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# Science Supporting the Economic and Environmental Benefits of Using Wood and Wood Products in Green Building Construction

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## Abstract

The objective of this report is to summarize the scientific findings that support the environmental and economic benefits of using wood and wood products in green building construction. Despite documented advantages in many peer-reviewed scientific articles, most building professionals and members of the public do not recognize wood as a renewable resource or the role that efficient wood utilization plays in mitigating climate change and promoting healthy forests. Research and development of wood products and building systems also are lagging behind that of other materials. Both scientific advancement in the areas of life cycle analysis and development of new technologies for improved and extended wood utilization are needed to continue to advance wood as a green construction material. We provide three research and technology transfer recommendations that will allow USDA to help to achieve its climate change objectives while creating jobs, bolstering the competitive position and long-term economic stability of the industry, and reducing U.S. dependence on foreign oil.

Keywords: wood, green building, sustainability, environment, life cycle assessment

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## Executive Summary

The objective of this report is to summarize the scientific findings that support the environmental and economic benefits of using wood and wood products in green building construction. Wood has been used as a structural material in North America for hundreds of years, primarily for single- and multiple-family housing, commercial buildings, and transportation structures such as bridges. The market share for wood in commercial buildings, such as schools and strip malls, has been small compared with that for other materials. Today, a growing awareness of environmental sustainability and a desire on the part of consumers for quality building materials at competitive prices could boost markets for wood products.

Use of forest products in the United States now supports more than 1 million direct jobs and contributes more than \$100 billion to the U.S. Gross Domestic Product. Forest management and sustainable forestry practices have evolved and expanded to include the manufacture of wood products from small-diameter trees, dead trees, or brush. This returns to land managers much-needed revenue to treat ecosystems devastated by fire, pathogens, or invasive species. Using wood obtained through sustainable forestry practices in green building applications promotes a healthy environment and a strong economy. Sustainability of forest products can be verified using any credible third-party rating system, such as Sustainable Forestry Initiative, Forest Stewardship Council, or American Tree Farm System certification.

To take advantage of this win-win opportunity, the U.S. Department of Agriculture (USDA) and other stakeholders must overcome existing misconceptions about wood as a green building material and help lead the research and development efforts on green building materials. Despite documented advantages in many peer-reviewed scientific articles, most building professionals and members of the public do not recognize wood as a renewable resource or the role that efficient wood utilization plays in mitigating climate change and promoting healthy forests. Sustainable forest management can produce stronger, healthier forests that serve as a “carbon sink” to clean air of greenhouse gases (GHGs) and purify drinking water for wildlife and U.S. municipal water systems. Harvested trees can find economic and societal value in the life cycle of wood products and systems for green building construction that further optimize benefits to the environment.

A recent life cycle analysis found that harvesting, transporting, manufacturing, and using wood in lumber and panel products in building yields fewer air emissions—including greenhouse gases—than the resource extraction, manufacture, and use of other common building materials. In fact, wood-based wall systems can require significantly less total energy for manufacturing than thermally comparable wall systems using other materials. Currently, some

building codes and standards related to green building do not consider a life cycle environmental analysis that will reveal the environmental advantages of using wood. Greater use of life cycle analysis in building codes and standards would improve the scientific underpinning of building codes and standards and thereby benefit the environment.

Research and development of wood products and building systems also are lagging behind that of other materials. Both scientific advancement in the areas of life cycle analysis and development of new technologies for improved and extended wood utilization are needed to continue to advance wood as a green construction material.

USDA will take a lead role in advancing wood as a green building material through the development and implementation of programs that are publicly relevant and appropriate for government. Policy makers, the forest products industry, and resource management organizations support a science-based approach to outlining the benefits of using wood and wood-based products in green building in the United States. The inherent benefits of using wood go beyond economic gains. Robust markets for green building materials can enhance the economic incentives for maintaining privately owned forests in forest use—an important consideration given continuing concerns regarding loss of forestland to development and fragmentation. An “all hands” approach by policy makers, government agencies, industry, academia, and private landowners will be needed to advance scientific knowledge, to bolster development and dissemination of new technologies, and to raise awareness and use of wood in green buildings.

In proclaiming 2011 as the International Year of the Forest, USDA Secretary Tom Vilsack directed the Forest Service to favor wood in new building construction; maintain commitment to certified green building standards; examine ways to enhance research and development projects using green building materials; and actively work to identify innovative nonresidential construction projects that use wood as a green building material. This USDA policy is consistent with President Obama’s executive order on Federal Leadership in Environmental, Energy, and Economic Performance.

“Our country has the resources, the work force, and the innovative spirit to reintroduce wood products into all aspects of the next generation of buildings,” said Forest Service Chief Tom Tidwell. “As we move forward with restoring America’s forests, we are getting smarter and more efficient in how we use wood products as both an energy and green building source. Our progress in this area will also help maintain rural jobs.”

Three inter-related wood industry initiatives will help further USDA’s climate change mitigation and job creation objectives. This latter objective is particularly noteworthy

given the fact that the sector has lost more than one-fourth of its work force over the past five years.

Although most people are aware that North American forests help to address climate change by absorbing carbon dioxide from the atmosphere, the fact that wood products continue to store carbon, thus keeping it out of the atmosphere indefinitely, is less well known. Substituting wood products for fossil-fuel-intensive alternatives also results in significant amounts of “avoided” GHG emissions. To capitalize on wood’s carbon benefits, we recommend that USDA provide information on the following projects:

1. *Research and development—life cycle assessment:* A partnership of government, universities, and industry is proposed to undertake research needed to support widespread recognition of wood’s carbon benefits under emerging green building codes, standards, and rating schemes. Led by the Green Building Strategy Group, a newly established organization composed of industry and non-government organizations (NGOs) to advance green building, this project includes expanding the library of transparent information available to the industry and public, filling critical gaps for wood products in the U.S. Life Cycle Inventory Database, increasing acceptance and specification of wood as a green building material through the application of complete and current life cycle assessment (LCA) data and tools, and increasing technical knowledge of and preference for wood products among building science and design/engineering professionals.
2. *Technology transfer—wood use in nonresidential buildings:* The WoodWorks program is a North American program funded by U.S. and Canadian companies, the Forest Service, and some other groups to raise awareness among engineers and architects of the environmental and economic benefits of wood as a green building material. The WoodWorks program is nearing the end of its three-year pilot phase and has demonstrated that education and technology transfer activities aimed at design and building professionals, including information on wood’s carbon benefits, can increase the amount of wood used in nonresidential structures. The program is already supporting more than 450 building conversions, which represent an additional 400 million board feet of lumber and 100 million square feet of panels (3/8-in. basis). Between the carbon stored in the wood products and avoided GHGs, these projects represent a carbon savings of 2.2 million metric tons of CO<sub>2</sub> (equivalent). Supporting WoodWorks as a national initiative over the next five years is expected to increase these wood volumes to a total of 5.5 billion board feet and 3 billion square feet, respectively, which represents a carbon savings of over 30 million metric tons of CO<sub>2</sub> (or about 6 million cars off the road for a year). Further,

it is expected to significantly contribute to USDA’s job creation objectives.

3. *Technology transfer—carbon and green building benefits of typical wood structures:* Working under an established Memorandum of Understanding with the USDA Forest Service Forest Products Laboratory (FPL), APA—The Engineered Wood Association will partner with government and forest research organizations to show how carbon-storing wood products can be used in typical residential and nonresidential construction. The partnership will pursue research and technology transfer activities that demonstrate the advantages of wood over other building materials in green building. This includes activities that build on the success of APA’s Florida Carbon Challenge, a program created to educate design and building professionals about the relationships between climate, carbon, and everyday building. Design competitions, educational seminars, and the construction of three or four demonstration houses are proposed. This activity will also further the development and use of new or improved wood composites (such as cross-laminated timber) to improve the environmental importance of buildings as measured by LCA tools.

By supporting these recommendations, USDA can help to achieve its climate change objectives while creating jobs, bolstering the competitive position and long-term economic stability of the industry, and reducing U.S. dependence on foreign oil.

# Science Supporting the Economic and Environmental Benefits of Using Wood and Wood Products in Green Building Construction

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## Introduction

The U.S. Department of Agriculture (USDA) is a strong supporter of sustainable forest management on federal, state, and private lands and manages approximately 20% of U.S. forest land. A key to maintaining healthy forests is to keep management costs reasonable by developing a market for sustainably harvested green products that advance green building. The use of forest products in the United States supports more than a million direct jobs and contributes more than \$100 billion to the U.S. Gross Domestic Product. The sustainable use of wood products supports forests, jobs, national income, and a healthy environment. It also contributes to green building by reducing environmental burdens associated with constructing, operating, and decommissioning many other types of buildings.

## Benefits of Wood as a Green Building Material

The use of wood as a building material can provide substantial economic and environmental benefits. Economic benefits from producing solid wood products included more than 350,000 direct jobs and \$12.0 billion in payroll in 2009, down significantly from 460,000 jobs and \$15.6 billion in payroll for 2008. Many of these jobs and associated payroll are especially important in the economic development of rural forested areas. In addition to economic benefits, the development of construction applications for wood from small-diameter and insect- or disease-killed trees can support forest conservation management by providing revenue to offset treatment costs on forest land needing ecological restoration. Increased use of wood for construction also provides revenue to forest land owners and incentive for them to keep lands forested, thereby conserving forest ecosystems and a wide range of forest ecosystem services, including water purification, water flow regulation, erosion control, stream bank stabilization, carbon sequestration, biodiversity, recreation, and cultural heritage values.

The environmental benefits of using wood over other common construction materials are documented in numerous peer reviewed papers:

- Twenty-two peer-reviewed articles in *Wood and Fiber Science* report the lower environmental emissions associated with U.S. production of 17 wood products used for building construction (Bergman and Bowe 2008, 2010; Hubbard and Bowe 2010; Johnson and others 2005; Lippke and others 2010; Kline 2005; Milota and others 2005; Oneil and others 2010; Oneil and Lippke 2010; Perez-Garcia and others 2005a, b; Puettmann and Wilson 2005a, b; Puettmann and others 2010a, b; Wilson and Sakimoto 2005; Wilson and Dancer 2005a, b, Wilson 2010a, b, c; Winistorfer and others 2005).
- Two peer-reviewed articles in *Energy and Buildings* report less environmental emissions to construct residential and commercial buildings with wood than with steel and concrete (Gustavsson and Joelsson 2010; Dodoo and others 2011).
- A paper in *Environmental Science and Technology* reviewed 21 international studies and found that, on average, each ton of carbon in wood products that is used in place of non-wood products reduces greenhouse gas (GHG) emissions by 2.1 tons of carbon (Sathre and O'Connor 2010).
- A paper in the *Forest Products Journal* (FPJ) indicates how use of wood for all components in a residential wall system—replacing non-wood products—can reduce GHG emissions for product production by as much as two-thirds compared with a conventional wood wall (Lippke and others 2004). Another peer-reviewed FPJ article shows significant energy reduction and higher material efficiencies over a 30-year time-period for the forest products industry (Meil and others 2007).

Examples of specific research findings include the following:

- Fossil fuel consumption, contributions to GHG emissions, and quantities of solid waste tend to be less for manufacturing and use of wood products than for competing products (Werner and Richter 2007).
- Wood products that are installed and used appropriately tend to have lower environmental burdens than functionally equivalent products of other materials (Lippke and others 2004).
- The analysis of example homes in Minneapolis and Atlanta indicate lower environmental emissions over the life of building materials for homes built with wood than those with steel framing or concrete (Lippke and others 2004).
- Houses with wood-based wall systems require 15% less total energy for manufacturing than thermally comparable houses using steel- or concrete-based building systems. Over 100 years, net GHG emissions associated with wood-based houses are 20% to 50% lower than emissions associated with thermally comparable houses using steel- or concrete-based building systems (Upton and others 2008).
- Replacing all non-wood building products in a house with wood alternatives (such as cedar siding, wood windows, and cellulose insulation) could result in a net reduction of atmospheric carbon (Salazar and Meil 2009).
- Information on the life cycle environmental impacts of wood and alternative construction materials is incomplete. Improved life cycle information and simple comparison methods for different materials and building systems are needed to aid building professionals and consumers in the selection of wood as an environmentally preferable construction material.
- Research and development of wood products and building systems is significantly lagging behind that of other materials. Despite large public sector financing of new technology and product development for other materials, comparative expenditures for wood have been small.
- Most codes and standards related to green building do not include adequate provisions to recognize the benefit of a life cycle environmental analysis to guide selection of building materials. Comparing the true environmental benefits and costs of wood use relative to other materials in green building without life cycle analyses (LCAs) is impossible.
- Insufficient education, technology transfer, and demonstration projects are hindering the acceptance of wood as a green building material. Despite documented advantages, most building professionals and the public in general do not recognize the sustainability of wood and the role that efficient wood utilization plays in mitigating climate change and contributing to maintaining the health and vitality of our forests.

## Barriers to Increasing Wood Use as a Green Building Material

Wood has been used as a structural material in North America for hundreds of years. Historically, the primary markets for structural wood applications have involved single- and multiple-family housing, commercial buildings, and transportation structures such as bridges. Although wood has been used with a good performance record in nonresidential building applications such as schools, hotels, strip malls, and offices, the relative market share for wood has been small compared with that of other construction materials. However, a growing emphasis on sustainability and environmental awareness is providing an opportunity for wood to demonstrate attributes that clearly make it a preferred green building material and thus advance the potential to significantly increase the market share for wood products and enhance the vitality of our forests.

Despite clear sustainability advantages, wood is often not considered to be a “green” building material by design professionals and the general public; further, there is confusion about the benefits of renewable (wood) versus recyclable (steel) materials and the true environmental impacts associated with each. Barriers to the full recognition of wood as a green building material include the following:

## Research and Development Can Advance the Use of Wood in Green Buildings

Despite the barriers to increasing wood use as a green building material, the challenges are not overwhelming and positive results can be achieved in a reasonable time period. In response to this opportunity, research and development can play a lead role through a combination of scientific advancement in the areas of LCA and the development of new technologies for improved and extended wood utilization. Significant contributions can also be made in the areas of codes and standards, education and technology transfer, and the development of demonstration projects.

### Life Cycle Assessment

Life cycle assessment is a well-established set of methods for measuring the environmental impacts of a product or service across its entire life cycle (ISO 2006a, b). LCA methods are standardized, transparent, credible, and internationally recognized. LCA identifies the flow of materials and energy through various stages, from the point of extracting raw materials from the environment, through manufacture, construction, use, and final disposal. Inputs (material and energy) and outputs (emissions) are found for each stage (Fig. 1). Using estimates of inputs and outputs, the LCA

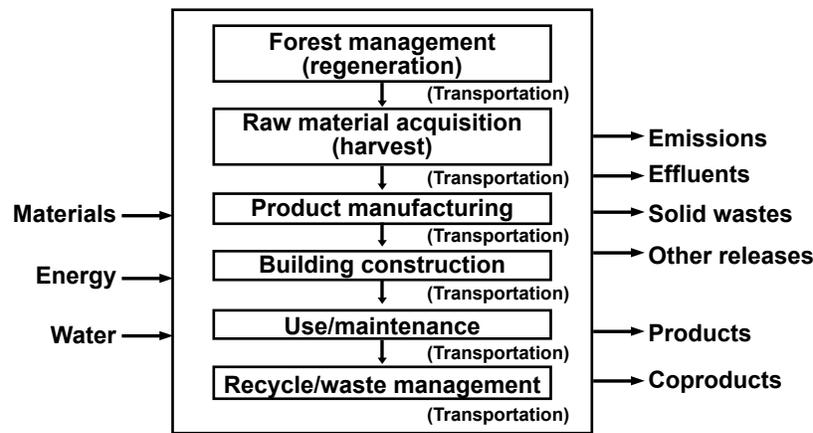


Figure 1. Cradle-to-grave life cycle assessment for wood building products.

indicates the burdens the product or service places on the environment over its life cycle.

Specifically, LCAs can identify emissions to air, water, and land associated with building products and product applications (such as construction). For example, an LCA would estimate the GHG emissions per cubic foot of product produced, or for construction of a 2,000-ft<sup>2</sup> house.

LCAs can also be used to improve products or applications by identifying “hot spots” of environmental impacts within a product life cycle. As a result, LCA is increasingly used by businesses to help them identify hot spots and make changes to reach environmental performance goals for products they produce.

Obtaining and organizing life cycle information to allow LCA practitioners to develop LCAs is an ongoing and research-intensive task. Life cycle information is publicly available through the U.S. Life Cycle Inventory (LCI) Database maintained by the U.S. Department of Energy’s National Renewable Energy Laboratory.

LCA information is needed to prepare environmental product declarations (EPDs) for individual products (ISO 2006c, 2007). An EPD is a summary of the environmental impacts associated with producing and using a product or service (Table 1). The life cycle information in EPDs can be used to compare the environmental burdens of alternative products. EPDs are meant to communicate standardized LCA information in a way that is meaningful to people who may not be familiar with LCA.

Building architects and engineers can make choices about environmentally preferable materials only if complete life cycle information is readily available for wood and non-wood products and for alternative designs of building components (such as walls, floors, roofs).

Research is needed in two broad areas to make life cycle information available:

1. To aid in improving the environmental performance of wood products in buildings, there is a need to identify

new wood products and building assemblies that have lower life cycle emissions by conducting LCAs for such products and assemblies. In the building industry, individual wood components make up building assemblies, and whole buildings are composed of building assemblies. Each of these—product, assembly, and whole building—requires LCAs to determine its environmental performance.

There is a need to provide software tools for building professionals to evaluate the LCA for a wide range of products and building assemblies for residential and commercial buildings. Developing LCA-based tools for building assemblies and whole buildings is a complex endeavor. LCA-based tools require detailed regional life cycle information on wood and non-wood products. Providing software tools for building professionals not familiar with LCA will allow the design of new buildings and redesign of older buildings with less environmental impacts. The ATHENA EcoCalculator for Assemblies is one tool that can analyze a limited number of building assemblies. The ATHENA Impact Estimator for Buildings analyzes a larger set of possible materials and assemblies in a whole-building context; however, there is a need to further develop these and other tools and make them widely available so more assemblies and whole-building designs can be assessed on a regional geographic basis that takes into account such factors as hot, humid weather, earthquakes, and flooding.

2. To make life cycle information available to consumers and the general public as well as architects and builders, there is a need to develop additional product LCAs specifically to prepare EPDs for all wood construction materials. EPD information can be condensed into a table similar to nutritional labels on food products (Table 1). The United States trails Europe and parts of Asia in instituting requirements for EPDs. France, Japan, and Korea are all in the process of implementing

**Table 1—Life cycle information provided by EPD for western redcedar siding**

Impact category	Unit	Per 1 m <sup>2</sup> of siding	Per 100 ft <sup>2</sup> of siding
Total primary energy	MJ	280.08	2601.96
Non-renewable, fossil	MJ	138.84	1289.80
Non-renewable, nuclear	MJ	8.28	76.89
Renewable, SWHG <sup>a</sup>	MJ	17.00	157.97
Renewable, biomass	MJ	4.50	41.81
Feedstock, non-renewable fossil	MJ	6.46	60.00
Feedstock, renewable biomass	MJ	105.00	975.49
Renewable material consumption (wood)	kg	4.65	43.24
Non-renewable material consumption (nails, paint)	kg	0.37	3.42
Fresh water use	L	1.01	9.40
Total waste	kg	5.02	46.66
Hazardous	kg	0	0
Non-hazardous	kg	5.02	46.66
Global warming potential (GWP) <sup>b</sup>	kg CO <sub>2</sub> eq	4.64	43.11
Acidification potential	H <sup>+</sup> mol eq	4.15	38.59
Eutrophication potential	kg N eq	$6.71 \times 10^{-3}$	$6.23 \times 10^{-2}$
Smog potential	kg NO <sub>x</sub> eq	$6.17 \times 10^{-2}$	$5.73 \times 10^{-1}$
Ozone depletion potential	kg CFC–11 eq	$3.20 \times 10^{-7}$	$2.97 \times 10^{-6}$

<sup>a</sup>SWHG: solar, wind, hydroelectric, and geothermal.

<sup>b</sup>GWP includes all biogenic carbon sinks and sources throughout the product system boundary.

requirements for EPDs on all imported products. It is anticipated that EPD requirements will be considered in the United States at state or federal levels, or through green building codes and standards.

- Basic life cycle information previously compiled for some wood products needs to be updated to meet EPD requirements. In order to make the best product comparisons, life cycle information needs to be updated every 3 to 5 years to account for technology changes and new regulations.
- To ensure transparent and peer-reviewed data for EPDs, there is a need to provide up-to-date life cycle information to the U.S. LCI Database. The U.S. LCI Database ([www.nrel.gov/lci](http://www.nrel.gov/lci)) is a library of life cycle data for many products, including building products. Life cycle information has been uploaded for more than 15 region-specific wood products to date. The data were provided from research conducted by the Consortium for Research on Renewable Industrial Materials (CORRIM) funded in part by the FPL. CORRIM is a non-profit research consortium of 15 universities that have partnerships with the FPL.
- In addition to basic life cycle information for the processes to produce a product, an EPD requires life cycle information on product use in specific applications such as buildings and disposal of products from these buildings. Obtaining life cycle information for applications and disposal is a

research-intensive activity requiring a large amount of data and analysis.

## New Technology

Research can advance the use of wood in green buildings through development of new product technologies. An example of a new technology in the United States for wood-based building systems is cross-laminated timber (CLT), which allows for large, solid-wood structural panels to be factory manufactured from low-value, small-diameter, and insect- and disease-killed trees. Suitable for multi-story buildings that substantially exceed current height limitations on conventional wood-frame construction, CLT is a good material for nonresidential green building construction. Although previously used in Europe, CLT is a new product in the United States, and research is needed to establish economic and resource parameters for market development and structural performance criteria required for building code acceptance.

Nanotechnology is another new technology that has the potential to significantly advance wood as a green building material (Atalla and others 2005). Nanotechnology is the understanding and control of matter at dimensions approximately 1 to 100 nm (a nanometer is  $1 \times 10^{-9}$  m), where unique phenomena enable novel applications. A sheet of paper is about 100,000 nm thick, and a gold atom is about one-third of a nanometer in diameter. Unusual physical, chemical, and biological properties can emerge in materials at the nanoscale. These properties differ in important ways from the properties of bulk materials and single atoms.

Nanotechnology holds great promise to revolutionize materials used in the 21st century, while wood-based nanomaterials provide the key materials platform for the sustainable production of renewable, recyclable, and environmentally preferable goods and products to meet the needs of people in our modern society (Wegner and Jones 2009). Our ability to see materials down to nanoscale dimensions and to determine and alter how materials are constructed at the nanoscale provides an opportunity to develop new materials and products in previously unimagined ways. Nanotechnology will result in novel forms of wood-based construction materials and products that have superior performance and serviceability under the most severe end-use environments. Use of nano-dimensional cellulose in nanocomposites also will allow the production of much lighter weight materials to replace metals and plastics in many applications.

### Codes, Rating Systems, and Standards

The provisions of building and material codes and standards are critical for the widespread acceptance of wood as a green building material. The use of scientifically consensus-based green building certification standards can also help the USDA meet climate mitigation strategic objectives nationwide. The USDA 2010–2015 Strategic Plan, Strategic Goal No. 2, is intended to ensure that our national forests and private working lands are conserved, restored, and made more resilient to climate change, while enhancing our water resources. Objective 2.2 is intended to lead efforts to mitigate and adapt to climate change. The mitigation role of forests under Objective 2.2 includes identifying and supporting the appropriate role that wood products can play in building construction that mitigates GHG emissions and other environmental burdens. Green building certification standards that identify and credit use of materials that mitigate GHG emissions as well as other environmental burdens can support achievement of Objective 2.2.

There are two key privately developed green building rating systems for commercial buildings (information for this section from Bowyer and others 2010):

1. Leadership in Energy and Environmental Design (LEED) by the U.S. Green Building Council (USGBC)
2. Green Globes, an outgrowth of the Building Research Establishment Environmental Assessment Method (BREEAM) developed in the United Kingdom, operating in the United States under the auspices of the Green Building Initiative (GBI)

On March 24, 2010, the GBI Green Building Assessment Protocol for Commercial Buildings was approved as the nation's first and only American National Standard Commercial Building Rating System by the American National Standards Institute (ANSI/GBI 01-2010). In addition to the GBI Green Building Assessment Protocol for Commercial Buildings, there are three other green building consensus-based standards:

1. The National Green Building Standard (NGBS), ICC 700-2008, developed by the National Association of Home Builders and the International Code Council under the ANSI standards process is for new construction and remodeling for all residential building types, including single-family, multi-family, and residential portions of mixed-use buildings. The scope of the NGBS rating standard is inclusive of land development, lots, and buildings. It is the only ANSI-accredited standard for residential construction.
2. The ASHRAE 189.1 Standard for the Design of High-Performance Green Buildings developed with USGBC and the Illuminating Engineering Society (IES), released on January 22, 2010, is a standard intended as a commercial green building standard.
3. International Green Construction Code (IGCC), now in development through the International Code Council (ICC), is intended for incorporation in 2012 international codes.

CALGREEN is the first state-wide green building code law. The California state legislature approved measures to adopt LEED as code for commercial and residential construction but was vetoed by Governor Schwarzenegger, affirming that the state should have a role in developing and adopting standards. The State Standard Commission was directed to develop a statewide green code. The code became mandatory on January 1, 2011. Currently many elements are voluntary, but it is anticipated by state leaders that many will become required over time.

In January 2010, New York City leaders announced that they will develop a green building code for the city based on the IGCC. The city of Phoenix, Arizona, developed a green building code to be implemented in July 2011.

As a research organization, USDA Forest Service Research and Development supports the use of LCA science to guide development of green building certification standards. All the codes and standards referenced above, except LEED, incorporate LCA in one way or another within existing standards. LCA has been a pilot credit within LEED and is now included in the draft revision that is currently being circulated for public comment. Proposed standards vary in the degree to which they use LCA science in determining which system designs and materials would cause the lowest environmental burdens.

The existing national scope of green building certification standards differs to a limited degree in how and to what degree wood use is considered "green":

- The NGBS, ICC 700-2008, is an ANSI-approved standard that allows wood to contribute in the resource efficiency section with use of certified wood products, engineered wood, locally sourced wood, recycled-content materials, and salvaged materials. Credit is also given if

LCA tools are used in building design and in the selection of materials.

- ASHRAE/USGBC/IES 2009 requires that 60% of all wood used in construction be chain-of-custody certified (with the certification program to meet standards of ISO/IEC Guide 59 or the WTO Technical Barriers to Trade document). Support is given for use of recycled-content materials, salvage and reuse, and locally sourced materials. There is an optional requirement that LCA be performed for a minimum of two alternative building designs.
- IGCC draft standard is comprehensive and includes language supporting the use of certified wood and LCA in building design and the selection of construction materials.
- LEED currently provides credits only for use of wood certified by the Forest Stewardship Council and locally sourced wood. LEED is considering an approach in the 2012 revision to incorporate LCA into all its standards. If adopted, structural/envelope assemblies will be evaluated with an LCA impact calculator based on the magnitude of impact of the selected assemblies compared with the average and lowest impact options.
- The GBI Green Globes design, assessment, and rating system recognizes and gives credit for use of wood from forests that are certified to any of the major forest certification systems such as the Forest Stewardship Council, Sustainable Forestry Initiative, and American Tree Farm System. This approach to recognition of forestry certification systems was supported by the ANSI teams and is included in the ANSI/GBI 01-2010: Green Building Assessment Protocol for Commercial Buildings.

The latest green building initiatives indicate a clear trend toward requiring green in building construction that includes demand for recycled content, re-used/refurbished products, regionally sourced materials, and certified wood. Currently, all green building standards except LEED recognize forest certification standards of the Sustainable Forestry Initiative, Forest Stewardship Council, and American Tree Farm System. In addition, with language regarding LCA now in all the new national scope standards as well as the new California code and the Green Globes standard, and perhaps fully integrated into the USGBC LEED program in the future, there is every indication that use of LCA represents a new way of doing business in green building evaluation.

LEED is the most widely used green building standard for new nonresidential buildings. An estimated 2.4 billion square feet of low-rise residential buildings (four stories or less) were constructed in 2009. This is based on estimated expenditures from the U.S. Department of Commerce and the estimated square feet per dollar of expenditures from

McGraw-Hill Corporation. Based on some analyses, as many as 25% of all nonresidential building starts are registered with LEED. However, a recent estimate indicates that only half the registered building starts follow through with full certification (Watson 2009). Using these fractions and wood use rates per square foot of low-rise buildings, an estimated 294 million square feet was certified and the associated wood use was approximately 390 million board feet. However, these figures should be considered order-of-magnitude estimates and require confirmation. Wood is also used in other residential and commercial buildings that are green certified by LEED or other standards, so the total wood use will be larger. However, even if the amount is off by a factor of two or more, it is likely to be only a small fraction of the estimated 57 billion board feet of lumber consumed in the United States in 2009.

Steps that the USDA could take in the area of codes and standards to expand the use of wood in green building include the following:

1. Support standards that use LCA to choose building designs and materials that reduce environmental burdens.
2. Endorse Forest Service adoption of the American Society for Testing and Materials Standard D 7612-10, Standard Practice for Categorizing Wood and Wood-Based Products According to Their Fiber Sources.
3. Support research that provides necessary data for the U.S. Life Cycle Inventory Database.

### Education and Technology Transfer

Although most people are aware that North American forests help to address climate change by absorbing carbon dioxide from the atmosphere, less well known is the fact that wood products continue to store carbon, thus keeping it out of the atmosphere indefinitely. Substituting wood products for fossil-fuel-intensive alternatives also results in significant amounts of “avoided” GHG emissions.

Technology transfer and education are key components of research that can significantly influence the preference for wood as a green building material. USDA Forest Service Research and Development is a partner in the U.S. WoodWorks program, which is nearing the end of its three-year pilot phase. This program has clearly demonstrated that education and technology transfer activities aimed at design and building professionals, including information on wood’s carbon benefits, can increase the amount of wood used in nonresidential structures. The program already supports more than 450 building conversions to wood from other materials, representing 400 million board feet of lumber and 100 million square feet of panels (3/8-in. basis). Between the carbon stored in the wood products and avoided GHGs, these projects represent a carbon savings of 2.2 million metric tons of CO<sub>2</sub> (equivalent). Supporting WoodWorks with

continued funding and technical expertise over the next five years is expected to increase these wood volumes to 5.5 billion board feet and 3 billion square feet, respectively, which represents a carbon savings of over 30 million metric tons of CO<sub>2</sub> (equivalent to removing approximately 6 million cars from the road for a year).

The Forest Service is currently involved in four demonstration projects in three locations: two structures at the Forest Products Laboratory in Madison, Wisconsin; one on the campus of Mississippi State University; and one under construction on the campus of Haywood Community College in Canton, North Carolina. These demonstration structures provide educational outreach on wood as a sustainable building material and afford an opportunity to conduct “real world” research specific to a geographic region. The structures are each unique, but all demonstrate wood as a green building material and emphasize the influence of regional climatic parameters on durability, energy efficiency, and livability.

A demonstration-related project recently promoted by the Forest Service and the wood products industry was the Florida Residential Carbon Challenge, a competition for architects to design a house with the lowest carbon footprint. The objectives of this competition were to increase understanding and development of single-family house designs that meet the structural and thermal requirements of the 2007 Florida Building Code and to move toward reduced carbon footprint and fossil fuel use in Florida (and the broader U.S. South). The visibility of a state-wide competition was aimed at encouraging building professionals and developers to incorporate such designs into their homes and communities. Although the competition did not specifically require the use of wood as a primary construction material, all 36 of the submissions involved wood-frame designs. The winning design was awarded to True Design Studios of Jacksonville at the 2011 National Association of Home Builders International Builders Show in Orlando. As a follow-up to the competition, APA—The Engineered Wood Association is sponsoring 10 seminars to educate architects and engineers on the sustainability aspects of wood-frame housing.

Although green building and sustainability are typically associated with buildings, the same principles can be applied to the transportation infrastructure. The Forest Service has partnered with Iowa State University to construct several demonstration bridges in Iowa. In these cases, sustainability considerations and availability of local wood species have demonstrated that wood is an excellent material for bridge replacement for the rural transportation infrastructure.

Several potential cooperative demonstration projects will further demonstrate the use of wood as a green building material:

- Six research/demonstration houses located in Washington, California, Arizona, Florida, Georgia, and North Dakota
- A partnership to construct the Forest Service National Museum using CLT
- Numerous CLT demonstration structures with the Forest Service National Forest System
- Demonstration projects involving nonresidential buildings with other government agencies
- Construction of 10 demonstration wood highway bridges in the Midwest and South

## Concluding Remarks and Recommendations

The USDA has the opportunity to take a lead role in advancing wood as a green building material through the development and implementation of programs that are publically relevant and are an appropriate role for government. Policy makers, the forest products industry, and resource management organizations support a science-based approach to outlining the benefits of using wood and wood-based products in green buildings in the United States. An interdisciplinary approach is needed to further develop scientific knowledge and provide technology transfer and education relevant to evaluating and advancing these benefits. It must be noted that the inherent benefits of using wood go beyond economic gains. Sound forest management leads to increased forest productivity, cleaner water, and enhanced wildlife habitat. Part of maximizing the environmental benefits of wood as a building material is to fully understand the benefits of sustainable forestry practices on the overall environmental impact. This includes assessing the impact of outreach and education, conservation cost share, and certification programs on the footprint of wood building materials. From this it will be possible to identify techniques for maximizing benefits and transfer these practices through partner networks of state forestry agencies, extension services, and sustainable forestry organizations.

The following annual programs are proposed to advance wood use in green building:

- *Life cycle assessment*—A partnership of government, universities, and industry is proposed to undertake research needed to support widespread recognition of wood’s carbon benefits under emerging green building codes, standards, and rating schemes. Led by the Green Building Strategy Group, a newly established organization composed of industry and non-government organizations to advance green building, this project includes expanding the library of transparent information available to industry and the public, filling critical gaps for wood products in the U.S. LCI Database, increasing acceptance and specification of wood as a green building material through the application of complete and current LCA data and tools, development of EPDs, and increasing technical knowledge of and preference

for wood products among building science and design/engineering professionals. For maximum impact, the group will also ensure that all key stakeholders understand the science behind LCAs and EPDs and appropriately promote their use. Workshops to engage key stakeholders, share research findings, solicit input, and further environmental understanding will extend outreach to materials scientists, public agencies, the conservation community, and policy makers.

- *Wood use in nonresidential buildings*—The U.S. WoodWorks program, which is nearing the end of its three-year pilot phase, has demonstrated that education and technology transfer activities aimed at design and building professionals, including information on wood’s carbon benefits, can increase the amount of wood used in nonresidential structures.
- *Carbon and green building benefits of typical wood structures*—A partnership is proposed between government and forest research organizations to show how carbon-storing wood products can be used in typical residential and nonresidential construction. The partnership will pursue research and technology transfer activities that demonstrate the advantages of wood over other building materials in green building. This effort includes activities that build on the success of the Florida Carbon Challenge, a program designed to educate design and building professionals about the relationships between climate, carbon, and everyday building. In addition to design competitions, educational seminars and the construction of three or four demonstration houses are proposed. This effort will further the development and use of new or improved wood products and technologies (such as cross-laminated timber) to extend utilization of the forest resource and improve the environmental importance of buildings as measured by LCA tools.

By supporting these initiatives, the USDA can help to achieve its climate change objectives, while creating jobs, bolstering the competitive position and long-term economic stability of the industry, and reducing U.S. dependence on foreign oil.

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