabilization of the loft barn at Pickering Barns ECO Center, Issaquah, Washington (KPG, Inc.)	61
Figure 37.	Photo showing the interior of the stall barn during construction at Pickering Barns ECO Center, Issaquah, Washington	62
Figure 38.	Photo of the south elevation of the Pickering Barns ECO Center, Issaquah, Washington	62
Figure 39.	Photo showing the interior of the loft barn at the Pickering Barns ECO Center, Issaquah, Washington	62
Figure 40.	Illustration of Moscow, Idaho Main Street by Kurt Rathmann	64



Figure 41.	Photo showing the conservative disassembly of the Pickering Barns, Issaquah, Washington (KPG, Inc.)	64
Figure 42.	Photo showing the conservative disassembly of the Bowl-A-Rama by Wasankari Building Recyclers, Moscow, Idaho	64
Figure 43.	Duluth Timber Company's trademark "logging the industrial forest" (Duluth Timber Company)	65
Figure 44.	Photo of Keith Smith's timber framed studio under construction, Moscow, Idaho	66
Figure 45.	Three photos of University of Idaho architecture students dismantling a sauna, Moscow, Idaho	67
Figure 46.	Illustration of proposed reconstructed sauna	67
Figure 47.	Photo of bricolage sculpture at Dick and Jane's Spot, Ellensburg, Washington	69
Figure 48.	Photo of Victor Moore's junk castle near Pullman, Washington	69
Figure 49.	Photo of Franklin Institute's multi-media center by Alley Friends Architects, Philadelphia, (Bruce Millard, Architect)	70
Figure 50.	Photo of the Black Banana Restaurant, Philadelphia, Pennsylvania (Bruce Millard, Architect)	70
Figure 51.	Photo of Seattle Salvage's showroom, Seattle, Washington	71
Figure 52.	Two photos showing potential for "organic growth" by reusing salvaged materials	71
Figure 53.	Two photos of salvaged wood materials at Second Use, Woodinville, Washington	72

Figure 54.	Three photos of typical displays of building materials at reuse facilities	73
Figure 55.	Diagram of life cycle analysis framework	76
Figure 56.	Photo of Faswall wall-form block	78
Figure 57.	Photo of Kimball Art Museum, Fort Worth, Texas	79
Figure 58.	Photo of Environmental Works Community Design Center, Seattle, Washington	81
Figure 59.	Illustration of William McDonough Architects' proposal for day care center	81
Figure 60.	Three photos of the Advanced Green Builder Demonstration Project, Austin, Texas (Center for Maximum Potential Building Systems)	82
Figure 61.	Illustration of ground floor plan of the Advanced Green Builder Demonstration Project, Austin, Texas	83
Figure 62.	Photo and illustrations of University of Idaho 5 <sup>th</sup> -year design project by Kurt Rathmann	84
Figure 63.	Photo of WOBO bottle construction	85
Figure 64.	Photo of earthship near Boise, Idaho	85
Figure 65.	Illustrations of section and elevation views of the Dora Crouch house	86
Figure 66.	Photo of Bryant House and smoke-house by Remote Rural Studio at Auburn University (Timothy Hursley)	87
Figure 67.	Photo of chapel by Remote Rural Studio at Auburn University (Timothy Hursley)	88
Figure 68.	Three photos of the exterior of Stookey's Plant Nursery, Moscow, Idaho	89

Figure 69.	Illustration of exploded axonometric view of Stookey's Plant Nursery, Moscow, Idaho	90
Figure 70.	Two photos of wood waste at the University of Idaho chipper facility and a Faswall wall-form block made from wood waste and cement	91
Figure 71.	Three photos during construction of Stookey's Plant Nursery, Moscow, Idaho	92
Figure 72.	Two photos of the straw bale wall-raising at Stookey's Plant Nursery	93
Figure 73.	Photo of salvaged and refinished vertical grain fir doors	93
Figure 74.	Photo of community open-house at Stookey's Plant Nursery	94
Figure 75.	Photo of interior construction in-progress at Stookey's Plant Nursery	94
Figure 76.	Two photos of Real Goods Solar Living Center, Hopland, California, by Ecological Design Institute (Daniel Smith and Associates, Architects)	101
Figure 77.	Two photos of Trinity Springs Bottling Plant, Pine, Idaho showing <b>straw bale warehouse</b> (Underground Water People) and stone springhouse (Erik Barr)	102



## **Abstract**

We never educate directly, but indirectly by means of the environment. Whether we permit chance environments to do the work, or whether we design environments for the purpose makes a great difference.

—*John Dewey*

As part of the Sustainable Architecture Compendium, this educational module on the Recycling and Reuse of Building Materials demonstrates an interdisciplinary and place-based approach to architectural education. The professor and student are provided with a “blueprint” in the form of four learning units, which cover waste prevention, construction and demolition recycling, architectural reuse, and design for recovery.

Each learning unit is further subdivided to expose nested topics. These are structured to include interdisciplinary discussions of the background and theory, case study examples describing the “real-world” application of the theory, and “field” exercises that encourage students to venture out of the studio and explore the issues within their own community and region.

This is not intended as a stand-alone document. Recycling and reuse issues overlap a range of disciplines including architecture, construction, ecology, economics, industrial design, manufacturing, art, and public policy, to name a few. Throughout the module are references to other works that enable the architecture educator and student to investigate ideas beyond those revealed here. The methodology for research integrated the review of existing and evolving literature, personal interviews, a survey of regional case studies, and the design and construction of a community demonstration project.

## Introduction

### **Background**

In *Building Community*, a special report on architecture education and practice, Ernest Boyer and Lee Mitgang recognize the need for architecture schools to join with other disciplines to help students “expand their knowledge of energy, the use of renewable resources, the recycling process, the use of carcinogenic materials, and the safe disposal of waste.”<sup>1</sup> To satisfy this need, Boyer and Mitgang espouse an integrative, “learning by doing” approach to architectural education that reaches out to other academic departments as well as to the community. They remind us that “schools of architecture can no longer afford to be strangers in their own settings.”<sup>2</sup> Their suggested reforms include:

- 1) tying studios to more “real life problems;”
- 2) developing “a fabric of many voices in studio instruction;”
- 3) replacing the “architect as hero” model with “architect as team player;” and
- 4) “promoting an interdisciplinary/collaborative approach among designers, sociologists, ecologists, etc.”<sup>3</sup>

If “wisdom is the capacity to know what we don’t know,” what Wes Jackson of the Land Institute in Salina, Kansas, calls ignorance-based thinking,<sup>4</sup> then it stands to reason that no single discipline is equipped with the ability to solve all of the problems associated with the steady stream of wastes entering our environment. No longer are we able to work in a vacuum, blindly making decisions without regard to the spill-over effects. The merging of disciplines is essential.

David Wann’s *Biologic* and *Deep Design* and Sim Van der Ryn and Stuart Cowen’s *Ecological Design* describe the attitudes and applications of synthesizing technology and ecology, while stressing the importance of an interdisciplinary and place-based approach to design. Pliny Fisk III, William McDonough, John Tillman Lyle, and Sim Van der Ryn are examples of some architects whose work reflects this approach and who recognize that human processes at a local or regional scale contain useful byproducts requiring systematic planning for their recapture.<sup>5</sup>

Van der Ryn's first principle of ecological design, "Solutions Grow From Place," states that

Ecological design begins with an intimate knowledge of a particular place. Therefore, it is small-scale and direct, responsive to both the local conditions and local people. If we are sensitive to the nuances of place, we can inhabit without destroying.<sup>6</sup>

This principle is rooted to the regional survey proposed by Lewis Mumford in *Values for Survival*. The survey becomes

[the] backbone of a drastically revised method of study, in which every aspect of the sciences and arts is ecologically related from the bottom up, in which they connect directly and constantly in the student's experience of his (or her) region and community.<sup>7</sup>

Industrial and natural processes are at work in everyone's backyard. To gain an awareness of this interaction requires us to turn our attentions outward — beyond the architecture studio and the profession. Randy Croxton of Croxton Collaborative, Architects, suggests reaching beyond the traditional expertise of architects comfortably tucked between *Sweet's Catalog* of building products and the construction documents.<sup>8</sup> In *The Audubon House*, Croxton examines the role of the architect "upstream" as well as "downstream" throughout the design process of the National Audubon Society offices in New York City. He addresses natural resource extraction, transportation, manufacturing, and distribution as well as building operation, maintenance, and disposal strategies after the building's usefulness has expired.

Considering the environmental effects of a material or building throughout its existence from extraction from the earth through disposal is called life cycle analysis (LCA). When the recycling and reuse of building materials influence the design process, the circulation of materials and the role of waste products within local and regional boundaries become important considerations for architects.

The circulation of materials is considered one of the principle laws of general ecology. The principle states that

- 1) the rate of cycling of materials is a more important indicator in determining productivity than the amount present at any one place at any one time;

- 2) material cycles become more closed as a system matures (i.e., fewer materials are lost or wasted); and
- 3) the role of waste products in the overall health of the system increases.<sup>9</sup>

The practical application of this ecological theory lies within the burgeoning field of industrial ecology. According to Robert M. White in the preface of *The Greening of Industrial Ecosystems*, industrial ecology is defined as

the study of the flows of materials and energy in industrial and consumer activities, of the effects of these flows on the environment, and of the influences of economic, political, regulatory, and social factors on the flow, use, and transformation of resources.<sup>10</sup>

In *The Ecology of Commerce*, Paul Hawken incorporates the overlapping ideas of industrial ecology, life cycle analysis, pollution prevention, resource efficiency, and materials recovery into a zero-waste vision. This vision includes the reuse and recycling of building materials throughout the architecture process from design through demolition. Reuse and recycling issues are most effectively explored through an interdisciplinary and place-based style of learning. This educational resource module is both the product of and model for this approach.



## ***Problem Statement***

To address the problems of scarcity, costly extraction, and increased regulatory provisions associated with unsustainable natural resource consumption and waste disposal, architecture students need to become critical of the “upstream” and “downstream” effects of building design, construction, use, and disposal. In Kevin Lynch’s last book, *Wasting Away*, he wrote: “Architects must begin to think about holes in the ground and about flows of materials.”<sup>11</sup> As the next generation of designers and material specifiers, architecture students need opportunities to gain an awareness of the “metabolic activity” of building components at both regional and community scales. This module seeks to validate an interdisciplinary and place-based approach to architectural education.

## ***Methodology***

The methodology for this research incorporated a cross-disciplinary literature review on waste-related issues, a place-based survey of individuals, organizations, and businesses that influence the recycling and reuse of building materials, and the design and construction of Stookey’s Plant Nursery in Moscow, Idaho, using regionally significant reused, recycled-content, and byproduct-based building materials.

As disposal fees, regulatory provisions, and natural resource extraction and refinement costs increase, numerous community and regional models for the recycling and reuse of building materials are gaining attention. A few examples include the efforts of the Center for Resourceful Building Technology in Missoula, Montana; Urban Ore, Inc., in Berkeley, California; Metro Portland Solid Waste Department and River City Resource Group in Portland, Oregon; and Turner Construction Company and Environmental Works Community Design Center in Seattle, Washington. In the spirit of Mumford’s regional survey, these models support the discussions and function as case studies throughout the learning units. The exercises following each case study evolved from streamlined “field notes” based upon my own experience. Their purpose is to guide students who wish to explore the issues of recycling and reuse within the context of their own communities.

## ***How to Use This Educational Resource Module***

This educational resource module consists of a series of discussions, case studies, and suggested “field” exercises, which encourage cross-disciplinary communication within the community and regional exploration to investigate potential barriers and workable solutions for recycling and reusing building materials. It is designed to be flexible to the needs of existing architecture seminars, lectures, and design studios, especially those that focus on materials and methods. It will be most effective as a basis for a dedicated seminar or independent study course on recycling and reuse issues that culminates in a design-build experience. Regardless of the curriculum, this module will encourage an active and participatory learning experience.

Learning Unit A, *Waste Prevention*, covers the broad fundamentals of resource efficiency, materials recovery, and industrial ecology. Although the connections to building and design are mentioned, this learning unit is intended to ground architecture students in the waste-related issues that effect multiple disciplines.

Learning Units B and C, *Construction and Demolition Recycling and Architectural Reuse*, present the fundamentals of the recycling and reuse of building materials. Job-site material recovery strategies, existing studies on the economics of job-site disposal, and architectural reuse from whole buildings to building components are some of the major topics.

Learning Unit D, *Design for Materials Recovery*, distills the essential design considerations for the recycling and reuse of building materials from the previous learning units. It is important that the principles of Learning Units A, B, and C are understood before beginning Learning Unit D. The focus of this learning unit is to demonstrate how a regional understanding of recycling and reuse can inform the design-build process. Stookey’s Plant Nursery in Moscow, Idaho, provides an in-depth case study of the design-build project that serves as both research tool and results for the development of this educational resource module.

## Endnotes

- <sup>1</sup> Ernest L. Boyer and Lee D. Mitgang, *Building Community: A New Future for Architecture Education and Practice*. (Princeton, NJ: The Carnegie Foundation for the Advancement of Teaching, 1996), 45.
- <sup>2</sup> *Ibid*, epilogue.
- <sup>3</sup> *Ibid*, 45.
- <sup>4</sup> David Wann, *Deep Design: Pathways to a Livable Future* (Washington: Island Press, 1996), 115.
- <sup>5</sup> Pliny Fisk III, "Integration vs. Conservation: A Renewable Energy Building Block for the 21<sup>st</sup> Century," (*Integration Compendium*. Austin, TX: Center for Maximum Potential Building Systems, Inc.), 1.
- <sup>6</sup> Sim Van der Ryn and Stuart Cowen, *Ecological Design* (Washington: Island Press, 1996), 57.
- <sup>7</sup> Louis Mumford, *Values for Survival: Essays, Addresses, and Letters on Politics and Education* (Freeport, NY: Books for Libraries Press, 1946), 151.
- <sup>8</sup> National Audubon Society and Croxton Collaborative, Architects; *Audubon House: Building the Environmentally Responsible, Energy-Efficient Office* (New York: Wiley, 1994), 37
- <sup>9</sup> Eugene Odum, *Ecology* (New York: Holt, Rinehart and Winston, 1963), 38.
- <sup>10</sup> Braden R. Allenby and Deanna J. Richards, editors, *The Greening of Industrial Ecosystems* (Washington: National Academy Press, 1994), v.
- <sup>11</sup> Kevin Lynch, *Wasting Away*. (San Francisco: Sierra Club Books, 1990), 84.

