Key Elements of Green Design

Building Green with Wood

MODULE 1

What is Green Design?

"Green building is the practice of increasing the efficiency with which buildings use resources - energy, water, and materials - while reducing building impacts on human health and the environment during the building's lifecycle, through better siting, design, construction, operation, maintenance, and removal." [1]

The ultimate goal of a green design is to achieve true sustainability and open up new opportunities to design and build structures that use less energy, water and materials, and minimize impacts on human health and the environment.

Green design incorporates environmental considerations into every stage of a building's life – from the earliest planning through site development, design, construction, operation and maintenance and, eventually, removal and reuse. It involves countless decisions about materials, systems and methods.

Green design embodies a holistic, integrated and multidisciplinary approach in which every decision is evaluated against multiple criteria to find the best solution. As the understanding of green design has increased in sophistication over the last two decades, the strategies adopted have evolved, and the quantitative performance of buildings has improved.

1 Frej, Anne B., editor. Green Office Buildings: A Practical Guide to Development. Washington, D.C.: ULI--The Urban Land Institute, 2005. Pp 4-8.

Avalon Anaheim Stadium Apartments, Anaheim CA
Architect: Withee Malcolm Architects
Photos by Michael Arden - Arden Photography

Basics of Sustainable Development

Green design fits within the overarching objective of global sustainable development, as defined by the 1992 World Commission on Environment and Development (the Brundtland commission):

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

To achieve this objective, it is necessary to practise environmental stewardship and manage renewable resources responsibly to meet the growing needs of the planet. Sometimes this means using less, and often it means choosing naturally renewable products that have a lighter carbon footprint and come from responsible and sustainable sources.

Also fundamental to sustainable development is the consideration and evaluation of all the impacts of buildings, whether economic, social or environmental.

Green design considers

- Planning
- Site development
- Design
- Construction
- Maintenance
- Removal and reuse

The Role of Green Design

Constructing and operating buildings has an immense environmental impact. Globally, buildings are responsible for 20 per cent of all water consumption, 25 to 40 per cent of all energy use, 30 to 40 per cent of greenhouse gas emissions and 30 to 40 per cent of solid water generation.[2]

The extraction and processing of materials for use in buildings is also a significant cause of environmental degradation, and these materials can be a major source of the environmental contaminants that contribute to health problems for building occupants.

Building professionals can reduce impacts on the environment and human health in key areas, including:

[2] United Nations Environment Programme, Sustainable Consumption and Production Branch. www.unep.fr/scp/bc/.

- **Site design:** Green design encourages the use of building sites that maximize passive solar heating and cooling, conserve natural resources such as trees and wildlife habitat, and minimize soil disturbance and erosion. Both location and design can encourage the use of alternate transportation methods such as transit, cycling and walking.
- **Water quality, conservation and efficiency:** Green design uses on-site mechanisms such as rainwater harvesting, water-conserving fixtures, waste water treatment and recycling, green roofs and controlled storm water discharge. This ensures water is used efficiently, and reduces the burden on municipal or other infrastructure to supply potable water, collect and discharge storm water, and treat and dispose of waste water.
- **Energy efficiency and renewable energy:** Green design addresses building massing and orientation, and may incorporate high levels of insulation, capture of heating and cooling energy from geothermal or other natural sources, renewable energy installations (such as photovoltaics, wind turbines or solar hot water heating systems), energy-efficient equipment and appliances, careful envelope design to harvest daylight, and the use of solar shading devices, daylight and occupancy sensors.
- **Conservation of materials and resources:** Green design considers the environmental impacts of materials and products across their entire life cycle. It gives preference to those with low environmental impact and embodied energy in their extraction or manufacture; that are self finished, non-toxic, multi-functional, durable, and easily salvaged and recycled at the end of a building's service life.
- **Indoor environmental quality:** Green design aims for high levels of natural ventilation and daylight in all occupied areas of the building. It also strives for high indoor air quality through construction protocols aimed at eliminating dust, airborne toxins and other contaminants, and through the specification of materials that contain no chemicals or compounds harmful to human health.

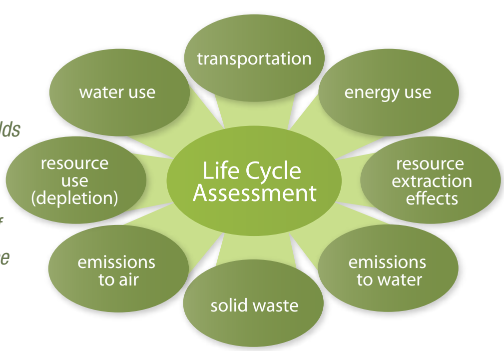
Pocono Environmental Education Center *in Digmans Ferry, Pennsylvania, designed by Bohlin Cywinski Jackson, boasts many sustainable properties such as passive solar heating, natural ventilation methods, energy-efficient insulation, day-lighting, and the use of recycled and non-toxic materials for construction, including glue-laminated timbers.*

Life Cycle Assessment

Construction and design issues are complex, and the decision-making processes of green design are often hampered by a lack of hard data on the products, processes and materials under consideration.

The best way to understand the full environmental impact of any product is through life cycle assessment, which looks quantitatively at all environmental impacts, not just one single attribute, and provides an effective basis for comparing alternate designs. Module 2 has more information about life cycle assessment.

Understanding the full environmental impact
Life cycle assessment adds up all the environmental effects of decisions and processes over the life of a product – from resource extraction to disposal or reuse.



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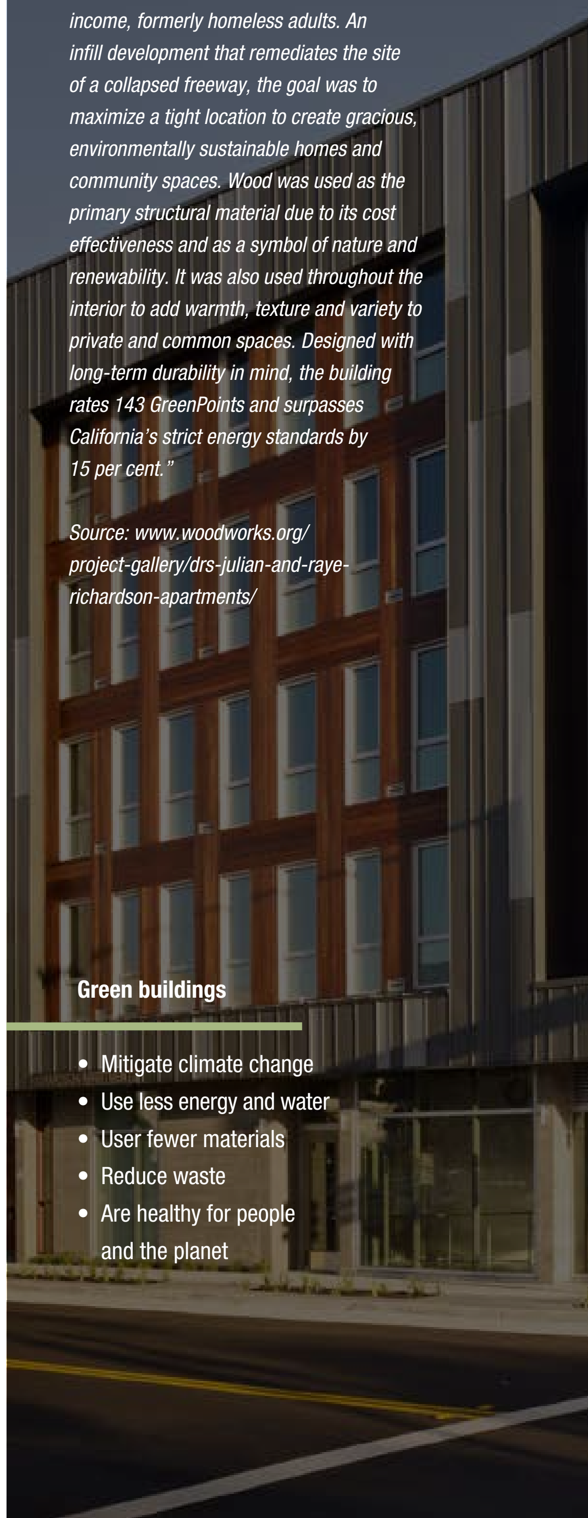
Left and Cover Page:
Drs Julian & Raye Richardson Apartments
San Francisco, CA
Architect: David Baker Architects

This four-story affordable housing project provides permanent residences for low-income, formerly homeless adults. An infill development that remediates the site of a collapsed freeway, the goal was to maximize a tight location to create gracious, environmentally sustainable homes and community spaces. Wood was used as the primary structural material due to its cost effectiveness and as a symbol of nature and renewability. It was also used throughout the interior to add warmth, texture and variety to private and common spaces. Designed with long-term durability in mind, the building rates 143 GreenPoints and surpasses California's strict energy standards by 15 per cent."

Source: www.woodworks.org/project-gallery/drs-julian-and-raye-richardson-apartments/



Green buildings

- Mitigate climate change
- Use less energy and water
- User fewer materials
- Reduce waste
- Are healthy for people and the planet

Life Cycle Assessment

Building Green with Wood

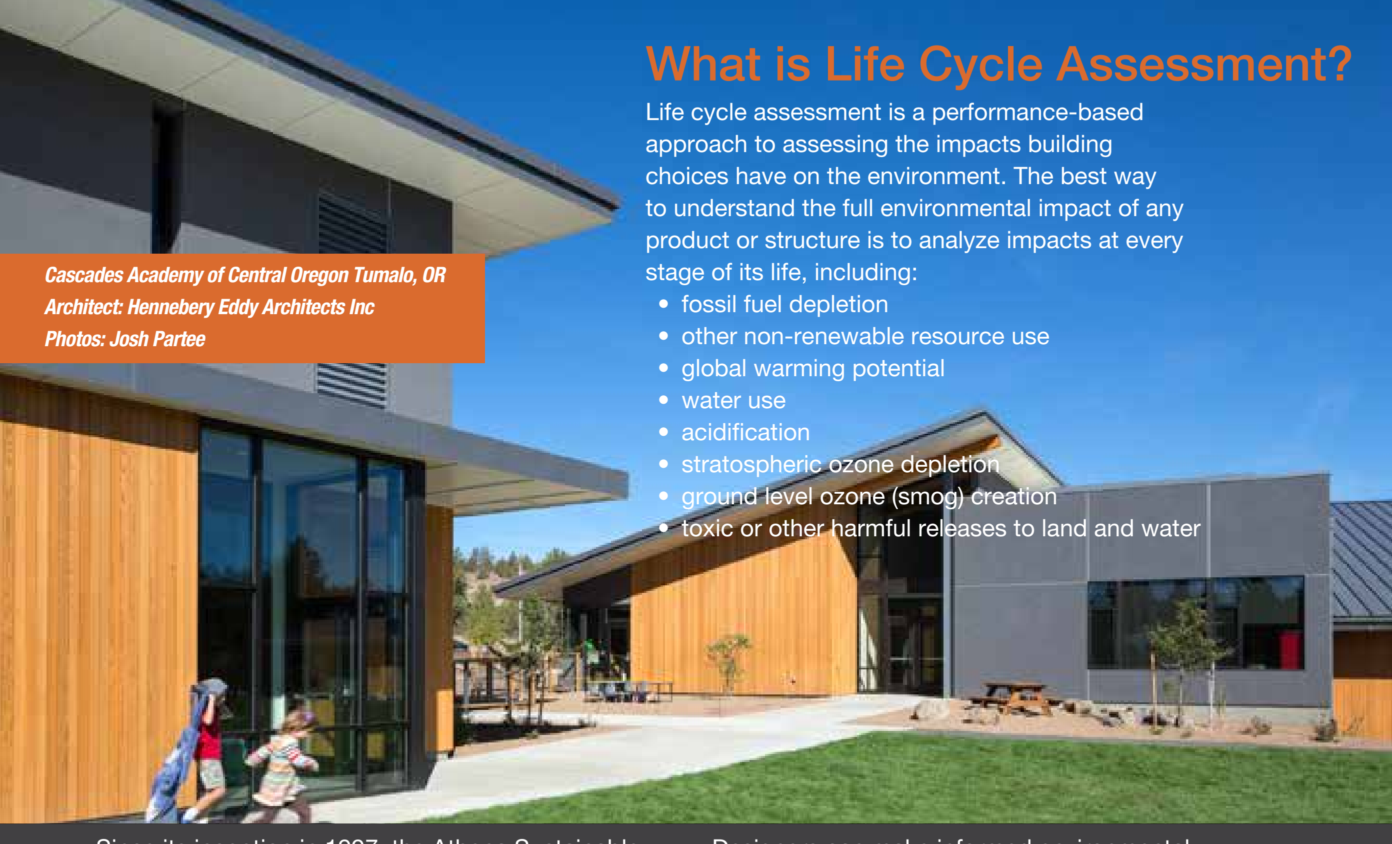
MODULE 2

Making the Right Environmental Choice

The choice of products used to build, renovate and operate structures of all types has a huge impact on the environment, consuming more of the earth's resources than any other human activity, and producing millions of tonnes of greenhouse gases, toxic emissions, water pollutants and solid waste.

Obviously, building with the environment in mind can reduce this negative impact. But to be effective, decisions need to be based on a standardized, quantified measurement system that allows an impartial comparison of materials and assemblies over their entire lives. Prescriptive approaches to green design often focus on a single characteristic, such as recycled content, with an assumption it will yield the greatest environmental advantage.

The most widely accepted scientific method to compare design choices and building materials effectively is life cycle assessment (LCA). It has existed in various forms since the early 1960s, and the protocol for completing life cycle assessments was standardized by the International Organization for Standardization (ISO 14040-42) in the late 1990s.



Cascades Academy of Central Oregon Tumalo, OR
Architect: Hennebery Eddy Architects Inc
Photos: Josh Partee

What is Life Cycle Assessment?

Life cycle assessment is a performance-based approach to assessing the impacts building choices have on the environment. The best way to understand the full environmental impact of any product or structure is to analyze impacts at every stage of its life, including:

- fossil fuel depletion
- other non-renewable resource use
- global warming potential
- water use
- acidification
- stratospheric ozone depletion
- ground level ozone (smog) creation
- toxic or other harmful releases to land and water

Since its inception in 1997, the Athena Sustainable Materials Institute has focused on bringing rigorous quantification to the pursuit of sustainability in the built environment. Athena works with product manufacturers, trade associations, green building associations, and architectural and engineering firms to help quantify environmental impacts and to demystify and assist teams with LCA.

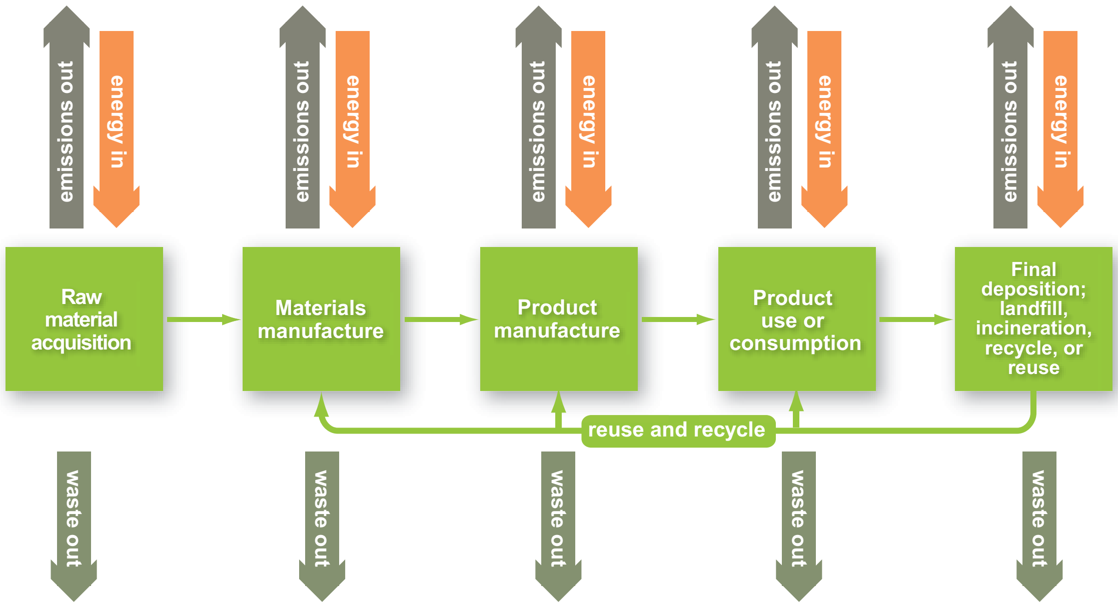
It enables an objective comparison to be made between alternate materials and assemblies over their lifetime, based on quantifiable indicators of environmental impact. Life cycle assessment clarifies the environmental trade-offs associated with choosing one material over another and, as a result, provides an effective basis for comparing alternate designs in a specific geographic location.

Designers can make informed environmental decisions using life cycle assessment tools such as BEES (Building for Environmental and Economic Sustainability) and the ATHENA Impact Estimator for Buildings or EcoCalculator. BEES evaluates the environmental performance of individual products whereas the ATHENA software tools deal primarily with whole building design.

The ATHENA Institute is also working with other organizations to assist the integration of life cycle assessment methodology into third-party green building rating systems such as LEED (Leadership in Energy and Environmental Design) and Green Globes.

Life cycle assessment considers every input and output

This diagram illustrates the general concept of life cycle assessment, where all of the environmental inputs and outputs are measured at each stage of a product's life.



Life Cycle Assessment and Wood

Life cycle assessment studies worldwide have consistently shown that wood products yield clear environmental advantages over other building materials at every stage. Wood buildings can offer lower greenhouse gas emissions, less air pollution, lower volumes of solid waste and less ecological resource use.

A comprehensive review of scientific literature looked at recent research done in Europe, North America and Australia pertaining to life cycle assessment of wood products. It applied life cycle assessment criteria in accordance with ISO 14040-42 and concluded, among other things, that:

- Fossil fuel consumption, the potential contributions to the greenhouse effect and emissions to air and water are consistently lower for wood products compared to competing products.
- Wood products that have been installed and are used in an appropriate way tend to have a favorable environmental profile compared to functionally equivalent products out of other constructed materials.

Similar results were found for whole buildings in a comparison of three hypothetical buildings of identical size and configuration. Designed for the Atlanta geographical area, the building was two stories in height, had a footprint of 20,000 ft.^{2}, a total floor area of 40,000 ft.^{2}, and was built on a concrete foundation and slab. A commonly used LCA tool, the Athena Eco-Calculator, was used to evaluate three alternative configurations of the building – wood, concrete, and steel. To simplify analysis, the theoretical building was analyzed without windows, doors, or internal partitions. Impacts associated with the steel design as compared to the wood design were found to be 1.02 to 3.0 times greater. Comparison of the concrete vs. wood design shows even greater differences. In this case environmental impacts associated with the concrete design ranged from 1.9 to 5.8 times greater than for the wood design.

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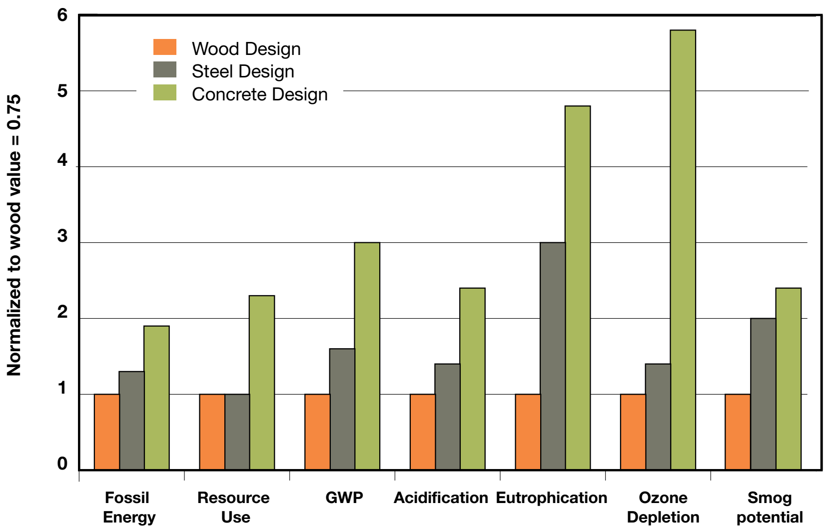

Source: Dovetail Partners using the Athena Eco-Calculator (2014)

Comparing Environmental Impact of a Wood, Steel and Concrete Home

In this graph, three hypothetical buildings (wood, steel, and concrete) of identical size and configuration are compared. Assessment results are summarized into seven key measures covering fossil energy consumption, weighted resource use, global warming potential, and measures of potential for acidification, eutrophication, ozone depletion, and smog formation. In all cases, impacts are lower for the wood design. Source: Dovetail Partners using the Athena Eco-Calculator (2014)

On the cover:
The Craig Thomas Discovery and Visitor Center, Grand Teton National Park, Wyoming
Architect: Bohlin Cywinski Jackson

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MODULE 3

Energy Conservation

The Importance of Energy

As much as one third of the energy produced in North America is used to heat, cool and operate buildings. Since much of the energy consumed to build and operate buildings comes from burning fossil fuels, this releases a significant amount of greenhouse gases.

Types of Energy

Three types of energy are considered through life cycle assessment:

- **Initial embodied energy** – The energy required to extract and process raw materials, fabricate or manufacture them into building components, transport them to site, and install them into the building.
- **Recurring embodied energy** – The energy required to maintain, upgrade or replace, and eventually dismantle and dispose of, materials and components throughout the service life of the building.
- **Operating energy** – The energy required to heat, cool, and ventilate the building, and provide hot water, lighting and power for services and equipment on an ongoing basis.

Wood is low in embodied energy. It's produced naturally and requires far less energy than other materials to manufacture into products. Much of the energy used to process wood in Canada, such as the energy needed for kiln drying, also comes from renewable biomass, including chips and sawdust– a self-sufficient, carbon-neutral energy source.

Energy Consumption in Buildings

Wood has low thermal conductivity and good insulating properties, and light wood-frame technology lends itself readily to the construction of buildings with low operating energy.

A study conducted by the Consortium for Research on Renewable Industrial Materials (CORRIM)[1] compared the environmental impact of a wood-frame house typical for the Minneapolis/St. Paul metropolitan area to an otherwise identical steel-frame house. CORRIM also compared a wood-frame house typical of the Atlanta area to an otherwise identical concrete block house. In both cases, life cycle assessment from raw material extraction through building construction showed lower embodied energy and global warming potential for the wood framed homes. Compared to wood construction, steel and concrete embody and consume 17 and 16 per cent more energy, and emit 26 and 31 per cent more greenhouse gases.

Wood also does well when compared with concrete systems. Concrete can reduce the cost of cooling in climates like the southwest United States desert areas where there are large day-night temperature variations. Wood buildings with a high mass exterior finish, such as brick facing, can achieve the same benefits, potentially with less embodied energy.

The wood industry is investing in research to increase energy efficiency through continual improvement, developing building systems that offer greater air tightness, less conductivity and more thermal mass where appropriate—including prefabricated systems that contribute to the low energy requirements of Passive House and Net Zero designs.

In many scenarios, the variations in operating energy consumption between otherwise identical wood, steel and concrete buildings are small, and they are becoming less significant as insulation levels increase and building envelope technology becomes more sophisticated. However, the reverse is true with embodied energy.

[1] Perez-Garcia, J., Lippke, B., Briggs, D, Wilson, J., Bowyer, J., and Meil, J. 2005. The Environmental Performance of Renewable Building Materials in the Context of Residential Construction. Wood and Fiber Science, Vol. 37, pp. 3-17.

Green design reduces both operating and embodied energy. A typical concrete house has nearly as much energy embodied in the materials as it takes to run the house for 20 years.

The Evolving Relationship between Operating and Embodied Energy

In the U.S., up until the beginning of the 21st century, the environmental impacts of buildings were seldom considered in conception and design. Operating energy was typically considered only to the extent required by code. At that time energy consumption associated with US buildings was high compared to most other developed countries. Since that time, interest in high-performance buildings has come into the mainstream, driven primarily by the emergence of a number of green building programs. One result is that many of the commercial buildings constructed today are much more energy efficient than only several decades ago, with use of operating energy in the best performing buildings 50% or less of average[1,2]. Attention is now also being given to embodied energy, in part because the energy required to create a building becomes increasingly important as operating energy efficiency increases[2]. Studies referenced within the U.S. LCI Database Project[3] consistently show that buildings built primarily with wood have a lower embodied energy than those built primarily of brick, concrete or steel. Extensive use of wood in construction of the new David and Lucile Packard Foundation headquarters building resulted in an estimated 25 percent reduction in embodied energy compared to concrete and steel alternatives[4].

[1] General Services Administration. 2011. Green Building Performance – A Post-Occupancy Evaluation of 22 GSA Buildings. U.S. Government, GSA Public Buildings Service. (http://www.gsa.gov/graphics/pbs/Green_Building_Performance.pdf)

[2] Fish, D. 2012. (by)Metrics (by) Design: Building for Endurance. University of Washington, College of Architecture, MS Thesis. (https://digital.lib.washington.edu/xmlui/handle/1773/22681)

[3] National Renewable Energy Laboratory. 2014. US LCI Database. U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. (http://www.nrel.gov/lci/)

[4] Urban Land Institute. 2013. The David and Lucile Packard Foundation Building: Best Practice Case Study. ULI San Francisco District Council Sustainability Committee.

(http://sf.uli.org/wp-content/uploads/sites/47/2013/05/ULI-CaseStudy-PackardBuilding-FINAL.pdf)

Embodied Plus Operating Energy Over 60 Years

Wood buildings of all sizes and types can be easily designed to meet or surpass energy standards in any climate.

Energy performance depends more on insulation, air sealing and other factors than the choice of structural material. All houses are typically insulated well, so they tend to have essentially comparable energy performance.

However, embodied energy is very much affected by structural material so it is important to look at both operating and embodied energy when evaluating structural materials in terms of energy consumption.

A Wood Building is Easier to Insulate

While a good thermal assembly can be created with any structural material, wood is a better natural insulator in most climates than steel and concrete.

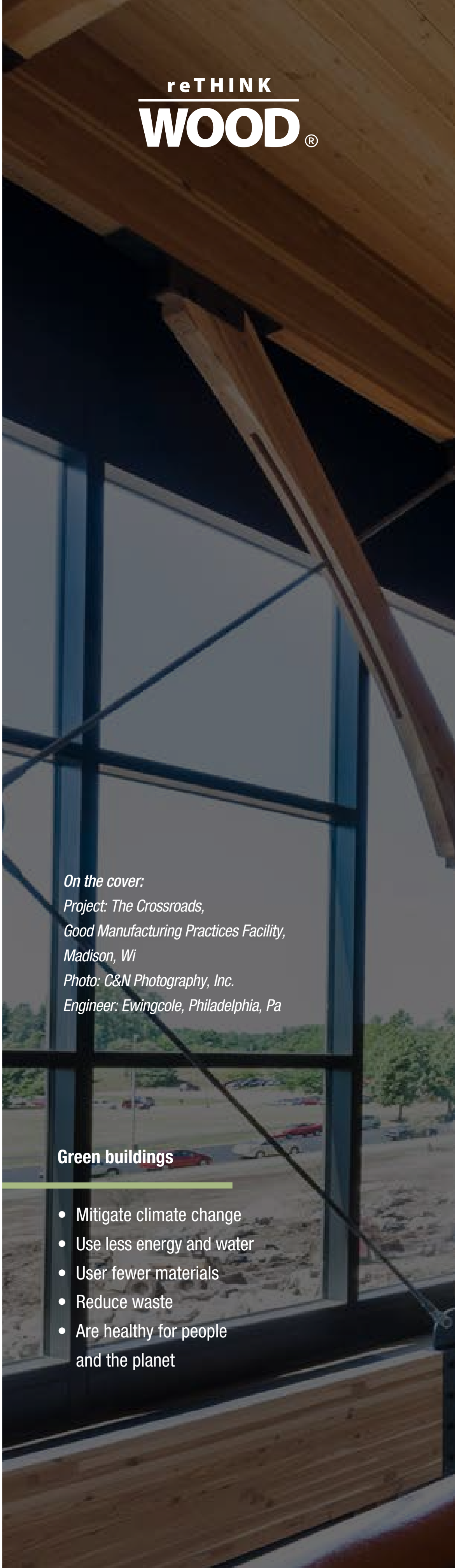
Due to its cellular structure and lots of tiny air pockets, wood is 400 times better than steel and 10 times better than concrete in resisting the flow of heat. As a result, more insulation is needed for steel and concrete to achieve the same thermal performance as with wood framing.

This graph shows the energy performance in two buildings near Chicago. The 2002 study prepared by the National Association of Home Builders Research Center Inc.[6] compared long-term energy use in two nearly identical side-by-side homes, one framed with conventional dimensional lumber and the second framed with cold-formed steel. It found the steel-framed house used 3.9 per cent more natural gas in the winter and 10.7 per cent more electricity in the summer.

The steel building has significantly more insulation than the wood building yet it still did not perform as well. It also has more embodied energy, which is not reflected in the graph.

The data was measured for one year and also simulated with software in order to normalize and validate results. Both houses have fiberglass insulation between the studs.

[6] NAHB Research Centre Inc, 2002: 'Steel versus Wood: Long Term Thermal Performance Comparison.



On the cover:
Project: The Crossroads,
Good Manufacturing Practices Facility,
Madison, Wi
Photo: C&N Photography, Inc.
Engineer: Ewingcole, Philadelphia, Pa

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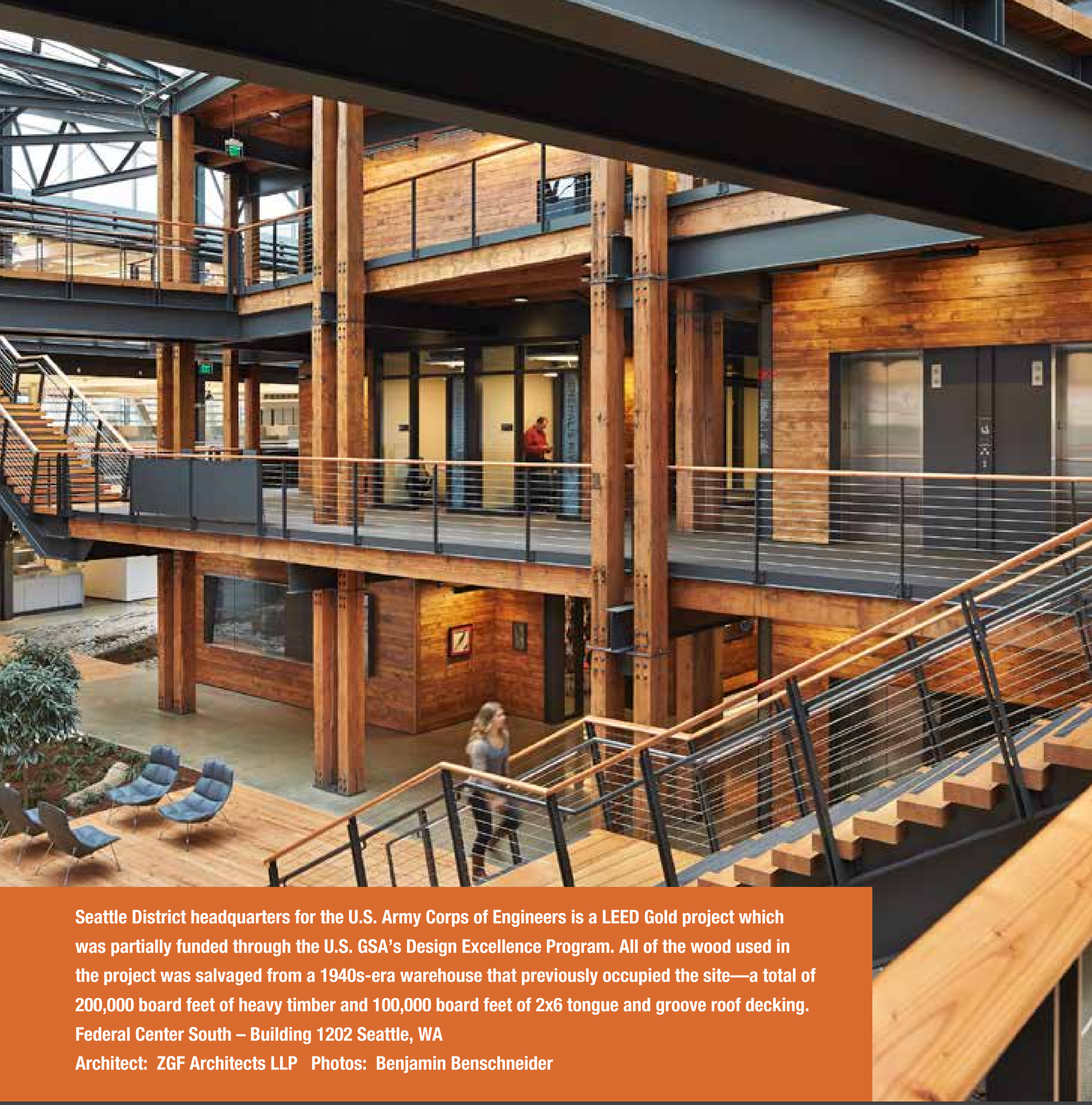
Building Green with Wood

MODULE 4

Resource Conservation



Seattle District headquarters for the U.S. Army Corps of Engineers is a LEED Gold project which was partially funded through the U.S. GSA's Design Excellence Program. All of the wood used in the project was salvaged from a 1940s-era warehouse that previously occupied the site—a total of 200,000 board feet of heavy timber and 100,000 board feet of 2x6 tongue and groove roof decking.
Federal Center South – Building 1202 Seattle, WA
Architect: ZGF Architects LLP Photos: Benjamin Benschneider

Using Resources Wisely

Responsible resource management is essential if we are to reach the goal of true sustainable development. Sometimes this will mean using less, but it will always mean choosing products with the lightest carbon footprint possible.

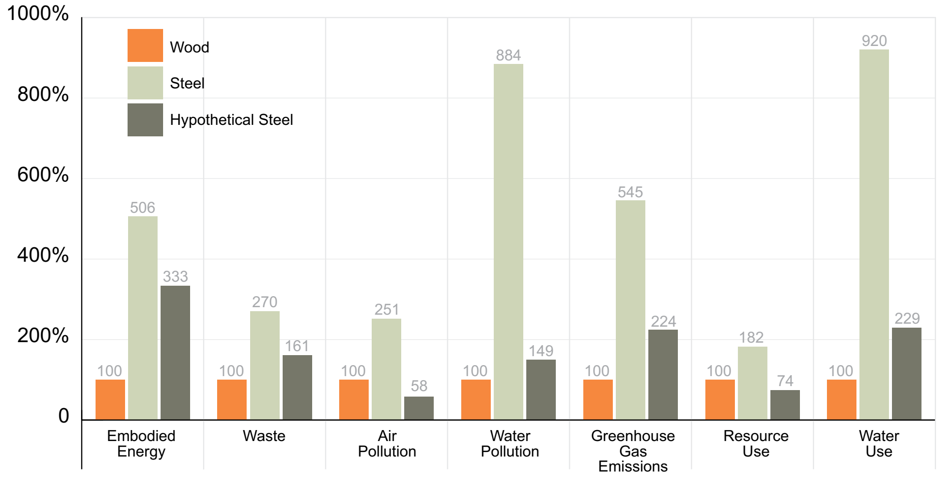
When it comes to building construction and renovation, this means identifying materials, manufacturing processes and design strategies that:

- minimize the use of non-renewable resources
- minimize waste during the extraction and manufacturing process
- minimize the use of fossil fuel energy during extraction and manufacturing
- use products that are flexible, adaptable and durable
- enable the reuse of materials and products from dismantled buildings
- recycle materials only when no longer fit for their original purpose.

A Closer Look at Recycled Content

This bar chart compares life cycle assessment environmental profile of two standard structural post-and-beam systems, and one theoretical steel structure with 100 per cent recycled content.

Source: FPInnovations, calculated using the ATHENA Impact Estimator for Buildings.



Benefits of Wood

Selecting wood building products offers the following advantages related to resource conservation:

1. **Wood is 100 per cent renewable.** When grown and harvested according to internationally recognized sustainable forest management practices, it is the only major construction material that can be regenerated for the benefit of future generations.

2. **The portion of harvested wood volume entering primary processing mills in North America that is converted to marketable products, or converted to useful energy, is near 100%.** In other words, the wood waste at these mills is near 0 per cent; therefore, in terms of wood use, these are zero-waste facilities. Secondary processing plants are similarly diligent in utilization of raw materials[1].

3. **Wood has the least embodied energy of all major building materials[2].** In other words, the energy consumed to grow, harvest, transport and manufacture wood products is less than for other products. Not only does wood require less energy to manufacture into products, half of that is generated from wood waste such as chips and sawdust. Burning wood waste for energy is considered carbon neutral because it only releases the carbon sequestered in the wood during the growing cycle.

4. **Wood is versatile and adaptable.** A building's structural design and spatial subdivision determines its ability to be flexible in use, and adaptable so it can meet new requirements. Separating these functions makes it easier to reconfigure the space. Wood lends itself to this design approach, especially through the use of post-and-beam structures (in solid sawn lumber or engineered wood) and non-load-bearing partitions made up of smaller members (either solid laminated or in stud frame construction).

5. **Wood lends itself to dismantling,** a fact borne out by the continued predominance of wood and wood products in the architectural salvage market. It can generally be reclaimed without diminishing its value or usefulness for future applications. This contrasts with materials like concrete, which is usually crushed for future use as aggregate or ballast, or brick, which can be easily damaged when cleaned for reuse, and which can rarely be reassembled with the original precision.

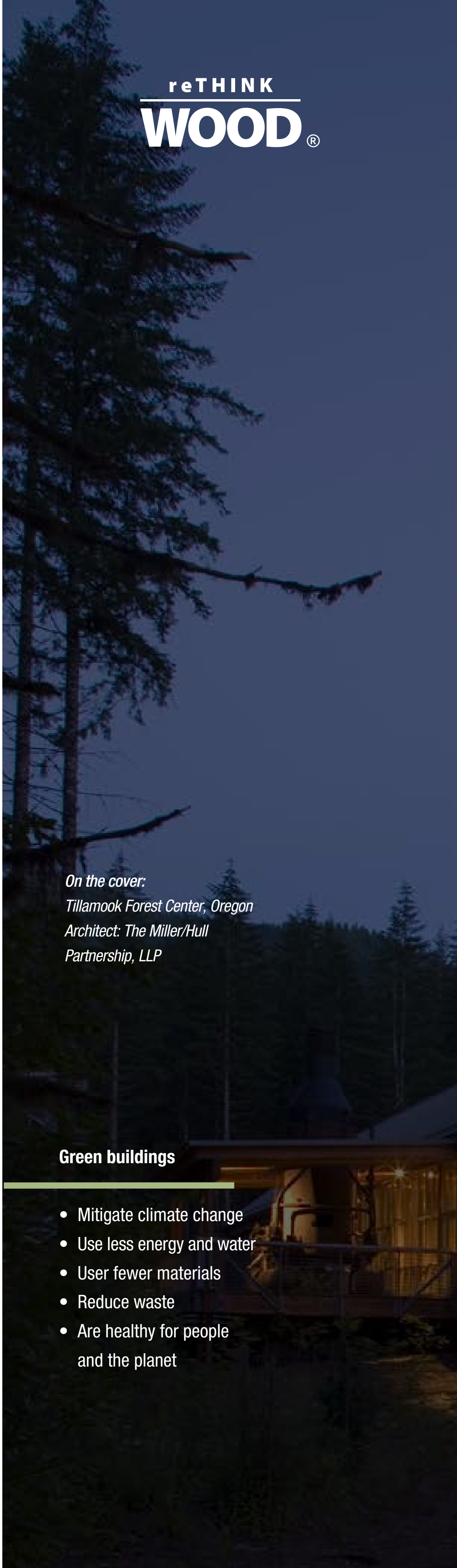
6. **There is growing interest in wood recycling during deconstruction.** Many wood products and materials can be reclaimed and reused for the same or similar purpose with only minor modifications. Lumber can be remilled and made into other products, such as flooring, cladding, window and door frames, or millwork and trim. Some communities have enacted ordinances to require materials from construction and demolition be recovered. For example, San Diego County, California requires that 90 per cent of insert materials and 70per cent of all other materials (including wood cabinets, doors, windows, pallets, and unpainted wood) be recovered from C&D projects.[3]

[1] Bowyer, J., Bratkovich, S., and Fernholz, K. 2012. Utilization of Harvested Wood by the North American Forest Products Industry. Dovetail Partners. 8 October 2012. Available at: www.dovetailinc.org

[2] Werner, Frank and Richter, Klaus, Scientific Journals April 2007: Wooden Building Products in Comparative LCA: A Literature Review.

[3] Howe, J., Bratkovich, S., Bowyer, J., Frank, M., and Fernholz, K. 2013. The Current State of Wood Reuse and Recycling in North America and Recommendations for Improvements. Appendix E: Case Studies. Dovetail Partners. May 2013. Available at: www.dovetailinc.org

Jungers Culinary Center, Bend, OR
Architect: Yost Grube Hall Architecture
Photo courtesy of RealCedar.com



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On the cover:
Tillamook Forest Center, Oregon
Architect: The Miller/Hull Partnership, LLP

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MODULE 5

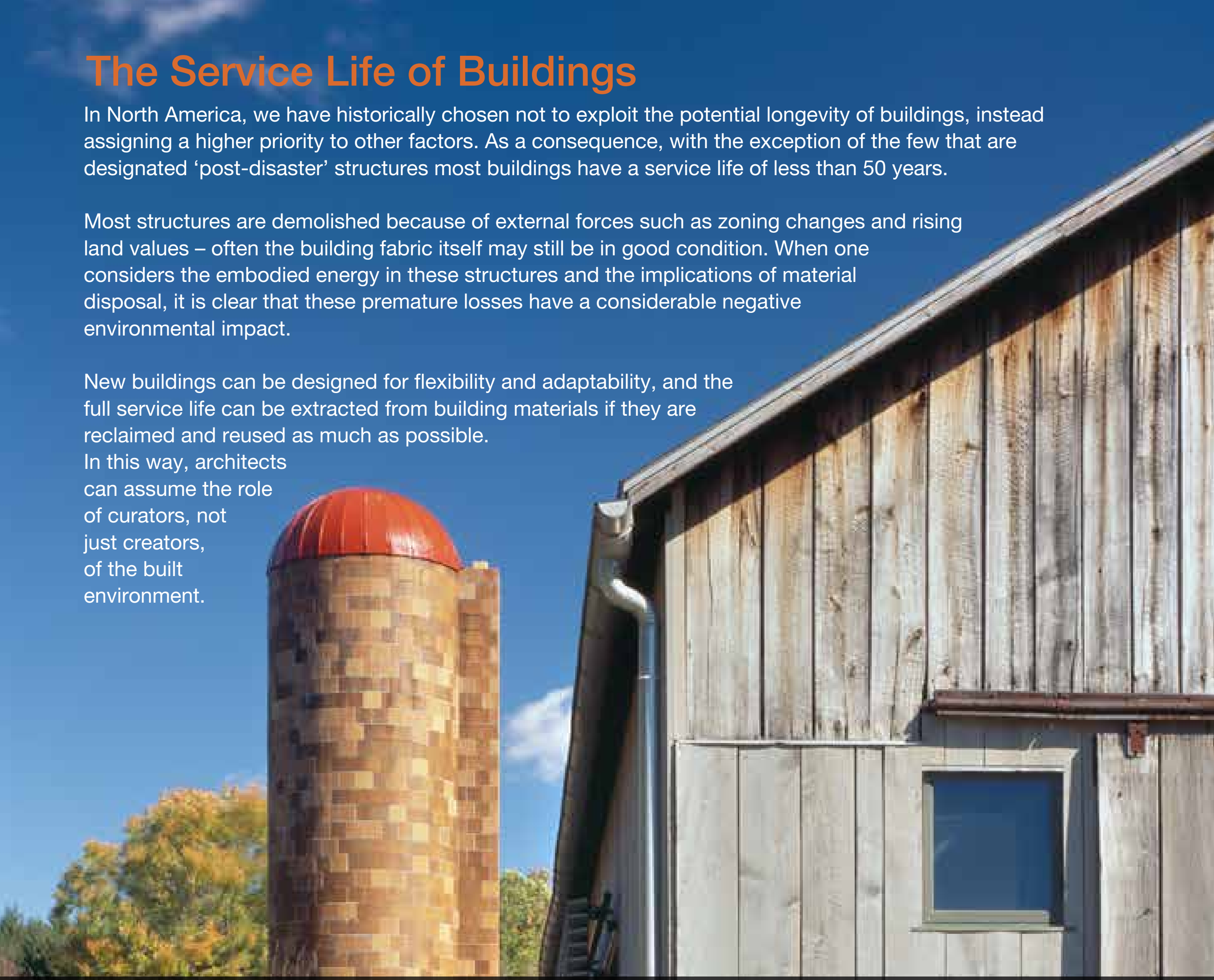
Durability and Adaptability

The Service Life of Buildings

In North America, we have historically chosen not to exploit the potential longevity of buildings, instead assigning a higher priority to other factors. As a consequence, with the exception of the few that are designated 'post-disaster' structures most buildings have a service life of less than 50 years.

Most structures are demolished because of external forces such as zoning changes and rising land values – often the building fabric itself may still be in good condition. When one considers the embodied energy in these structures and the implications of material disposal, it is clear that these premature losses have a considerable negative environmental impact.

New buildings can be designed for flexibility and adaptability, and the full service life can be extracted from building materials if they are reclaimed and reused as much as possible. In this way, architects can assume the role of curators, not just creators, of the built environment.



Durability of Materials and Structures

Designers can get maximum performance and service life out of every building material as long as they understand the necessary steps. Improperly detailed masonry and concrete may spall or crack, steel may rust, and wood may rot. In each case, this compromises the integrity of a building and reduces its life expectancy.

Used properly, all of these materials are inherently durable and can endure for decades or even centuries. The most ancient wood buildings still in existence include eighth century Japanese temples, 11th century Norwegian stave churches, and the many medieval post-and-beam structures of England and Europe. These buildings endure partly because of their cultural significance, and partly because they were built and maintained properly.

For example, long posts supporting the multi-tiered roofs of stave churches were air dried for up to two years to prevent shrinkage and distortion after they were installed. Wood foundation beams were laid on a gravel-filled trench to protect the structure from long-term contact with water. Vertical planked walls were protected from the weather by large overhanging eaves, and shingle roofs were steeply pitched to shed rain and snow.

Although we need a more sophisticated understanding of building physics to ensure the integrity and longevity of materials and structures, the same basic principles still apply.

The Cathedral of Christ The Light in Oakland, California, (on the cover) is an extraordinary timber cathedral designed to last 300 years using a unique structural system. Designed by Skidmore, Owings & Merrill LLP (SOM), the soaring 36,000-square-foot, 1,500-seat structure replaces another cathedral

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Post-disaster Design

While all buildings are at risk of experiencing damage during natural disasters, wood has a number of characteristics that make it conducive to meeting the challenges of seismic- and wind-resistive design.

Light weight. Wood-frame buildings tend to be lightweight, reducing seismic forces, which are proportional to weight.

Ductile connections. Multiple nailed connections in framing members, shear walls and diaphragms of wood-frame construction exhibit ductile behavior (the ability to yield and displace without sudden brittle fracture).

Redundant load paths. Wood-frame buildings tend to be comprised of repetitive framing attached with numerous fasteners and connectors, which provide multiple and often redundant load paths for resistance to seismic and wind forces. Building codes also prescribe minimum fastening requirements for the interconnection of repetitive wood framing members; this is unique to wood-frame construction and beneficial to a building's performance.

Stella
Marina del Rey, CA
Architect: DesignARC
Photo: Lawrence Anderson

The luxury Stella development in California includes four and five stories of wood-frame construction over a shared concrete podium. It was designed to meet requirements for Seismic Design Category D.

The Barn at Fallingwater, designed by Bohlin Cywinski Jackson, is a renovated 19th-century barn with a 1940s dairy barn addition. This adaptive reuse project is immediately adjacent to Frank Lloyd Wright's Fallingwater and is the first phase of a conference complex for Western Pennsylvania Conservancy. The Barn's interior is rich with recycled and salvaged materials that celebrate the region's agrarian heritage. More than 80 per cent of the construction debris was recycled.

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destroyed during a 1989 earthquake. Architecturally stunning, the new building features a space-frame structure comprised of a glulam and steel-rod skeleton veiled with a glass skin. Given the close proximity of fault lines and non-conformance of the design to a standard California Building Code lateral system, the City of Oakland hired a peer review committee to review SOM's design for toughness and ductility. Through the use of advanced seismic engineering, including base isolation, the structure has been designed to withstand a 1,000-year earthquake. Engineers were able to achieve the appropriate structural strength and toughness by carefully defining ductility requirements for the structure, using three-dimensional computer models that simulate the entire structure's nonlinear behavior, testing of critical components relied on for seismic base isolation and superstructure ductility, and verifying their installation.

The Fulton County Stadium in Atlanta, Georgia, was imploded in 1997 – just 32 years after it was built and shortly after it had been refurbished to host the baseball events for the 1996 Olympics. It is a clear example of premature demolition because the building could not meet changing needs.

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Left image:
Islandwood Environmental Interpretive Center, Bainbridge Island, Washington
Mithun Architects + Designers + Planners
The Center was designed so materials can be reclaimed at the end of the structure's service life.

Flexibility and Adaptability

Designing for flexibility and adaptability is also critical to secure the greatest value for the net energy embodied in building materials. Wood structures are typically easy to adapt to new uses because the material is so light and easy to work with. The inherent structural redundancy in light-weight wood-frame structures provides many opportunities for adaptation, while post-and-beam structures provide complete flexibility in the reconfiguration of non-load bearing partitions.

Wood also lends itself to dismantling. The Islandwood Environmental Interpretive Center on Bainbridge Island in Washington state has a post-and-beam frame so partitions can be non-load-bearing, with fully demountable bolted connections to permit reclamation of the complete structure at the end of its service life. In contrast to other materials, reclaimed wood can often be reused for its original purpose (e.g., as structural members), with little or no loss of value.

On the cover:
Cathedral Of Christ The Light
Oakland, CA
Architect: Skidmore, Owings & Merrill LLP
Award Category: Landmark Wood Design
Photos: Timothy Hursley & Cesar Rubio
Architecturally stunning, the Cathedral of Christ The Light features a space-frame structure comprised of a glulam and steel-rod skeleton veiled with a glass skin. Twenty-six, 110-foot glulam Douglas-fir ribs curve to the roof to form the framework for the sanctuary superstructure. A total of 724 closely spaced glulam "louver" members interconnect and provide lateral bracing for inner rib members. Green ceramic fritted glass panels jacket the Cathedral's outer shell to insulate the building, reduce glare, and change the quality of light throughout the day and seasons.

Green buildings

- Mitigate climate change
- Use less energy and water
- User fewer materials
- Reduce waste
- Are healthy for people and the planet

MODULE 6

Health and Well-being

Impacts of Buildings on Human Health

Green building objectives are broader than just environmental effects, and have come to embrace human health issues as well, including performance. In the developed world where people spend much of their time inside buildings, the design of the indoor environment is of critical importance to human health.

Within the context of green design, measures frequently explored for a better indoor environment include:

- monitoring of carbon dioxide levels
- ventilation effectiveness
- management of dust and contaminants during construction
- control of indoor chemical and pollutant sources
- personal control of environmental systems
- provision of daylight and views.

Yountville Town Center
Yountville, CA
Siegel & Strain Architects

Designing for Human Well-being

Health and well-being embraces both physical health, and the psychological aspects of human performance.

Over time, physical issues have been dealt with incrementally through legislation that has banned the use of toxic or otherwise dangerous substances in buildings. In addition, new standards have been introduced to ensure adequate ventilation, reduce condensation and inhibit the growth of moulds and mildew.

Designers are also interested in potential psychological and related physiological benefits of environmental design factors. For example, intuition tells us that a connection to nature improves our sense of well-being when indoors. This can be achieved through access to daylight or views, or by providing a visual or tactile connection with natural materials such as wood and stone.

For many years, research has shown the human health benefits of forests. The benefits of time spent in forests include reduced stress, lower blood pressure, and improved mood. Medical research shows exposure to forests can boost our immune system and may even correlate to lower cancer rates. The benefits of forests are strongly recognized in some cultures. In Japan, the term “forest bathing” refers to time spent in the forest atmosphere and is encouraged by public policy. New research is beginning to show that the visible use of wood in buildings provides human health benefits as well.

A recent study at the university of British Columbia and FPInnovations[1] identified a link between the use

[1] Fell, David. 2013. Wood and Human Health. FPInnovations. https://fpinnovations.ca/MediaCentre/Brochures/Wood_Human_Health_final-single.pdf .

Continued on next page....

.....Continued from previous page

of wood and human health. The study compared the stress levels of participants in different office environments with and without wood finishings.

The results found that "Stress, as measured by sympathetic nervous system (SNS) activation, was lower in the wood room in all periods of the study." Studies have shown that SNS activation increases blood pressure and heart rate while inhibiting digestion, recovery, and repair functions in the body. People that spend a lot of time in a state of SNS activation can show physiologically and psychologically impacts. The use of visual wood surface can reduce SNS activation and promote health in building occupants.

The Herrington Recovery Center in Milwaukee, Wisconsin, is one example of designing with wood and natural environments to support the mission of the facility. Rooms maximize views of the outdoors and interior uses of wood include woodwork, ceilings, soffits, and other elements.

The growing knowledge of the health benefits of building with visual wood surfaces is being incorporated into healthcare environmental to support patient recovery, school environments to support student learning, and offices to support employee health.

Wood and Interior Air Quality

Dust and Particulates

Solid wood products, particularly flooring, are often specified in environments where the occupants are known to have allergies to dust or other particulates. Wood itself is considered to be hypo-allergenic; its smooth surfaces are easy to clean and prevent the buildup of particles that are common in soft finishes like carpet.

Off-gassing

Interior wood panel products, such as particleboard, medium density fibreboard (MDF), and hardboard, were once identified as having a negative impact on indoor air quality because of their use of urea-formaldehyde (UF) glues. The concern was that, if panels were left unsealed, volatile organic compounds would be released into the air.

In 2004, the Composite Panel Association (CPA) (www.pbmdf.com) introduced an Environmentally Preferable Product (EPP) Certification Program to lower formaldehyde emissions from wood-based panels intended for interior use. EPP-designated products have since been third-party certified as complying with the environmental criteria referenced in the U.S. Environmental Protection Agency's Guidelines for Environmentally Preferable Purchasing.[2] Compliance requires rigorous quarterly audits at the manufacturing site and independent third-party product emission testing.

The Composite Panel Association's EPP Certification Program is the first EPP certification program accredited by the American National Standards Institute (ANSI).

Some manufacturers also produce formaldehyde-free panel products, made with an urethane-type (MDI) resin. Once cured, MDI-based wood panel products are very stable, without measurable off-gassing.

Humidity Control

The use of wood products can also improve indoor air quality by moderating humidity. Acting like a sponge, the wood absorbs or releases moisture in order to maintain equilibrium with the adjacent air. This has the effect of raising humidity when the air is dry, and lowering it when the air is moist – the humidity equivalent of the thermal flywheel effect.

[2] Wood panels certified to CPA's EPP Certification Program must demonstrate that they are made from 100% recycled or recovered fibre and meet emissions of maximum 0.2 parts per million of formaldehyde.

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Left Image:
U.S. Land Port of Entry Warroad, MN
Julie Snow Architects, Inc. Minneapolis, MN

On the cover:
Sema 4,
Leucadia, CA
Brian Church Architecture, CA
Photo courtesy of RealCedar.com

Green buildings

- Mitigate climate change
- Use less energy and water
- User fewer materials
- Reduce waste
- Are healthy for people and the planet

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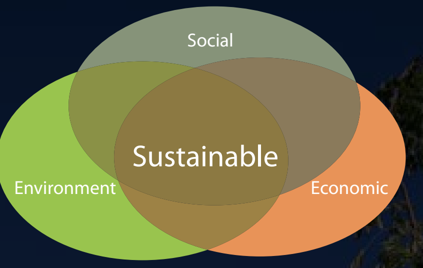
Social & Economic Sustainability

Building Green with Wood

MODULE 7

Sustainable Development

Green building supports a built environment that is socially, environmentally and economically responsible. These are the three pillars of sustainable development.
While it is important to promote environmental sustainability, there is also a need to consider social and economic issues. Buildings must be designed with people in mind – and this will in turn lead to communities that are thriving and vibrant.



Cascades Academy of Central Oregon Campus
Architect: Hennebery Eddy Architects, Inc.
Photographer: Josh Partee

Meeting Social Needs

Social sustainability relies on a collaborative approach to building and community development, one that involves all stakeholders, reinforces social networks, and allows people of every age and ability to reside and participate in their community throughout their life. Sustainable communities make it easier for people to travel by foot, bicycle and transit, and they bring together residential, commercial and retail development.

The objective of green design is to create communities where people will want to live and work now and in the future. Where appropriate, there should be preference given to renewable and recyclable materials that are regionally harvested or manufactured, and can be installed and maintained by local labour.

Once again, life cycle assessment has a key role to play in identifying the most appropriate product choices. There may be times when local materials are not the most environmentally sound choice; and it may be better to import products that have lower extraction, processing and disposal impacts.

U.S. forestry regulations, best management practices, monitoring and training programs assure that products are harvested responsibly.

Meeting Economic Needs

A green design may cost more but often saves operating costs throughout the life of the building – through more efficient lighting and better windows, smaller and less costly HVAC, better use of materials, and reduced demolition costs. A green building is also likely to maintain a higher value.

A 2009 report by the U.S. General Services Administration studied 12 sustainably designed buildings and found they not only cost less to operate and have excellent energy performance, but that occupants are more satisfied with the overall building than those in typical commercial buildings.[1]

While it is often hard to quantify, studies show that environmental air quality improvements can actually improve performance and productivity, and may reduce the time lost to illness. In Nevada, a post office was renovated at a cost of $300,000 to lower the ceiling and install energy-efficient lighting. It was estimated that energy savings would pay back the total cost in about 13 years – and that productivity gains through improved employee efficiency and reduced errors would return the full cost in less than a year.

[1]Assessing Green Building Performance. A Post Occupancy Evaluation of 12 GSA Buildings. Pacific Northwest National Laboratory (2008) www.gsa.gov/graphics/pbs/GSA_Assessing_Green_Full_Report.pdf

Responsible Forest Products

Builders can use their buying power to improve forest management by choosing wood products they know are from legal, sustainable sources. This demonstrates their corporate social responsibility and shows customers they care about the environment.

Illegal logging is an urgent global problem that leads to the loss of wildlife habitat and public revenues. Lower prices for illegal forest products distort global markets and discourage sustainable forest management.

Private and public procurement policies are increasingly requesting proof that forest products are derived from known and legal sources.

These policies generally accept wood from certified sources as evidence of both legality and sustainability.

North America is a world leader in forest certification. It also has comprehensive governance structures, and can assure buyers that its forest products are harvested legally and sustainably.

Photographer: Michael Bednar

U.S. Resource Communities

In the United States, forest products provide economic opportunities for people in communities across the country. About one million workers are employed in the forest products sector. Forest products account for approximately six per cent of the total U.S. manufacturing GDP and is among the top ten manufacturing sector employers in 48 states. Forest products in the U.S. generate over $200 billion a year in sales and about $54 billion in annual payroll.

Source: USDA Forest Service. Accessed 4/15/14. http://www.fs.fed.us/research/forest-products/

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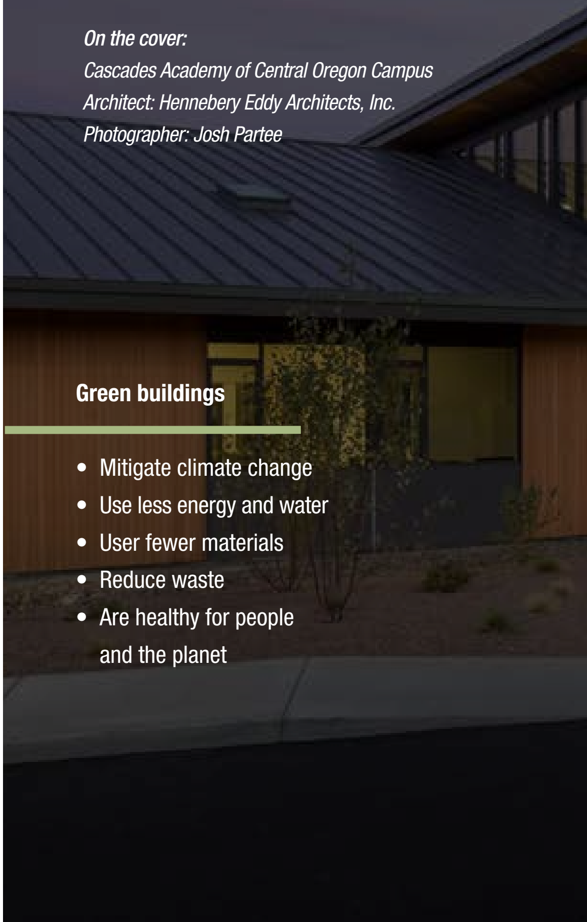

On the cover:
Cascades Academy of Central Oregon Campus
Architect: Hennebery Eddy Architects, Inc.
Photographer: Josh Partee

Green buildings

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MODULE 8

Transportation Effects

Looking at the Complete Picture

While a building's operation over time has the greatest environmental impact, there is also energy consumed in extracting, manufacturing and transporting the materials and components used for the building construction, installing them, and their ongoing maintenance. In combination, these energy inputs are referred to as embodied energy.

Calculating the amount of embodied energy is a complex issue, one that is often overlooked. For example, LEED (Leadership in Energy and Environmental Design), the most widely used green design tool in North America, does not measure embodied energy at all. It awards credits for measures such as sourcing local materials, but does not require a life cycle assessment to determine that this is an important consideration.

There may be times when sourcing local products yields the most environmental benefit. But the decision should not be based on one factor alone, such as transportation impacts. Other aspects of embodied energy – and issues such as pollution or environmental degradation – may be of far greater significance in product selection than transportation energy. Life cycle assessment takes away much of the guesswork by calculating outcomes based on quantifiable indicators.

Photographer: Michael Bednar, Bednar Photo

Life cycle assessment accounts for the effects of transportation mode and not just distance. A product traveling a long distance using a highly efficient transportation method can actually have a smaller transportation footprint than a closer product traveling inefficiently.

Photographer: Moresby Creative

Deciding When to Buy Locally

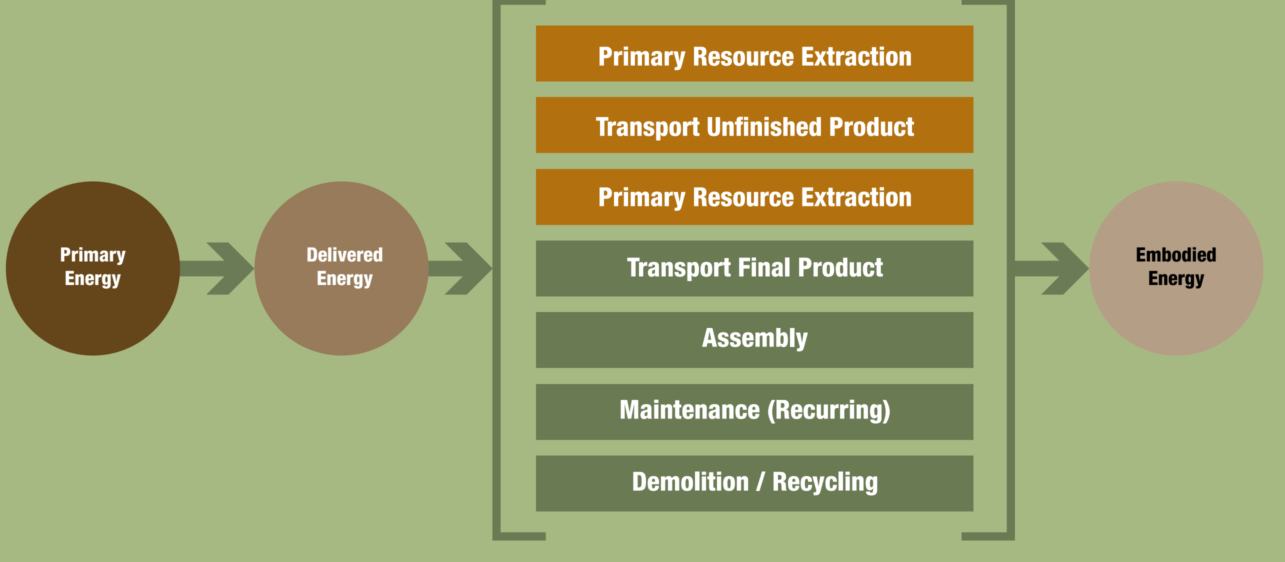
It is natural to expect that locally sourced products would be more environmentally responsible than those shipped a great distance. But this is usually based on the assumption that transportation energy contributes a lot to the overall energy equation – and life cycle assessment can prove that this is usually not the case.

While buying local may help the local economy, it is not necessarily the best environmental choice. In many cases, transportation energy is a very small component of overall energy consumption.

For example, the figure below illustrates those activities that contribute to the energy embodied in a completed structure. A recent study conducted by the EPA[1] found that in a single family wood-framed residential home in the United States, transportation energy accounts for about 8 per cent of the total embodied energy in the building prior to occupancy (i.e. up to the completion of assembly). Energy used to extract raw materials, convert them to useful products, and construct the building accounts for the remainder.

When operational energy (that used for heating and cooling and all other uses during occupancy) is also included in life cycle calculations, embodied energy through completion of building assembly accounts for about 8 per cent of total energy. When building maintenance through the life of a structure is also considered (replacement of shingles, painting, etc.) total embodied energy can account for 20-22 per cent of total life cycle energy. Life cycle assessment ensures that all aspects of energy use are considered, enabling materials selection decisions based on sound knowledge.

[1] Haynes. 2013. Embodied Energy Calculations within Life Cycle Analysis of Residential Buildings. (http://etool.net.au/wp-content/uploads/2012/10/Embodied-Energy-Paper-Richard-Haynes.pdf)
USEPA. 2013. Analysis of the Life Cycle Impacts and Potential for Avoided Impacts Associated with Single Family Homes. EPA 530-R-13-004. (http://www.epa.gov/waste/conserve/imr/cdm/pdfs/sfhomes.pdf)



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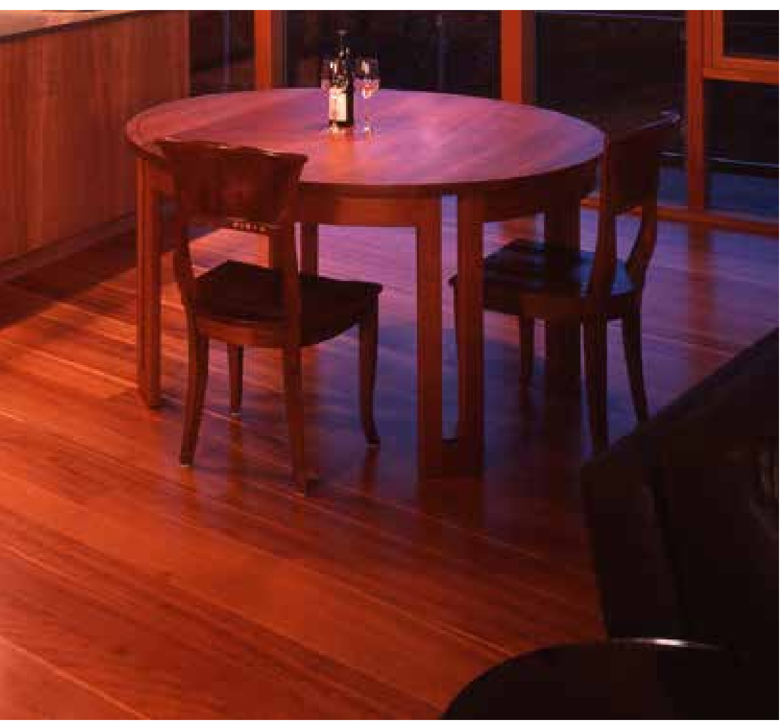
Green design requires careful choices. Life cycle assessment can help determine whether a product coming from a sustainably managed forest versus a rapidly renewable product that is high in processing emissions and transportation emissions is the better choice.

The best green choice is...?



On the cover:
Pocono Environmental Education Center, Dingman's Ferry, Pennsylvania
Architect: Bohlin Cywinski Jackson

Green buildings

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Building Green with Wood

MODULE 9

Climate Change

Climate Change: Causes and Consequences

The Fourth Assessment Report, released by the Intergovernmental Panel on Climate Change in 2007, states: “Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level.”

The consequences of climate change are difficult to predict because of the complexity of environmental systems that determine climate, but some of the trends are already clear:

- Changes in natural habitats will result in the loss of plant and animal species.
- Species that carry tropical diseases, such as mosquitoes (malaria), will spread and settle into new areas.
- Sea levels will continue to rise, with catastrophic results for those living in coastal or river delta areas or low-lying land.

Using Wood Can Help Tackle Climate Change

To mitigate climate change, it is necessary to reduce greenhouse gas emissions and store more carbon. A well-managed forest can do both.

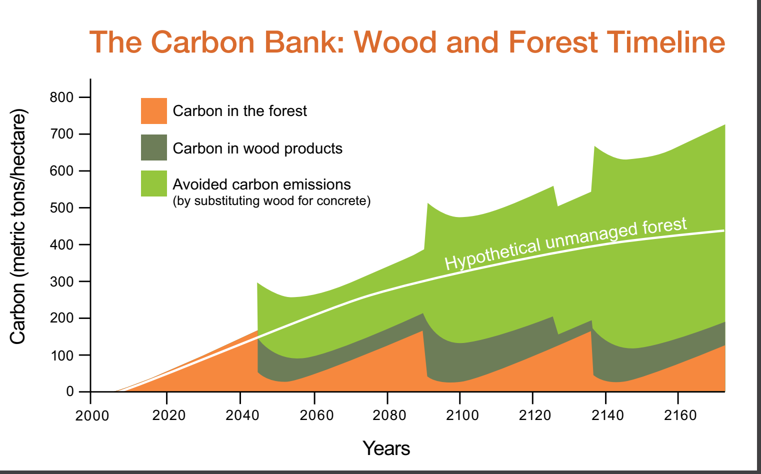
As trees grow, they absorb carbon dioxide and store it. When they decompose or burn, much of the stored carbon is released back into the atmosphere, mainly as carbon dioxide, and some of the carbon remains in the forest debris and soils.

Wood products continue to store much of the carbon absorbed during the tree’s growing cycle, while the regenerating forest once again begins the cycle of absorption. Manufacturing wood into products also requires far less energy than other materials, and most of that comes from residual biomass (such as bark and sawdust).

Michael Malinowski of AIA Applied Architecture, Inc. in Sacramento California is an advocate for wood in mixed use and podium design. His background includes extensive experience in architectural design, historic adaptive reuse, value engineering, permit streamlining, and getting to yes in the approval process. “Wood construction can help maximize value to the community, the environment and the development team,” says Malinowski.

In a 2007 report, the Intergovernmental Panel on Climate Change Working Group III pointed out that forests remove carbon from the atmosphere and, at the same time, provide products that meet society’s needs for timber, fibre and energy. A stable market for forest products encourages landowners to manage forests sustainably rather than converting them to other uses such as agriculture or urban development.

Securing the Future, a 2005 United Kingdom government strategy for sustainable development stated: “Forestry practices can make a significant contribution by reducing greenhouse gas emissions through increasing the amount of carbon removed from the atmosphere by the national forest estate, by burning wood for fuel, and by using wood as a substitute for energy-intensive materials such as concrete and steel.”



The Carbon Bank: Wood and Forest Timeline[1] *This graph shows the movement of carbon from one pool to another. As we create more and more long-lived wood products, the balance in our account goes up and up.*

Sources:
Adapted from graphs in “Forests, Carbon and Climate Change: A Synthesis of Science Findings,” 2006, Oregon Forest Resource Institute.

Using a Wood Podium in Mixed-Use Design: An Architectural Case Study http://woodworks.org/wp-content/uploads/2014-Mar-TX-WS-Malinowski-Wood-Podium-Mixed-Use-Design.pdf

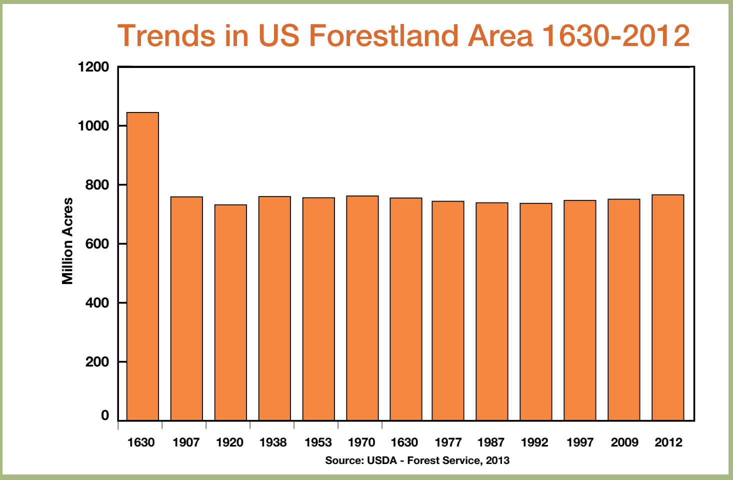
Michael Malinowski, Applied Architecture, Inc. http://woodworks.org/wp-content/uploads/2014-Mar-TX-WS-Malinowski-Wood-Podium-Mixed-Use-Design.pdf

Deforestation in developing countries is a leading contributor to CO_2 emissions.

Managing Forests to Mitigate Climate Change

When a tree is cut down, 40 to 60 per cent of the carbon stays in the forest, and the rest is removed in the logs, which are converted into forest products.[1] Some carbon is released when the forest soil is disturbed during harvesting, and the roots, branches and leaves left behind release carbon as they decompose.

The amount of carbon dioxide released through harvesting is small compared to what is typically experienced through forest fires and other natural disturbances such as insect infestations and disease. The United States has over 750 million acres of forestland. Forests cover about one-third of the nation, and the total forest area in the United States has been stable for about 100 years.[2] Wildfires can be a significant threat to forests and the people the live near them. Recent research has found that proactive forest harvesting and management techniques can reduce the risk of high-severity wildfires. "Recent megafires in California and the West have destroyed lives and property, degraded water quality, damaged wildlife habitat, and cost taxpayers hundreds of millions of dollars," said David Edelson,



Sierra Nevada Project Director with The Nature Conservancy. "This study shows that, by investing now in Sierra forests, we can reduce risks, safeguard water quality, and recoup up to three times our initial investment while increasing the health and resilience of our forests."[3]

[1] Does harvesting in Canada's forests contribute to climate change? Canadian Forest Service, 2007, www.sfmcanada.org/images/Publications/EN/CFS_DoesHarvestingContributeToClimateChange_EN.pdf

[2] National Report on Sustainable Forests - 2010, USDA Forest Service

[3] Source of quote: Sierra Star. New study could save on future fires. April 10, 2014. Accessed 4/15/14. http://www.sierrastar.com/2014/04/10/67208/new-study-could-save-on-future.html

Greenhouse Gases, Carbon, and Forests

The Greenhouse Effect

The glass panels of a greenhouse let in light and keep heat from escaping, providing warmth for the plants growing in them. A similar process occurs when the sun's energy reaches the Earth – some is absorbed by the Earth's surface, some radiates back into space, and some is trapped in the Earth's atmosphere, which keeps the planet warm enough for life to flourish. This is called the greenhouse effect.

The carbon cycle affects the amount of energy trapped in the atmosphere. Plants absorb carbon dioxide and emit oxygen during photosynthesis; oceans also absorb carbon dioxide. Humans and other animals inhale oxygen and exhale carbon dioxide. Carbon dioxide is emitted when substances decompose or burn.

Scientists agree this natural balance has been upset. The biggest human cause is the amount of carbon dioxide being released into the atmosphere through the burning of non-renewable fossil fuels, such as oil, natural gas or coal. Carbon dioxide accounts for more than 75 per cent of total greenhouse gas emissions.

Close to eight billion tonnes of carbon dioxide are emitted every year – most of this through fossil fuel combustion and deforestation in tropical regions. Some is absorbed by water bodies, some is absorbed by forests – and some is emitted into the atmosphere.

If too much carbon is emitted, it causes the atmosphere to trap more heat, warming the planet. Rising temperatures may, in turn, produce changes in weather, sea levels, and land use patterns, commonly referred to as climate change.

Forests and the Carbon Cycle

Quantifying the substantial role of forests as carbon stores, as sources of carbon emissions and as carbon sinks, has become one of the keys to understanding and modifying the global carbon cycle.

In its Global Forest Resources Assessment 2010[4], the United Nations Food and Agriculture Organization (FAO) found that world's forests store more carbon than the entire atmosphere. Forests store more than 650 billion tonnes of carbon, with 44 per cent in the biomass, 11 per cent in dead wood and litter, and 45 per cent in the soil. In 2014, the FAO reported that net greenhouse gas emissions from land use change and deforestation decreased by 10 per cent between 2001 and 2011 due to decreased deforestation and increased sequestration in many countries.

[4] Global Forest Resources Assessment 2010 (FRA 2010). Food and Agriculture Organization of the United Nations. http://www.fao.org/forestry/fra/fra2010/en/

FAO. 2014. FAO Data Show Rising Agriculture Emissions, Declining Net Land-use Change Emissions. April 11, 2014. http://climate-l.iisd.org/news/fao-data-show-rising-agriculture-emissions-declining-net-land-use-change-emissions/240227/

Carbon sequestered in a typical 2,400-square-foot North American home is the equivalent of offsetting the greenhouse gas emissions produced by driving a passenger car over five years (about 12,500 litres of gasoline).

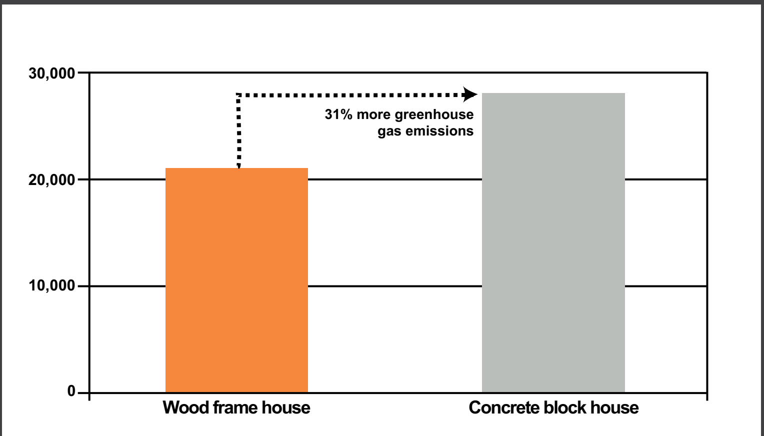
Solid Wood and Climate Change

Using wood products that store carbon instead of building materials that require large amounts of fossil fuel energy to manufacture can help to reduce greenhouse gases in the atmosphere. Trees grow naturally, and the little waste generated during processing is often used to meet the energy needs of the mill. At the end of their first life, forest products can be easily reused, recycled or used as a carbon-neutral source of energy.

A typical 2,400-square-foot wood-frame house contains 29 metric tonnes of carbon, which is the equivalent of offsetting the greenhouse gas emissions produced by driving a passenger car for five years (about 12,500 litres of gasoline). No other material offers this kind of carbon credit.

Around the world, government and business leaders are developing policies and procurement processes that encourage the use of more forest products from well-managed forests.

As part of its promotion of a carbon-neutral public service, the Government of New Zealand is requiring that wood or wood-based products be considered as the main structural materials for new government-funded buildings up to four floors. In the U.S., federal initiatives have been announced to support innovative, sustainable wood building materials with a goal to protect the environment and create jobs.



Life cycle assessment is the appropriate tool for examining the carbon footprint of building materials because it considers the greenhouse gas emissions associated with their production, transportation, construction, use and eventual disposal.

- *In this graph, the embodied effects are shown for two typical, identical homes, one made with wood and one with concrete. (Embodied effects are the environmental impacts associated with manufacturing, transporting and constructing the houses – heating and cooling the houses are not included);*
- *It shows that the concrete-block house resulted in 31 per cent more greenhouse gas emissions than the wood-frame house.*

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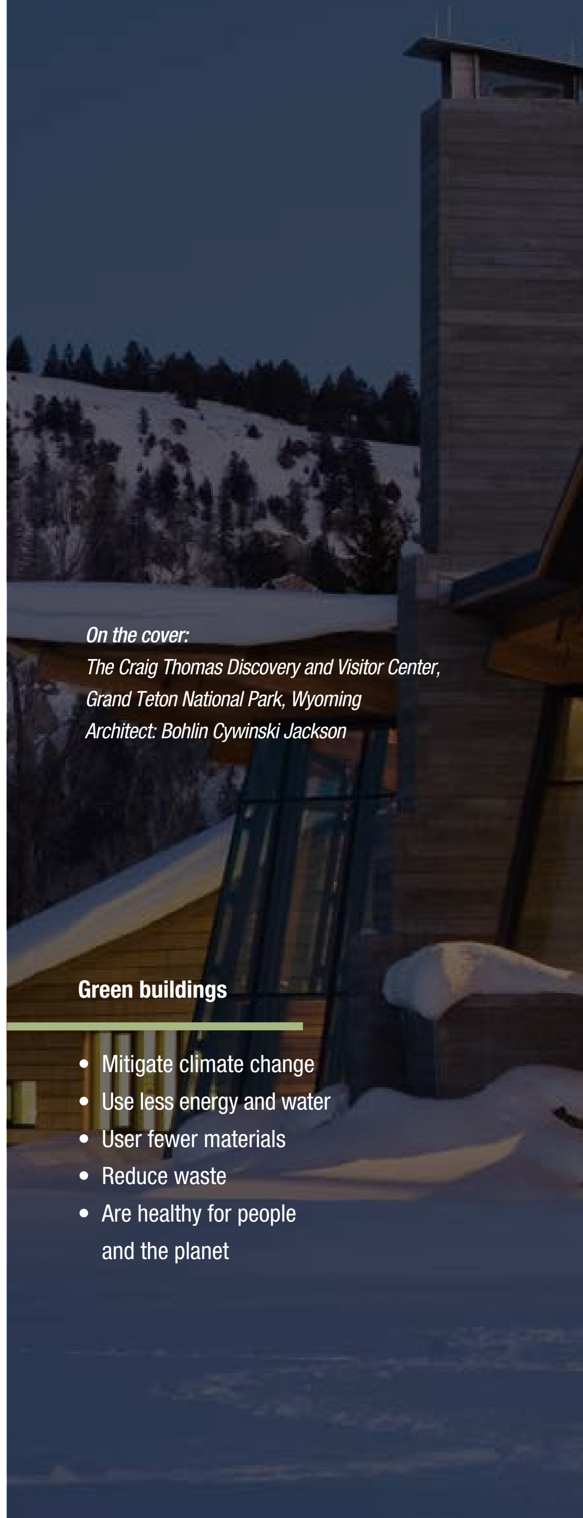
The United States has over 750 million acres of forestland. More than ninety per cent of forests in the United States are naturally reforested. Additionally, more than 1.5 million acres of forest is replanted in the U.S. annually.

Source: FRA 2010 – Country Report, United States, Available at: http://www.fao.org/forestry/fra/fra2010/en/



On the cover:
The Craig Thomas Discovery and Visitor Center, Grand Teton National Park, Wyoming
Architect: Bohlin Cywinski Jackson

Green buildings

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Building Green with Wood

MODULE 10

Forest Practices in the United States

Forest Practices in the United States

Forestry as a profession in North America is about 100 years old. Over the past century, the field has evolved from practices that were focused on maximizing timber values to approaches that are deeply rooted in ecology, science, and principles of sustainability. Modern day foresters complete rigorous college programs and participate in continuing education, certification, and licensing programs to establish and maintain professional credentials, much the same process as other professions such as engineering and architecture.

Forest management in the United States operates under layers of federal, state, and local regulations and guidelines that foresters and harvesting professionals must follow to protect water quality, wildlife habitat, soil, and other resources. Laws addressing safety and workers' rights also govern forestry activities. Government agencies monitor forest management activities for compliance with regulations.

The United States and Canada together have about 15.5 per cent of the world's total forest cover and North America has about the same amount of forested land now as it did 100 years ago[1].

[1]State of the World's Forests Report, 1997 through 2009

A Snapshot of America's Forests

According to the National Report on Sustainable Forests – 2010,[2] the U.S. has approximately 751 million acres of forest area, which is about one third of the country's total land area. "This stability is in spite of a nearly three-fold increase in population over the same period and is in marked contrast with many countries where wide-scale deforestation remains a pressing concern."

Forty-three per cent of U.S. forests are owned by entities such as national, state and local governments; the rest are owned by private landowners, including more than 22 million family forest owners. The fact that net forest growth has outpaced the amount of wood harvested for decades supports the idea that landowners who depend economically on the resource have a strong incentive for their sustainable management. This aligns with global forest data, which indicates that forest products and industrial roundwood demands provide the revenue and policy incentives to support sustainable forest management.[3]

However, with urban development and other uses increasingly vying for land, an issue going forward will be making sure that landowners continue to have reasons to keep forested lands forested.

About 30 per cent of the forest area of the United States is classified as production forest where the production of forest products is a primary function. About 25 per cent of the forest area is designed for the protection of soil and water and the conservation of biodiversity, including more than 100 million acres of reserved and roadless areas. The remaining 45 per cent of the forest is used for multiple uses and is often referred to as "working forests".[4] These lands are cared for by public and private interests that balance needs for income with objectives for wildlife, water quality, recreation and aesthetics. Many of the nation's family forestlands reside in this category.

[2] National Report on Sustainable Forests – 2010, USDA Forest Service

[3] Ince, Peter J., Global sustainable timber supply and demand: Sustainable development in the forest products industry, Chapter 2, Porto, Portugal : Universidade Fernando Pessoa, 2010, http://www.fpl.fs.fed.us/documnts/pdf2010/ fpl_2010_ince001.pdf

[4] Classification based upon FAO, FRA 2010 – Country Report, United States of America

Defining Forest Sustainability

Forest sustainability was first described in the book Sylvicultura oeconomica by German author Hans Carl von Carlowitz, published in 1713—and, while our understanding of what constitutes sustainability has evolved significantly in 300 years, it has long been a cornerstone of forest management. Von Carlowitz's work planted the seed for what we now know as sustainable development, defined in the landmark 1987 report of the World Commission on Environment and Development (the 'Brundtland Report') as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

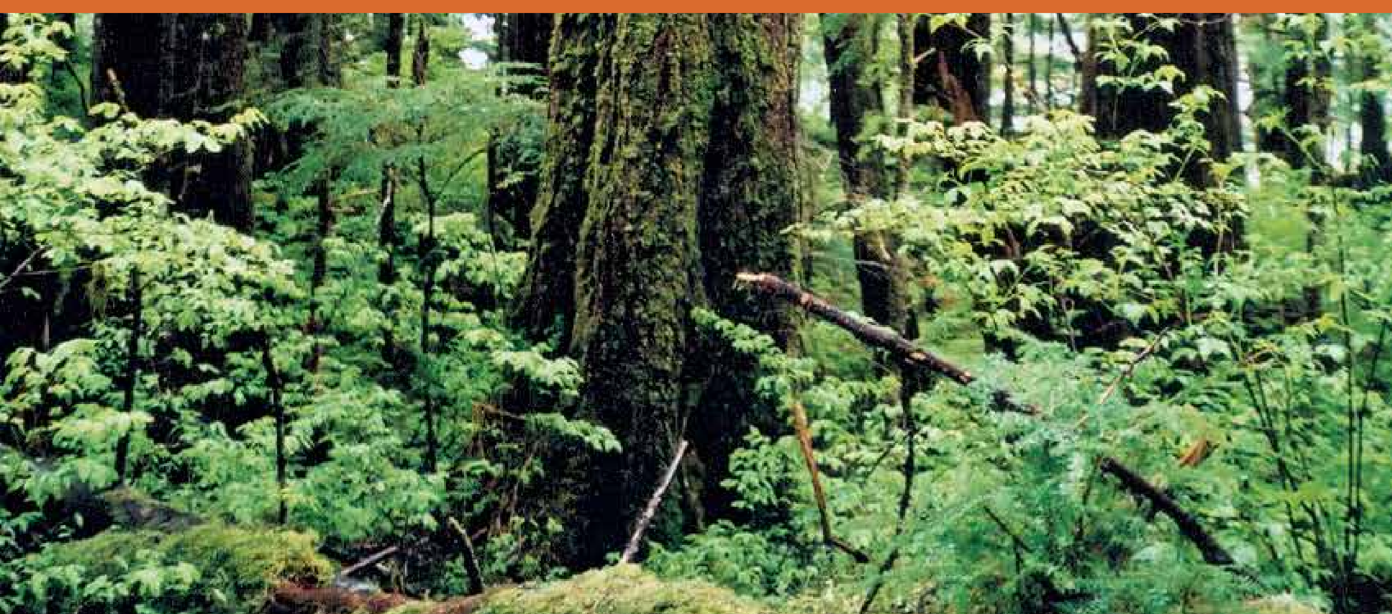
The United Nations Food and Agriculture Organization (UNFAO) defines sustainable forest management as "the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biological diversity, productivity, regeneration capacity, vitality and their potential to fulfill, now and in the future, relevant ecological economic and social functions, at local, national and global levels, and that does not cause damage on other ecosystems."

In the U.S. and Canada, forest sustainability is measured against criteria and indicators that represent the full range of forest values, including biodiversity, ecosystem condition and productivity, soil and water, global ecological cycles, economic and social benefits, and social responsibility. Sustainability criteria and indicators form the basis of individual country regulations as well as third-party sustainable forest certification programs

Managing Diverse Forests

Forest management is often described as a blending of art and science. Foresters must follow the laws, regulations and best practices of forestry and apply forest science and the results of ongoing research. Foresters must also nurture the art of recognizing the unique features of a specific forest and site and develop the management design that will meet diverse environmental, economic and social interests, including the needs and objectives of the owner. The blending of art and science that occurs in forest management is similar to what occurs in a building project. Like the multi-disciplinary team that designs and constructs buildings, sustainable forest management involves a team that includes foresters, engineers, biologists, hydrologists, surveyors and loggers that plan and care for the forest. In both cases, members of the team must address the technical requirements and obligations of their profession while taking into consideration the tastes and desires of the project partners and owners. In the case of forestry, this includes caring for the forest while meeting the needs of landowners, the environment and their community.

The use of responsible forest management in the United States has resulted in more than 75 consecutive years of net forest growth that exceeds annual forest removals. This track record of annually growing more wood than is harvested has continued despite increasing demands and growing populations. It is a testament to leadership in forestry practices and sustainability.



Growing New Forests

Today's forestry involves many different management tools and techniques. A common approach is the use of ecosystem-based management, which is an integrated, science-based approach to the management of natural resources. This approach aims to sustain the health, resilience and diversity of ecosystems while allowing for sustainable use of the goods and services they provide.

Through the use of diverse silviculture practices, foresters tend to the forest, ensuring regeneration, growth and forest health, and providing benefits that support a full range of forest values. For example, forest management practices are often selected to mimic natural disturbances and the cycles of nature that are associated with a specific region, forest type or species. Natural disturbances, including windstorms, hurricanes, ice storms, forest fires and insect or disease outbreaks, are a fact of life in the forest. To mimic these events, foresters may vary the size of the openings created by forest management, the intensity of management, the retention of wildlife reserve areas, and the frequency with which management occurs.

A silviculture system covers all management activities related to growing forests – from early planning through harvesting, replanting and tending the new forest. Forest managers consider a wide variety of factors when choosing a silviculture system, including tree species, their age, condition, soils, ecology, and considering other values such as wildlife habitat, water quality and scenery.

The diverse forests of the United States are managed with one or a blend of a few primary silviculture systems:

- The clearcut system removes most of the trees from an area, with patches of trees and buffers left to protect other values.
- The shelterwood system harvests trees in stages over a short period of time so the new forest grows under the shelter of the existing trees.
- The selection system removes timber as single trees or in small groups at relatively short intervals, repeated indefinitely. This is done carefully to protect the quality and value of the forest area.

Clearcutting is used when the young trees of a species need an abundance of sunlight to germinate and to compete successfully with grasses and other plants. It is usually used to grow tree species that historically found open sunlight by following large natural disturbances such as windstorms or wildfire. It provides the direct sunlight needed to effectively grow some native species, while helping to create a mix of forest ages across the landscape, including the young forests preferred by certain wildlife.

Conserving Forest Values

Biological diversity, or biodiversity, refers to the variety of species and ecosystems on earth and their ecological systems. An important indicator of forest sustainability, it enables organisms and ecosystems to respond to and adapt to environmental change. Conserving biodiversity is an essential part of forest sustainability and involves strategies at different scales. At the landscape level, networks of parks and protected areas conserve a range of biologically and ecologically diverse ecosystems. Tens of millions of acres of forests are protected within wilderness areas and parks and through regional and local programs. Forests are also protected by established conservation easements developed through the work of local land trusts.[5]

[5] Federal Sustainability Report 2010

Up until the early 20th century, settlers coming to the United States cleared an average of 2.1 acres of forest per person to survive and grow food.[6] The establishment of industrial agriculture and other changes in land use have mitigated the need for forest clearing since that time, and forest acreage in the United States has been stable for over a century. The U.S. reported an annual increase in forest area of 0.12 per cent in the 1990s and 0.05 per cent from 2000 to 2005.[7]

Outside of North America, however, the conversion of forestlands to non-forest uses continues at a significant rate, predominantly in developing tropical countries. Deforestation is the permanent conversion of forest land to non-forest uses, and globally it accounts for 17 per cent of the world's greenhouse gas emissions. More than two-thirds of global forest loss is still attributed to clearing for agriculture.

[6] American Forests: A History of Resiliency and Recovery by Douglas W. McCleary. 1997. Forest History Society, Issues Papers Series, Durham, NC 58 pp.

[7] The State of America's Forests, M. Alvarez, 2007, Society of American Foresters; State of the World's Forests Report, 2007

Third-party Forest Certification

While forestry is practiced in keeping with regulations and guidelines that consider environmental, economic and social values for that particular country, voluntary forest certification allows forest companies to demonstrate the effectiveness of their practices by having them independently assessed against sustainability standards.

Wood is the only building material that has third-party certification programs in place to demonstrate that products being sold have come from a sustainably managed resource. North America has more certified forests than any other jurisdiction.

As of August 2013, more than 500 million acres of forest in the U.S. and Canada were certified under one of the four internationally recognized programs used in North America: the Forest Stewardship Council (FSC), Sustainable Forestry Initiative (SFI), Canadian Standards Association's Sustainable Forest Management Standards (CSA), and American Tree Farm System (ATFS). This represents more than half of the world's certified forests.

According to the National Association of State Foresters, "credible forest certification programs include the following fundamental elements: independent governance, multi-stakeholder standard, independent certification, complaints/appeals process, open participation and transparency. [...] While in different manners, the ATFS, FSC, and SFI systems include the fundamental elements of credibility and make positive contributions to forest sustainability."[8] Similarly, the World Business Council on Sustainable Development released a statement supporting an inclusive approach that recognizes these programs as well as CSA (and others).

The FSC, SFI, CSA and ATFS programs all depend on third-party audits where independent auditors measure the planning, procedures, systems and performance of on-the-ground forest operations against the predetermined standard. The audits, performed by experienced, independent foresters, biologists, socio-economists or other professionals, are conducted by certification bodies accredited to award certificates under each of the programs. A certificate is issued if a forest operation is found to be in conformance with the specified forest certification standard.[9]

[8] Forest Certification as it Contributes to Sustainable Forestry, National Association of State Foresters, 2013, NASF- 2013-2, www.stateforesters.org

[9] http://www.naturallywood.com/sites/default/files/Third-Party-Certification.pdf; http://www.sfiprogram.org/sfistandard/american-tree-farm-system/

PEFC
PEFC/01-4-16

FSC
www.fsc.org
The mark of responsible forestry
FSC® F000205

SUSTAINABLE FORESTRY INITIATIVE
SFI-01569

CERTIFIED TREE FARM
AMERICAN TREE FARM SYSTEM
WOOD WATER RECREATION WILDLIFE

photographer: Candace Kenyon

Sources:

FAO. 2010. Country Report: United States. http://www.fao.org/forestry/fra/fra2010/en/

Society of American Foresters. 2007. The State of America's Forests. http://www.safnet.org/publications/americanforests/StateOfAmericasForests.pdf

Future of America's Forests and Rangelands – Forest Service 2010 Resources Planning Act Assessment. USDA – Forest Service. Gen. Tech. Rep. WO-87. August 2012. Available online at: http://www.treesearch.fs.fed.us/pubs/41976/ To download the pdf: http://www.fs.fed.us/research/publications/gtr/gtr_wo87.pdf

WoodWorks. 2011. Sustainable Forestry in North America: A Primer for Design and Building Professionals.

reTHINK WOOD®

Green buildings

- Mitigate climate change
- Use less energy and water
- User fewer materials
- Reduce waste
- Are healthy for people and the planet

Building Green with Wood

MODULE 11

Green Building Tools

Finding the Right Tools

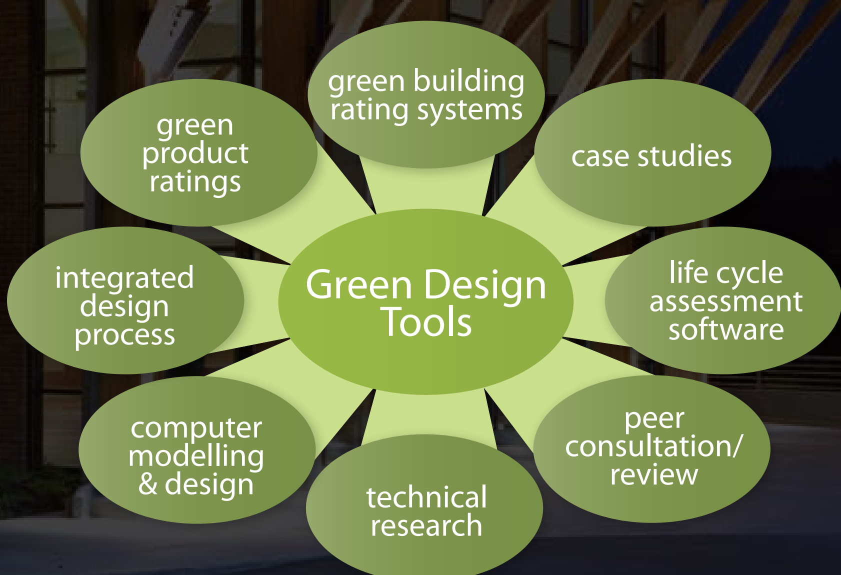
While the increased interest in sustainable building design has encouraged research into building products and performance, it continues to be a challenge to measure the overall impact of buildings on the environment over the course of their service lives – and advice is often contradictory.

Product directories, rating systems and other tools are available to support design and construction decisions. However, these must be evaluated carefully to ensure they meet the specific needs of each application, and to identify any limitations. For example, some green building rating systems may be too narrowly focused, ignoring the importance of far-reaching strategic decisions, while rewarding less important ones disproportionately.

Green building tools include:

- product labelling by third-party certifiers such as independent forest certification programs
- rating systems that evaluate products/designs such as LEED (Leadership in Energy and Environmental Design), Green Globes and the National Association of Home Builders (NAHB) National Green Building Standard
- practice guidelines such as green home building guidelines
- software such as the ATHENA Institute's EcoCalculator
- procurement policies such as the U.S. Environmental Protection Agency's environmentally preferable purchasing.

Green design requires smart tools to decipher all the conflicting information, lack of clarity on definitions, and a constantly changing landscape as the field evolves and expands.



Product Labelling and Certification

As demand grows for products and designs that represent a sound environment choice, more companies are labeling their products as "green."

TerraChoice Environmental Marketing (UL Environment) has produced a report called the Seven Sins of Greenwashing (www.sinsofgreenwashing.org) that offers criteria to help consumers judge whether a product or program is environmentally beneficial. It includes a list of some of North America's most credible eco-labels – including third-party forest certification labels, cleaning products and organic certification.

TerraChoice President and CEO Scott McDougall says a 2009 survey of 2,219 consumer products showed that 98 per cent of companies committed at least one Sin of Greenwashing, and some marketers are creating fake labels or false suggestions of third-party endorsement. "Despite the number of legitimate eco-labels out there, consumers will still have to remain vigilant in their green purchasing decisions," he says.

Wood is one of the few building products backed by well-established third-party certification programs, and North America has more certified lands than any other region of the world.

Green Building Rating and Assessment

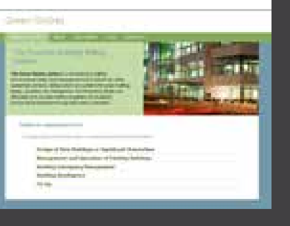
Environmental rating systems can help building industry professionals evaluate and differentiate their product or design. The standards set by rating systems generally exceed those required by building codes.

The best systems measure performance rather than prescribe solutions, and are based on life cycle assessment. They offer a credible, consistent basis for comparison, evaluate relevant technical aspects of sustainable design, and should not be too complex or expensive to implement or confusing to communicate.

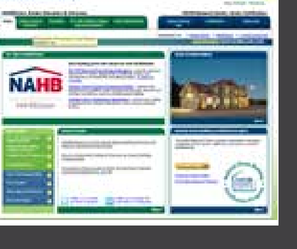
Most developed countries have adopted one or more green building rating systems, beginning with the United Kingdom, which introduced the BREEAM (Building Research Establishment Environmental Assessment Method) in 1990. In North America, green rating systems include LEED, Green Globes and the NAHB National Green Building Standard. A choice in rating systems helps to strengthen green design, with processes to meet the diversity of building needs, sizes and budgets. It also encourages market competition, ensuring continuous improvement.

The LEED green building rating system, developed by the U.S. Green Building Council, addresses specific building-related environmental impacts using a whole building environmental performance approach. In addition to LEED-NC (for new construction and major renovations), there are versions for existing buildings, commercial interiors, core and shell, homes, and neighbourhood development. In 2013, the US Green Building Council (USGBC) released the latest version of the LEED green building rating system (LEED v4). (For information in the United States: www.usgbc.org/LEED/. For information in Canada: www.cagbc.org)

Green Globes, is a web-based environmental assessment and certification system that bills itself as offering an effective, practical and affordable way to assess and improve the sustainability of new and existing buildings. In the U.S., it is offered exclusively by the Green Building Initiative (GBI) who initiated the first ANSI standard for commercial green building. In Canada, the federal government uses the Green Globes suite of tools and it is the basis for the Building Owners and Managers Association of Canada's (BOMA) "Go Green Plus" program. (For information in the United States: www.thegbi.org. For information in Canada: www.greenglobes.com)



The NAHB National Green Building Standard is the first green building rating system to be approved by the ANSI. Building on the Model Green Home Building Guidelines developed by the NAHB Research Centre, it provides a common benchmark for recognizing and rewarding green residential design, development, and construction practices in the United States. Known as ANSI/ICC 700-2008, the National Green Building Standard is a joint effort between the International Code Council and NAHB. (More information is available at www.nahbgreen.org)



Environmental Data Sources: Life Cycle Assessment

Software

Life cycle assessment software allows a designer to capture and account for the breadth of environmental and economic considerations in one application.

The **Building for Environmental and Economic Sustainability** (BEES) software program was created by the U.S. National Institute of Standards and Technology. BEES has 10 impact categories: acid rain, ecological toxicity, eutrophication, global warming, human toxicity, indoor air quality, ozone depletion, resource depletion, smog and solid waste. (For more information: www.wbdg.org/tools/bees.php)

The **ATHENA Institute** is a non-profit organization that provides life cycle assessment services and tools to support green building. Its Impact Estimator for Buildings is a full-capability tool that allows designers to evaluate the environmental impact of each decision as they go through the process of putting a building together conceptually. Its EcoCalculator is a simplified tool, where hundreds of common building assemblies have been pre-calculated, requiring minimal input from the designer. (For more information: http://www.athenasmi.org/tools/impactEstimator/)

Environmental Product Declarations

An **Environmental Product Declaration**, or EPD, is a standardized report of environmental impacts linked to a product or service. An EPD is based on life cycle assessment, which provides a basis for comparing environmental performance and substantiating marketing claims. Until recently, EPD development was limited to organizations associated with the ISO 14000 series of standards within the International Organization for Standardization (ISO) and the government agencies of several European countries. Now, the EPD concept is moving rapidly into the mainstream. The American Wood Council (AWC) and Canadian Wood Council (CWC) have released EPDs for North American wood products, including softwood lumber, plywood, oriented strand board, and glue-laminated lumber.

Procurement Policies

Globally, governments are introducing policies to increase the use of wood in an attempt to reduce greenhouse gas emissions and support their sustainability programs. Examples include:

- Changes in national building regulations in many European countries to encourage multi-storey wood buildings – in the United Kingdom, a nine-storey apartment building that includes eight stories of wood over one storey of concrete is considered the first modern tall timber residential building. The world's tallest wood building is currently the 10-story Forte Building completed in 2012 in Melbourne, Australia. Additional projects have been proposed, including a potential 34-storey building in Stockholm, Sweden and a 20-storey tower in Vancouver, Canada. A 30-storey wood building has been approved for construction in Sweden.
- In Canada, the governments of British Columbia and Quebec have policies that encourage the use of wood in public buildings.

A mixed-use project, Avalon Anaheim Stadium includes 251 luxury apartment units and 13,000 square feet of retail and restaurant space over a 210,000-square-foot podium deck with two levels of subterranean parking. It is located in the heart of Anaheim's Platinum Triangle district. "Podium" buildings, which include multiple stories of wood over an elevated concrete "podium deck," have become especially prevalent. With ever increasing land costs and the rising cost of steel and concrete, developers are turning to wood designs that offer greater density and a higher percentage of rentable square footage than traditional garden-style apartments while also being cost effective—both in terms of material and labor. Wood's other benefits, such as speed of construction, design flexibility, and reduced environmental impact, add to the value proposition.

Avalon Anaheim Stadium Apartments, Anaheim CA
Architect: Withee Malcolm Architects
Photos by Michael Arden - Arden Photography

Organizations and Networks

The **U.S. Green Building Council** (USGBC) and the **Canadian Green Building Council** are non-profit organizations that aim to transform the way buildings and communities are designed, built and operated, enabling an environmentally and socially responsible, healthy, and prosperous environment that improves the quality of life. USGBC has developed the LEED rating system. For more information:
www.usgbc.org (United States)
www.cagbc.org (Canada)
www.worldgbc.org (international)

The **National Association of Home Builders** (NAHB) is a trade association for the housing and building industry in the United States. NAHB is a federation of more than 800 state and local associations. Its affiliates include the NAHB Research Centre. For more information: www.nahb.org

The **Green Building Initiative** is a not-for-profit education and marketing initiative dedicated to accelerating the adoption of building practices that result in energy-efficient, healthier and environmentally sustainable buildings by promoting credible and practical green building approaches for residential and commercial construction. For more information: www.thegbi.org

The **American Institute of Architects** (AIA) serves as the voice of the architecture profession and the resource for their members in service to society. They carry out advocacy, information, and community outreach. Each year the AIA sponsors hundreds of continuing education experiences to help architects maintain their licensure, provides web-based resources, conducts market research and provides analysis of the economic factors that affect the business of architecture. For more information: www.aia.org

James and Anne Robinson Nature Center, Columbia, MD
Architect: GWWO, Inc / Architects
Photo: Robert Creamer Photography

The 23,000-square-foot James and Anne Robinson Nature Center reflects years of creative and innovative efforts of educators, community leaders, designers, wildlife experts, historians, and resource conservationists. Designed by GWWO Architects, the building demonstrates the latest in sustainable design ideas, craftsmanship, and materials, including geothermal heating, green roofing, and even recycled wood from the Robinsons' own barn. The Center has been recognized by Associated General Contractors as the "Best Sustainability Project of the Year in New Construction" and was recently awarded Platinum LEED (Leadership in Energy Design) Certification, the highest rating from the U.S. Green Building Council.

Other Resources

Energy Star

(www.energystar.gov) is an international standard for energy-efficient consumer products. First created as a U.S. government program in 1992, it operates in Canada, Europe, Japan and Australia. Energy Star rates energy-related value for products in more than 35 categories, including HVAC systems, lighting fixtures, office equipment, roofing products, windows, doors and skylights.

The U.S. Environmental Protection Agency's Environmentally Preferable Purchasing

(www.epa.gov/opptintr/epp) rates building materials and products based on pollution prevention, life cycle analysis, comparison of environmental impacts, environmental performance, and environment/price performance ratio. Product categories include: paints, plumbing, HVAC, lighting, gypsum board, carpets, concrete, coatings, sealants, flooring, doors, and windows.

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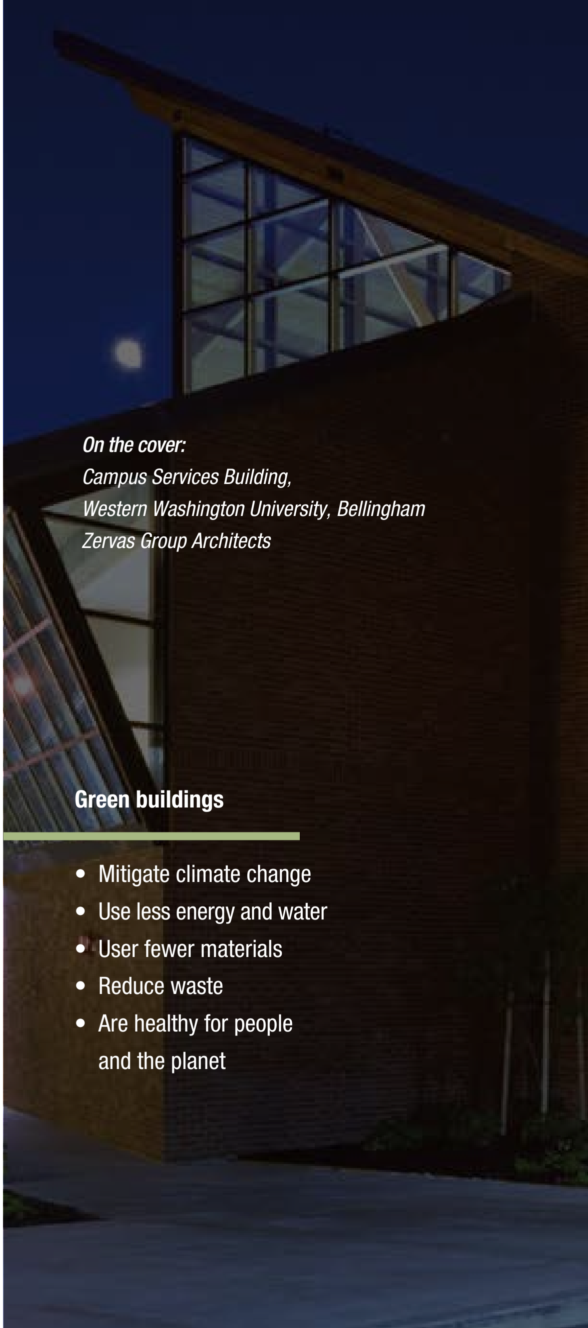

On the cover:
Campus Services Building,
Western Washington University, Bellingham
Zervas Group Architects

Green buildings

- Mitigate climate change
- Use less energy and water
- User fewer materials
- Reduce waste
- Are healthy for people and the planet

Links to Information Sources

Building Green with Wood

MODULE 12

Key Websites

American Forest Foundation www.forestfoundation.org	AFF works nationwide and in partnership with local, state and national groups to address ecological and economic challenges that require the engagement of family forest owners.
American Forest & Paper Association www.afandpa.org	The American Forest & Paper Association (AF&PA) serves to advance a sustainable U.S. pulp, paper, packaging, and wood products manufacturing industry through fact-based public policy and marketplace advocacy. AF&PA member companies make products essential for everyday life from renewable and recyclable resources and are committed to continuous improvement through the industry's sustainability initiative - Better Practices, Better Planet 2020.
American Wood Council www.awc.org	The American Wood Council (AWC) is the voice of North American traditional and engineered wood products, representing over 75 per cent of the industry. AWC's engineers, technologists, scientists, and building code experts develop state-of-the-art engineering data, technology, and standards on structural wood products for use by design professionals, building officials, and wood products manufacturers to assure the safe and efficient design and use of wood structural components. AWC also provides technical, legal, and economic information on wood design, green building, and manufacturing environmental regulations advocating for balanced government policies that sustain the wood products industry.
National Alliance of Forest Owners www.nafoalliance.org	NAFO is an organization of private forest owners committed to advancing national policies that promote the economic and environmental benefits of privately-owned forests. NAFO membership encompasses more than 80 million acres of private forestland in 47 states. Working forests in the U.S. support 2.4 million jobs.
USDA Forest Service – Research and Development http://www.fs.fed.us/research/	The research and development (R&D) arm of the Forest Service, a component of the U.S. Department of Agriculture, works at the forefront of science to improve the health and use of our Nation's forests and grasslands. Research has been part of the Forest Service mission since the agency's inception in 1905.

Key Websites

U.S. Global Change Research Program http://www.globalchange.gov	The U.S. Global Change Research Program (USGCRP) is a Federal program that coordinates and integrates global change research across 13 government agencies to ensure that it most effectively and efficiently serves the Nation and the world. USGCRP was mandated by Congress in the Global Change Research Act of 1990, and has since made the world's largest scientific investment in the areas of climate science and global change research.
U.S. WoodWorks www.woodworks.org	WoodWorks is an initiative of the Wood Products Council, which is a cooperative venture of major North American wood associations, research organizations and government agencies. Established to provide architectural and engineering support related to nonresidential and multi-family wood buildings in the U.S., WoodWorks offers a wide range of free resources—including one-on-one project support, online training, web-based tools (e.g., cost and other calculators, CAD/REVIT details, span tables), and educational events such as Wood Solutions Fairs and technical workshops.
reThink Wood www.rethinkwood.com	Formed in 2011, the reThink Wood initiative aims to project a unified front and present a common message as it relates to wood performance, cost and sustainability, making it easier for the industry to speak with a cohesive voice and educate about the advantages of using wood in building. reThink Wood is not an organization; it has no staff. Representatives from funders and partner associations such as the Binational Softwood Lumber Council, Forestry Innovation Investment and the Softwood Lumber Board work with key delivery agents such as WoodWorks, American Wood Council and the Canadian Wood Council.

Green Building Rating Systems

BREEAM (United Kingdom)	www.breeam.org
Green Globes United States (Green Building Initiative)	www.thegbi.org
LEED (Leadership in Energy and Environmental Design) U.S. Green Building Council	www.usgbc.org/LEED
National Association of Home Builders NAHB National Green Building Program	www.nahbgreen.org
ANSI ICC 700-2008 National Green Building Standard™	www.nahbgreen.org/Certification/ngbs.aspx/

Third-party Forest Certification Programs Used in the United States

American Tree Farm System www.treefarmsystem.org	Programme for the Endorsement of Forest Certification schemes www.pefc.org
Forest Stewardship Council www.us.fsc.org www.ic.fsc.org	Sustainable Forestry Initiative www.sfiprogram.org

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On the cover:
YMCA Camp Thunderbird
Duke Energy Pavilion
Lake Wylie, SC
Bulla Smith Design
Engineering, PA

Green buildings

- Mitigate climate change
- Use less energy and water
- User fewer materials
- Reduce waste
- Are healthy for people and the planet